Switch on to Safety

Electricity is the fuel we use in our everyday lives for things like: lighting, heating, appliances, computers, telephones and games. You cannot see it, but it's always there.

Electricity is part of our everyday life – designed to provide us with a safe and reliable source of energy. Staying safe around electricity is everyone's responsibility. You should watch out for yourself, your friends and your family.

This unit provides opportunities for students to learn about electrical energy through a series of activities, working with a range of materials and transferring the knowledge gained into the design and development of a working model that uses transformed electrical energy.

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

Ausgrid

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June Gehrig, Woronora River Public School

James Wratten, Yowie Bay Public School

Jenny Madsen, Chatswood Public School

Pat Sherring, Panania Public School

Rhiannon Gray, Marrickville West Public School

Gillian Mulholland, Senior Project Officer

Harris Vassila, Senior Education Adviser

Suzanne Ziems, Project Officer

Contents

Foreword

Helping the community understand the importance of electrical safety is at the forefront of Ausgrid's plans to operate a safe and reliable electricity network.

That's why we introduced Electricity Safety Week back in 2002. Events such as Electricity Safety Week help us educate people about how our electricity network works and how to behave safely around electrical equipment.

To support the teachers who are supporting us in delivering important safety messages to students, we have developed curriculum material in partnership with the Department of Education to help students learn about electricity and electrical safety.

This education material includes teachers notes, student lesson plans, extension activities, an electrical safety DVD, a kit for students to engage in electrical experiments and SMART notebook lessons with embedded resources.

This material will help teachers discuss how electricity works, how we use it and how everyone, including students can stay safe in their homes and around electrical equipment.

By working with schools we can encourage learning through scientific investigation and ensure students stay safe around electricity for the rest of their lives.

George Maltabarow
Managing Director
Ausgrid

Unit Overview

Sequence	At a glance
What do we know about electricity?	To capture students' interest and determine what students know about electricity using a KWL chart. To reinforce the importance of electrical safety.
Electrical Safety	Students complete an electrical safety officer test.
Making a light bulb glow	To provide hands-on shared experiences of electrical circuits.
Simulating the flow of electrons	Support the students conceptual development.
Investigating conductors and non-conductors	Students investigate scientifically to confirm an hypothesis·
Devising an electrical switch	Students apply their understanding of electrical circuits.
Investigating electro-magnets	Exploring electrical concepts.
Demonstrating the fuses	Teacher demonstration.
Investigating series and parallel circuits 1	Students investigate scientifically to confirm an hypothesis.
Investigating series and parallel circuits 2	Students investigate scientifically to confirm an hypothesis.
Transformation of energy	Students explore the transformation of electrical energy.
Planning for an electrical emergency	Students develop an electrical emergency action plan.
Generating electricity	Students research the generation of electricity.
Transportation of electricity	Students identify electrical dangers in the community.
Electrical consumption	Modifying habits to reduce electrical consumption.
Exploring the design task	Students undertake a design and make task applying their understanding of electric circuits, electricity to satisfy a personal need.
Generating design ideas and realising solutions	To provide opportunities for students to make their design task and solve the initial design brief.
Evaluating products and processes	To provide opportunities for students to reflect on their learning during the unit and to share their findings and understanding of electricity.

Unit outcomes

Science and Technology outcomes and big ideas*

Investigating

INVS3.7 Conducts their own investigations and makes judgements based on the results of observing, questioning, planning, predicting, testing, collecting, recording and analysing data, and drawing conclusions:

- constructs appropriate self-questions to guide investigations.
- decides the type of data needed and works cooperatively to collect such data.
- plans repeat trials of tests or experimental procedures.
- identifies factors that are to be kept the same when carrying out tests or conducting investigations, and recognises the term "controlled experiment".
- ensures that equipment is working and can be used effectively and safely.
- records data in an appropriate form and evaluates collected data to ensure that it satisfies the purpose of an investigation.
- transforms data to show important relationships, trends, patterns or associations.
- uses the ideas of fair testing to evaluate whether predictions or explanations are reliable and valid.
- communicates what has been learned by choosing from a variety of media, tools and forms, taking into account audience and purpose.

Physical Phenomena

PPS3.4 Identifies and applies processes involved in manipulating, using and changing the form of energy:

- energy may be moved in a range of ways (e.g. an electric current, radiation and conduction of heat). This is called transfer of energy.
- energy may be transferred as light, sound, heat, electrical and movement energy.
- energy can be stored in a variety of ways, e.g. in a battery, in a hydroelectric dam, in food. (Refer to Appendix 1).
- energy of one form can be changed to energy of another form, e.g. from electricity to heat, from chemical energy, e.g. petrol, to kinetic energy, e.g. movement. This change is called transformation.
- there are a variety of resources that provide us with energy, including oil, gas, coal, food, wind, waves and batteries. Some of these resources are renewable; others are non-renewable.

Designing and Making

DM S3.8 Develops and resolves a design task by planning, implementing, managing and evaluating design processes:

- researches needs that influence the development of products, systems and environments and establishes criteria for the evaluation of produced designs.
- generates design concepts that reflect the consideration of aesthetic, cultural, safety and functional requirements.
- produces annotated concept sketches and (freehand) drawings for use by other people.
- elects tools, equipment and resources to meet the requirements of production and use.
- assesses the efficiency of processes of design and production and evaluates the result against established criteria for success.

Products and Services

PS S3.5 Creates and evaluates products and services, demonstrating consideration of sustainability, aesthetic, cultural, safety and functional issues.

- communities create complex systems to manufacture products and provide services.
- systems that provide services to communities greatly influence how we live.

*Big ideas were first developed for the Supporting SciTech in the primary classroom CD ROM (2002) http://10ss.qtp.nsw.edu.au/supporting_scitech/index.html

Personal Development, Health and Physical Education outcomes and indicators

Safe Living

SLS3.13 Describes safe practices that are appropriate to a range of situations and environments.

- practices emergency response procedures, e.g. first aid, dial 000.
- devises strategies to respond to risky and dangerous situations, e.g. electrical equipment.
- an unsafe situation or practice.

Decision Making

DMS3.2 Makes informed decisions and accepts responsibility for consequences.

- recognises a medical emergency and knows how to give and gain assistance.

1. What do we know about electricity?

Observing and exploring

(ask questions, pose problems, find out what is currently known)

The purpose of this task is to ascertain what students currently know about electricity.

- What do we know about electricity?
- Ask students to identify some forms of energy i.e. heat, light, sound or movement. Can we see or feel energy?
- Form small groups and ask students to record what they know about electricity on a on a small KWL chart (know, what to know, learnt):
  - what do we know about electricity?
  - what do we want to find out about electricity?
  - what have we learnt about electricity? (leave until the end of the unit)
- Have groups share their KWL charts with the class.
- Discuss the groups KWL charts then combine the students KWL charts to construct a large class KWL chart to display on the classroom wall.
- Start a word wall – identify and write all new or technical words and place them around the class KWL chart. Students will be able to refer to and add to the word wall throughout the duration of this unit of work.
  - in the student's SciTech Journals, have students identify zzhzand list appliances that use energy in the classroom.
  - walk around school to identify and list items that use energy.
- Return to the classroom and discuss the list of appliances.
  - list all the items that students have identified and group them according to the energy form they use.
  - what is the most common energy form used in our school? (Electricity)
  - discuss where does electricity come from?
  - is electricity dangerous? Discuss possible safety issues.
- View the DVD **Electricity and Safety**
  - discuss the information presented. Discuss the electrical safety issues presented.
  - discuss issues relating to electrical safety at school, home and in rural settings, e.g. farms.
- Have students add new information to the KWL chart and word wall.
- Have all students complete Safety Officer pre-test (all students will be safety officers at some time during the scientific investigations). Safety Officer Licence Test (six key messages) to be glued into journal.

TEACHER NOTES

What is energy?

Energy causes change; it does things for us.

See Appendix – SciTech Journals

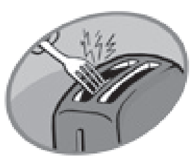
See Appendix – KWL chart

DVD Electricity and Safety and six key rules (cardboard chart)

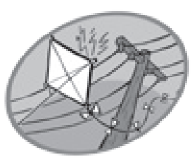
Electrical Safety Officer Test

Name: ______________________ **Date:** ______________

Here are three pictures of dangerous situations involving electricity.
Explain why each one is dangerous (what might happen?).



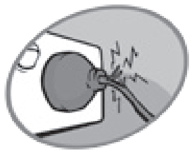
Picture 1 This is dangerous because



Picture 2 This is dangerous because

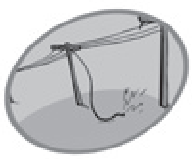
Picture 3 This is dangerous because

Here are three more dangerous situations. This time explain what to do in each one.



Picture 4 The boy should

Picture 5 Everyone should



Picture 6 I would

Here are six safety rules. Each rule goes with one of the six pictures you have seen already.
Match the right picture to each rule.

- Picture number ______ Rule: Stay away from electricity substations!
- Picture number ______ Rule: Electricity and water do not mix!
- Picture number ______ Rule: Know what to do in an electrical emergency!
- Picture number ______ Rule: Be careful around electricity poles and wires when you play!
- Picture number ______ Rule: If you see a dangerous situation tell an adult!
- Picture number ______ Rule: Metal is a conductor of electricity and can be dangerous!

Certificate
of
Electrical Safety

This certificate is awarded to

____

for successfully completing the Ausgrid
Electricity Safety Quiz.

The bearer of this certificate is authorised to
undertake the duties of an Electrical Safety Officer
during Science and Technology activities.

______________ ______________ ______________
Teacher School Date

Ausgrid

2. Observing and exploring electrical circuits

Task: To make a light bulb glow.

Observing and exploring

(ask questions, pose problems, find out what is currently known)

Investigate various ways of connecting a battery, bulb and wire.

Equipment

– Role badges for manager, safety officer and speaker (page 54)

– Each team member's SciTech journal

– 1.5 volt battery

– Light bulb

– 2 connecting wires

Suggested activity steps

- Have students use the battery and ONE connecting wire to make the light bulb glow.
- Have students draw and label a diagram showing how they connected the battery and light bulb.
  – Discuss where must they connect the wire to make the light bulb glow.
  – How many different ways were there to make the light bulb glow?
- Have students make the light bulb glow using TWO connecting wires.
- Discuss the methods used to make the light bulb glow; guide students' attention to the formation of circuit created by the battery, wires and light bulb.
- Class discussion:
  – ask some students to present their observations to the class.
  – what circuits made the light bulb glow?
  – what did the circuits that made the light bulb glow have in common?
  – what did the circuits that didn't work have in common? (introduce the terms open and closed circuit).
- Revise KWL chart and word wall.

TEACHER NOTES

In this investigation students should have noticed:

– both ends of the battery must be connected to the light bulb before it will glow.

– metal connection points are called terminals.

– the metal side of the light bulb is one terminal and the bottom is the other.

– the top of the cell is positive (+ve) and the bottom of the cell is negative (-ve).

– the light bulb has to be connected in two places zto complete the circuit.

– for the light bulb to glow there has to be a closed circuit joining the battery and the light bulb. This is called an electric circuit.

– when there is a gap or break in the circuit the light will not glow, this is called an open circuit.

2. Observing and exploring electrical circuits

Observing and exploring

(ask questions, pose problems, find out what is currently known)

Simulation activities:

- Mark out a circuit in the playground using a chalk line and place a small obstacle along the circuit e.g. a small box. Have a student stand near the obstacle, who will collect a counter from each passing student.
- Ask several students to stand at regular intervals along the drawn circuit while the teacher stands opposite an obstacle with a bowl of counters.
- Have students walk along the circuit maintaining their distance from the person in front and jumping over the obstacle.
- As students jump over the obstacle they give a counter to the student standing near the counter who smiles each time they receive a counter.
- As students pass the teacher they each receive another counter.
- Continue the simulation until all the counters have been used by the students.

• Discuss the circuit activity.

• Identify the various representations of the activity such as the:
  - chalk line representing wires.
  - obstacle representing the light globe.
  - teacher representing the battery.
  - students representing electrons.
  - counters represent the electrical energy.

• Discuss the function of each of the parts of the circuit such as the wires to allow the flow of electrons, the battery which provides more energy to the electrons and the light globe that uses some of the energy.

• Simulate an open circuit by placing the students on the circuit and asking them to walk around it.

• Rub out a section of the chalk line. (Once the circuit is open, all students should stop walking around the circuit.)

• Discuss the simulation. It is important that students develop an understanding that once a circuit is open, all electrons stop flowing.

• Simulate and discuss a short circuit by drawing a chalk line by-passing the light bulb (obstacle). Ask students to walk the circuit again using the easiest path.

• Discuss with students the easier path is a short circuit (electrons will follow the path of least resistance to return to their energy source).

• Discuss how this can be dangerous.

• Have students make notes of the new terminology and concepts in their SciTech log books and add to the KWL chart. This should include descriptions of open, closed and short circuits.

TEACHER NOTES

– Explain to students that electricity is a flow of electrons.

– Electrons flow through the wires to the globe and back to the battery.

– Discuss open, closed and short circuits.

3. Planning and conducting investigations

Investigating conductors and insulators

Task: Identify materials that conduct electricity.

Hypothesising and predicting

(define a problem that can be investigated scientifically)

Hypothesis

Metal objects conduct electricity.

Equipment

– Role badges for manager, safety officer and speaker

– Each team member's SciTech journal

– 1.5 volt battery

– Light bulb and lampholder

– Multimeter (if available, but not essential for experiment)

– 3 connecting wires

– Variety of items for testing, e.g. paper-clips, aluminium foil, rubber band, string, texta, wooden ruler and other classroom items.

Devising and testing

(describe a procedure for collecting data, identify appropriate equipment to carry out the procedure)

- How do we know that electrons are flowing in a circuit? (We could use an indicator such as a light bulb or a buzzer, when there is a flow of electrons the light bulb will glow or the buzzer will sound).
- Discuss with students how they could test different materials for electrical conductivity.
  - Guide students to suggest constructing an open circuit that includes a battery, wires and a light bulb. The items being tested should then be used to complete the circuit. If the light glows, then the material is a conductor of electricity.
- Discuss with students:
  - the idea of a "fair test."
  - how can we ensure that the test is fair?
  - what variables must we keep the same? (length of wires, same battery, etc.)
  - how will we record our observations?

3. Planning and conducting investigations

- Have students construct a table in their SciTech journal with a list of approximately ten objects in the left hand column. Have them predict conductivity. Example shown below:

Object	Material	Prediction: Will it conduct electricity? Yes/No	Does the light bulb glow?
Paper-clip	steel		
Plastic ruler	plastic		

- Allocate roles to the students and have students construct the open circuit.
- Ask students, in groups, to test their circuit by using the object to complete the circuit. If the light globe glows hen the object is a conductor of electricity. If the object did not allow the light to glow then it is a non-conductor.
- Have students test the provided objects. Ensure students record their observations.
- Have students present their findings to the class.
  - List the conductors and non-conductors.
  - Is there a pattern in the results?
  - Was the outcome different to their predictions?
  - Do the results support their hypothesis?
  - What difficulties did they experience when completing this investigation?
  - How could they improve this investigation?
- Have students suggest reasons why electrical wires are coated in plastic?
  Why should frayed electrical cords be replaced?
- Discuss:
  - Why is it useful to know which materials conduct electricity?
  - Will the human body conduct electricity? What injuries may happen to a person who has been electrocuted? (See discussion card B.)

Task: Devise an electrical switch (open ended task).

Teachers may like to allow students to design, make and test their own electrical switch.

Suggested equipment

– Role badges for manager, safety officer and speaker
– Each team member's SciTech journal
– 1 x 1.5 volt battery
– 1 x bulb and lampholder (or buzzer)
– Wire cutters, paper-clip and split pins
– A small piece of cardboard
– Connecting wires

Activity steps

- Review previous sessions (open and closed circuits), refer to word wall and KWL chart.
- As a class, discuss the criteria for successfully constructing a switch, i.e. the switch must be:
  – safe.
  – able to be switched on and off repeatedly.
- Have students in groups draw a labelled diagram of their design.
- Allocate roles to the students and obtain equipment from teacher.
- Have students construct and present their designs to the class.
- Have students discuss the safety features incorporated in their designs and how their design could be improved.

3. Planning and conducting investigations

Observing and exploring

(ask questions, pose problems, find out what is currently known)

Task: Create an electro-magnet.

Equipment

– Role badges for manager, safety officer and speaker

– Each team member's SciTech journal

– 1 x 1.5 volt battery

– Copper wire

– Nail

– Sticky tape

– Wire cutters

– Paper-clip

– Connecting wires

Activity steps

- Review previous sessions (open and closed circuits), refer to word wall and KWL chart.
- Have students cover approximately half of the nail with sticky tape.
- Ask students to wind a length of copper wire around the sticky taped section of the nail.
- Space the coiled wire so that the coils are not touching (just separated).
- Test the electro-magnet without the battery connection.
- Connect the ends of the copper wire to a battery to complete the circuit.
- Test the strength of the electro-magnet by picking up various metal objects such as a paper-clip, staples, etc.
- Once the students have constructed their electro-magnets have them independently investigate how they could increase the strength of their electro-magnet.
- Revise the steps involved in the process of investigating scientifically. (See Appendix 5.)

Sample hypothesis

Increasing the number of coils in the electro-magnet will increase the strength of the electro-magnet.

Increasing the voltage in an electro-magnet will increase the strength of the electro-magnetic (sample procedure not provided).

TEACHER NOTES

An electro-magnet is simply a coil of wire. It is usually wound around an iron core. When connected to a voltage source, the electro-magnet becomes energised, creating a magnet just like a permanent magnet.

Devising and testing

(describe a procedure for collecting data, identify appropriate equipment to carry out the procedure)

Varying the number of coils

- Wind a length of copper wire around 3 nails a) 10 times, b)20 times, c) 30 times.
- Space the coiled wire so that the coils are separate.
- Connect a battery to the ends of the copper wire to complete the circuit.
- Test the strength of the electro-magnet by picking up various metal objects such as a paper-clip, staples.

– Students should independently develop a method of measuring and recording their observations regarding the strength of the tested magnet.

Analysing and drawing conclusions

– Which electro-magnet was the strongest?

– Was your test fair?

– How could you improve your investigation?

– Why was sticky tape used on the nails?

3. Planning and conducting investigations

Teacher demonstration

How does a fuse work?

Equipment

– Role badges for manager, safety officer and speaker

– Each team member's SciTech journal

– 2 x 1.5 volt batteries

– Low amp fuse wire (1 amp) or strands of steel wool

– Connecting wires

– Dinner plate

Activity steps

- Revise open and closed circuits with students.
- Discuss what may happen to wires if too much electric current flows through them.
  – Wires would melt and may cause a fire.
- Teacher creates an open circuit using the battery and connecting wire.
- Place a short length of fuse wire on the dinner plate.
- Connect the wires to each end of the fuse wire to close the circuit.
- Have students observe:
  – What happened to the fuse wire?
- Have students suggest:
  – An explanation for their observation (too much electricity flowing through the fuse wire).
- Have students draw and label a diagram of the demonstration.
- Discuss:
  – Ask students to explain the simile "a fuse is like an electrical watch dog."
  – Why should you not plug too many appliances into a wall socket.
- Most modern houses have circuit breakers or safety switches. Research one of the devices.

TEACHER NOTES

A fuse is connected directly into an electrical circuit.
If the electric current surges to a dangerous level, the metal in the fuse melts and the circuit is broken, preventing overheated wires from starting a fire.

Investigating series and parallel circuits

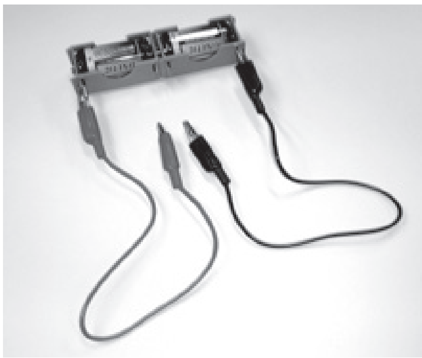
Observing and exploring

(ask questions, pose problems, find out what is currently known)

- Discuss with students the terms series and parallel

Batteries in series

1. Have students construct a closed circuit that includes 1 battery, 2 wires and a light bulb.
2. Place a dark coloured card behind the light bulb and observe its brightness.
3. Have students repeat step 1 using 2 batteries connected in series.
4. Place a dark coloured card behind the light bulb and compare the brightness of the light bulbs in each circuit.



- Discuss with students what they observed and have students suggest explanations for their observations.

Batteries in parallel

1. Have students construct a closed circuit that includes 2 batteries set in parallel, 2 wires and a light bulb.
2. Place a dark coloured card behind the light bulb and compare the brightness of the light bulb with the previous circuit.
3. Ask students to place a third battery in parallel and compare the brightness of the light bulb.

- Discuss with the class:
  - Did the additional battery make the bulb glow brighter?
  - What do you think is happening to the flow of electrons in a series and parallel circuit?

TEACHER NOTES

The word series means "following on from the previous one," like a TV series.

It's important to connect the batteries with their terminals in the correct order. Batteries in series need to be connected with the positive end of one battery to the negative end of the next battery.

If they are incorrectly connected, the batteries will cancel out each others energy and quickly flatten each other. This can be dangerous.

Batteries correctly placed in series, positive to negative, will add their output voltages, producing a greater voltage.

The word parallel means "alongside each other." When batteries are placed in parallel all the positive terminals are joined together with a single wire to one part of the circuit, and all the negative terminals are joined with a single wire to the rest of the circuit.

Remember the voltage increases when batteries are in series, but with batteries in parallel this is not the case. When two or more batteries are placed in parallel, the voltage in the circuit is the same as each individual battery. That is two, three, four or more 1.5 volt batteries in parallel will produce a voltage of 1.5 Volts!

3. Planning and conducting investigations

Hypothesising and predicting

(define a problem that can be investigated scientifically)

The greater the number of batteries connected in series the greater the voltage.

Equipment/Materials

– Role badges for manager, safety officer and speaker

– Each team member's SciTech journal

– 2 x 1.5 volt batteries

– Multimeter

- Discuss with students ways of accurately testing the hypothesis.
- Teacher introduces, explains and demonstrates the use of the multimeter to the students (see Appendix 3).
- Have students reconstruct their series and parallel circuits from the previous activity replacing the light bulb with multimeter to complete the circuit.
- Have students construct a table to record their observations in their SciTech Journals (sample below).

Type of circuit	Number of batteries	Multimeter reading (DCV)/(DCA)
	1 battery	
Series	2 batteries	
	3 batteries	
Parallel	2 batteries	
	3 batteries	

- Using the multimeter have students measure record and compare the voltage and amps of each circuit.

Analysing and drawing conclusions

(reach a conclusion which is communicated to others)

- Have students construct a graph using the collected data.
- Discuss with students what type of graph would best represent the data in a way that best addresses their hypothesis.
- What labels must they include on the X and Y axis?
- Once students have constructed their charts discuss the results and construct a statement summarising what they have learnt about batteries set in series and parallel circuits. Add the statements to the KWL chart and any new words should be added to the word wall.

Investigating series and parallel circuits 2

Observing and exploring

(ask questions, pose problems, find out what is currently known)

- Revise the previous activity of placing batteries in series or parallel.
- Ask students to predict what may happen to the brightness of 2 light bulbs if they were placed in series.
- Ask students to predict what may happen to the brightness of 2 light bulbs if they were placed in parallel.

Equipment/Materials

– Role badges for manager, safety officer and speaker

– Each team member's SciTech journal

– 1.5 volt battery

– 2 x light bulbs and lampholders

– Connecting wires

Devising and testing

(describe a procedure for collecting data, identify appropriate equipment to carry out the procedure)

- Have students construct a closed circuit that includes 1 battery, wires and 2 light bulbs connected in series.
- Place a dark coloured card behind the light bulbs and observe their brightness.
- Ask students to predict what would happen if 1 light bulb was removed from its holder. Discuss the student's answers.
- Remove one light bulb from its holder, observe what happens.
- Have students construct a closed circuit that includes 1 battery, wires and 2 light bulbs connected in parallel.
- Place a dark coloured card behind the light bulbs and observe their brightness. Compare the brightness of the light bulbs from both the parallel and series circuits.
- Ask students to predict what would happen if 1 light bulb was removed from its holder. Discuss the students' answers.
- Remove one light bulb from its holder, observe what happens.

3. Planning and conducting investigations

- Have students record their observations using a table (sample below).

Type of circuit	Number of bulbs	Brightness of bulbs	Circuit when one bulb removed (Yes/No)
Series	One bulb		
	Two bulbs		
Parallel	Three bulbs		
	Four bulbs		

- Discuss with students the advantages of each of the circuits and list some of their uses. Christmas tree lights used to be connected in series, what problems did this present? How are house circuits connected?
- Add new learning to the KWL chart and to the word wall.
- Have students draw, label and write a short description of their observations in their SciTech journals.

4. Transformation of energy

Observing and exploring

(ask questions, pose problems, find out what is currently known)

- Discuss with students the concept that energy can not be destroyed, but rather transformed i.e. the sun's energy is used by plants to grow and produce fruit, humans then consume the fruit which can be used to maintain our body temperature and allows us to move, walk or run.
- Ask students if they are aware of any other transformations of energy.

Big question: How is electrical energy transformed?

1. Review the simple circuit of the light bulb and have students reconstruct the circuit.

- Ask how is the electrical energy transformed in the light bulb?

  (Electrical energy is transformed to light making the light bulb glow and heat.)

- Ask students to lightly touch the light bulb.
- What can they feel – heat.
- Have students draw and label a diagram of their circuit indicating the transformation of electrical energy.

2. Have students replace the light bulb in their circuit with a buzzer.

- Ask how is the electrical energy transformed?

  (Electrical energy is transformed to sound and heat.)

- Have students draw and label a diagram of their circuit indicating the transformation of electrical energy.

3. Have students replace the buzzer in their circuit with an electric motor.

- Ask how is the electrical energy transformed.

  (Electrical energy is transformed to movement, sound and heat).

- Have students draw and label a diagram of their circuit indicating the transformation of electrical energy.
- Discuss the new learning with the students and add to the KWL chart and to the word wall.

5. Developing an electrical emergency plan

Developing an electrical emergency action plan

- Discuss situations where emergency assistance may be required. Consider the range of situations and injuries that may occur. In small groups, ask students to select an electrical emergency situation and suggest a sequence of actions to assist themselves and others within that situation. Ask questions such as:
  - what steps would you take to prevent this situation?
  - what steps would you take to deal with this situation?
  - who would you contact?
  - what basic first aid would you use?
  - what decisions may have to be made?
  - what may be the consequence of these decisions?
  - why is it important to think carefully before making decisions in an electrical emergency situation?
- In small groups have students develop an emergency action plan for an electrical emergency. The emergency action plan will need to be in the form of a poster, clearly identify the electrical emergency and clearly outline the appropriate procedure to follow. See the Electrical Safety Activities.

6. Generating electricity

Generating electricity

Observing and exploring

(ask questions, pose problems, find out what is currently known)

- Class discussion, how is electricity produced?
  - Electric generators
  - Chemical reactions
  - Solar cells
- Have students view the website http://www.wvic.com/how-gen-works.htm for an explanation of how an electric generator works.
- Allow students to explore the hand-held electric generator.
- Allow students to construct a variety of circuits with a light, motor or buzzer. Have students use the hand-held electric generator to supply electricity power to their circuits.
- Have students research one method of generating electricity.
- Construct a class summary of the various methods used to make an electric generator turn.
- Revise and discuss with students energy transfers. Discuss the energy transfers involved in the generation of electricity.
  - What form of energy is used to turn the generator?
  - What form of energy is used to turn the generator in a power station?
  - Identify sources such as:
    - Coal burning — chemical energy – heat – kinetic – electrical
    - Hydro — potential energy – kinetic energy – electrical
    - Wind — kinetic energy – electrical
    - Nuclear — nuclear – kinetic energy – electrical
    - Solar — light energy – electrical
    - Battery — Chemical energy – electrical
- Have students draw diagrams in their SciTech journal to show each form of generating electricity. Identify where the processes are the same and different.

7. Transportation of electricity

Transportation of electrical energy

Observing and exploring

(ask questions, pose problems, find out what is currently known)

- Ask students to collect pictures of items that transport electricity or items that are used to create electricity in their local environment.
- Have students group their pictures into items that:
  - transport electricity.
  - use electricity.
  - produce electricity.
- Have students in groups make a list of some of the dangers and safety features used in the identified items.

Safety features may include:

- warning signs/labels.
- fencing.
- insulation.
- fuses/circuit breakers.

Dangers may include:

- contact with bare wires.
- i.e. flying kites, flying metal balloon.
- climbing trees close to powerlines.
- drilling into walls.
- digging (underground lines).

TEACHER NOTES

– The discussion pictures included in the Electrical Safety Package should be used to initiate this discussion.

– See discussion cards A and B

8. Electrical consumption

Electrical consumption

- Review the sources of energy used to generate electrical energy.
  - Identify whether they are renewable or non renewable.
  - Identify some of disadvantages of using the various energy forms.
  - Discuss ways we could reduce energy consumption around our school and home.
  - Discuss how electricity is measured in your home – meter.
- Have students complete the Home Energy Saver http://saver.ausgrid.com.au/start.html
  - Have students modify their virtual home to reduce the amount of electrical energy used.
  - Discuss what appliance/s consume the most electrical energy in their home.
  - Identify some strategies they could use to reduce the consumption of electricity at school.
- Discuss or debate the issue – Why should we reduce the amount of electricity we use?

9. Exploring the design task

Design task

In SciTech, students demonstrate understanding gained through a scientific investigation by resolving a design brief.

Design brief: Design and make a product that uses the 'transformation of electrical energy' as an essential feature of its operation. The product must meet a personal need of students, i.e. be designed for self.

Exploring the task

(Define purpose of the product, develop criteria and find out what is currently available)

- In groups, students use the table below to review uses of electrical energy explored in earlier activities. Students identify the need addressed by the product or the system, and the energy transformations involved in its operation e.g.

Product	Need / Purpose	Energy transformations
Home security alarm	Warn off intruders Dissuade intruders Protect people and property	Sensor (light/sound energy) > electrical energy > sound energy
Vacuum cleaner	Remove dust and dirt Remove dust mites that cause allergies	Electrical energy > mechanical energy
Stove	Heat or cook food	Electrical energy > heat energy
Solar garden lights	Provide lighting for paths Provide security Increase enjoyment of garden	Light energy > electrical energy > chemical energy (battery) > electrical energy > light energy

- Discuss the personal needs of students and how designing and making a product that transforms electrical energy may solve a personal need.
- In pairs/groups students brainstorm problems, difficulties and interests that reflect a personal need, e.g.
  - my little brother reads my diary.
  - everyone barges into my room. I have no privacy.
  - I like reading in bed at night but the light disturbs my little sister.
  - we get very hot in our tree house.
  - the mosquitoes always bite me when I am in the garden.
  - how can I make a game that keeps my younger brother/sister amused?

- From the brainstorm, each pair of students prepares a list of problems/needs and decides which one they would like to work on together. The selected problem/need should have the potential to transform electrical energy as part of its design solution.
- Revise earlier design tasks and review the stages of the design process each group must work through. Discuss with each group how they will apply a design process to this product development task.
- Without pre-empting a solution, each group will generate a list of criteria to be used to judge the success of their solution. Ensure that each group includes in its list a criterion that states: 'uses the transformation of electricity as a feature of its operation'. All designs must identify their safety features.
- In pairs, students draft questions that will be addressed as they work through their design process e.g.
  - what products exist that address similar problems or needs? How do they work?
  - what resources are available to construct our product?
  - how will we test and evaluate our design solution?
  - how will we manage the time available to develop our product?
  - how much time do we have to design our product, to make it and to evaluate it?
  - is there a 'technical expert' who can provide assistance?
  - where can we purchase components and materials?
  - are there electrical safety issues?

10. Generating design ideas & realising solutions

Generating ideas and realising solutions

(explore and refine options and decide upon a design option, choose resources and equipment to plan and produce the design)

- Students sketch initial ideas for their product and annotate their sketch to explain how the product works. With each group the teacher discusses the method to be used to evaluate the initial idea, e.g. prepare questions for friends in another group, consult a mentor.
- Remind students to consider the circuit required to operate the product. Review earlier activities in which students constructed a circuit, e.g. to illuminate a light globe. To explore possible solutions for the circuit, provide students with a greater variety of functioning components, e.g. batteries, battery holder, switch, lampholder, globe, buzzer (peizo), solar panel, electric motor.
- Ensure that students understand that their product must be housed in a suitable casing. Discuss what functions the casing must perform, e.g. hold the circuit in place, hold the working parts, protect the product from dirt and damage, be easy to handle, be aesthetically pleasing, convey information about the operation of the product. Provide students with a wide range of materials that can be used to complete the product e.g. paddle pop sticks, construction blocks, elastic bands, cardboard, adhesive tape, styrene foam.
- The attached link provides background information for teachers on the design and development of a product that uses electrical energy, the Dyson vacuum cleaner: http://www.dyson.co.uk/education/default.asp

11. Evaluating problems & processes

Evaluating products and processes

(evaluates success of the design against the criteria and considers the effectiveness of the process)

- As each group completes the construction of its product, have group members prepare a survey to be used for the purposes of evaluation. Check each group to ensure that the questions in the survey clearly relate to the criteria for success established at the commencement of the project.
- Have each group work wzther group to test its product, i.e. user testing. Ensure that comments collected during user testing are included in the group's evaluation of its product.
- Provide all students with questions to be used when reflecting on their project.
  Questions you might ask students to consider:
  - What part of the project was most enjoyable?
  - What part of the project was least enjoyable?
  - What was learnt?
  - What part of the learning was most important? Why is it important?
  - What other things could have been done to assist groups?
  - If you were to undertake the task again what would you do differently and why?

Appendix 1

Physical phenomena
Teacher notes

Excerpts from the Physical Phenomena Resource Unit on Supporting SciTech in the primary classroom CD ROM

Basic conceptual ideas and understandings

Forms of energy

Energy is noticed in different ways when change occurs (these ways, or effects, have been called forms of energy).

Forms of energy include heat/thermal, chemical, light, gravitational, sound, elastic, movement/motion/kinetic, nuclear, gas and electrical.

Forms of energy that involve motion e.g. movement, heat and sound are examples of kinetic energy.

Some forms of energy are called potential (or stored) energy, e.g. chemical, elasticity, and gravitational. There is the potential for an energy transfer to occur. There really is no evidence of energy (transfer) present until a change occurs, e.g. a change in the height of an object or a change of state or a change in appearance as in a chemical reaction.

Electricity

A battery is a source of potential electrical energy in a circuit and a battery creates a flow of current.

Batteries vary in their ability to provide energy. A stronger battery provides more energy to the circuit.

Electric current is associated with energy transfer in a circuit.

A circuit must be closed (complete) for an electric current to flow.

There is the same amount of current in all parts of the circuit.

A switch in a circuit affects the flow of electricity in all parts of the circuit instantly. When open there is no current anywhere in the circuit; when closed there is current flowing everywhere at once.

The higher the voltage of a battery the greater the energy transferred to its circuit by the current.

The energy supplied by the battery is transferred to the bulb, increasing its energy.

Appendix 2

Progression of students' learning

What do students, and in particular primary students (K–6), think about some of the ideas related to this strand and are there some with which primary students have difficulty?

It is not possible to say precisely what students of any age think about particular phenomena. However there has been considerable research over the last 20 years which suggests how most learners think about phenomena and their associated explanations which help us to understand our world. What follows is an overview of what teachers might expect their class to be thinking about the topics in this content strand, e.g. forms of energy and their use in our lives. Some of your students will hold more acceptable scientific ideas than others.

Nursery learners (up to four-years-old) do not seem to recognise forms of energy, the transference of energy or that energy can be stored. They do however seem to appreciate that an action is required to initiate movement, and suggest that they see movement (action) as the same as energy. They also see movement as associated with something being alive. Early Stage 1 learners could be similar.

Alternative (non-scientific) views about energy held by some primary-age learners would include the following:

Energy (in general)

Students from the very youngest to those in upper secondary school (and probably beyond) tend to most regularly associate energy with living things. This tendency is reduced as students become older but will still be held by some secondary students.

Various other alternative or limited views of energy are held by students. These include that energy is: stored in certain objects in order to cause things to happen, e.g. water to turn a water wheel; always linked with force and movement; a fuel; and a fluid (that flows from one object to another); an ingredient or a product (e.g. chemicals give off heat).

Specific forms of energy

Some alternative (or limited) conceptions held by students about some of the specific forms of energy are:

Electricity

Most early learners do believe that in a circuit batteries give something to the bulb. They may however have a unipolar idea of a battery (i.e. that only one end needs to be attached to the light globe in a circuit). Also most upper infants students are probably unable to suggest how a switch works in a circuit.

Circuit

Most students think of a circuit as a series of sequenced events (e.g. current flowing from the battery to the wire, to the light etc.) rather than thinking of a circuit as a complete system.

Battery

Most students have little or no idea of voltage in a battery. Many see batteries as storing a certain amount of electricity.

Current and voltage

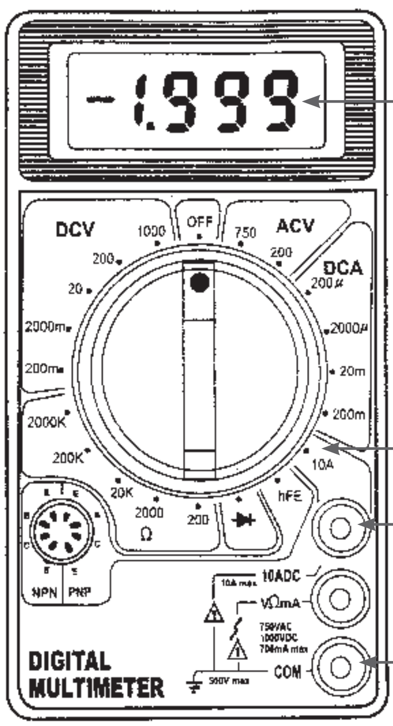
Current and energy are often confused. Voltage is sometimes thought of as the strength or force of the current; some students see voltage as the current.

Circuit components

Many upper primary students do not seem aware that various circuit components, e.g. buzzer and a motor, can be connected in the same way.

Appendix 3

Measuring electric current



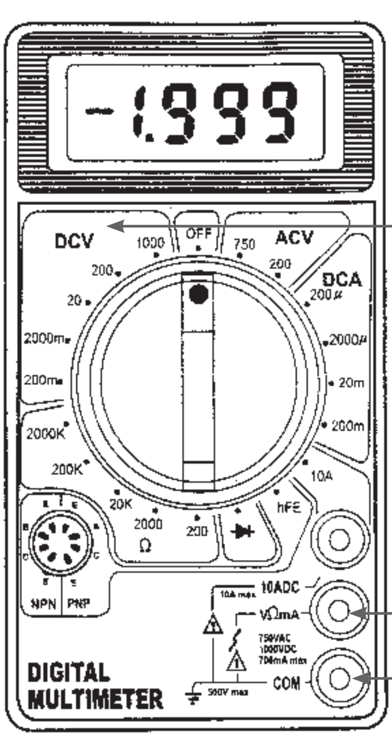
The display is measuring in amps.

Turn the dial to 10A. Use the probes from the jack leads to complete the circuit. To measure electric current all the electricity must pass through the meter so it must be connected in series.

Insert the red jack lead here. Make sure it is tight into the fitting.

Insert the black jack lead here.

Measuring voltage



Turn the meter to the DCV quadrant depending on your voltage supply. Start at 20V then work down through the dial until you get a reading that makes sense on the display. Remember 2000 m is representing 2000 millivolts or 2V while 200 m is measuring 0.2V. Most batteries are 1.5V.

Connect the red jack here. Make sure it is tight into the fitting.

Connect the black jack here.

Appendix 4

Know, want, learnt

What I know, what I want to know and what I learned

Teachers activate students' prior knowledge by asking them what they already know; then students (collaborating as a class unit or within small groups) set goals specifying what they want to learn; and after reading (or other experiences to provide input) students discuss what they have learned; students apply higher order thinking strategies which help them construct meaning from what they read and help them monitor their progress towards their goals. A worksheet is given to every student that includes columns for each of the activities.

K What do I know about electricity?	W What do I want to find out?	L What have I learnt?
In addition to initial brainstorming and discussion activities, students could answer questions after watching the DVD excerpt. For example: Electricity travels along power lines. Electricity travels in circuits. Don't touch an electric dryer if it falls in the water. Don't put your finger in a power switch. Don't go near fallen wires. Lots of appliances use electricity. Stay out of substations.	Possible questions to guide research. For example: What is a circuit? What does serial and parallel mean? Why can water conduct electricity? Are there alternative sources of power? What is a transformer? What should I do in an electrical emergency? Define an electrical emergency. What happens when you are electrocuted?	Completed as a class or by individual student.

Appendix 4

K What do I know about electricity?	W What do I want to find out	L What Have I learnt

Appendix 5

Planning to investigate scientifically

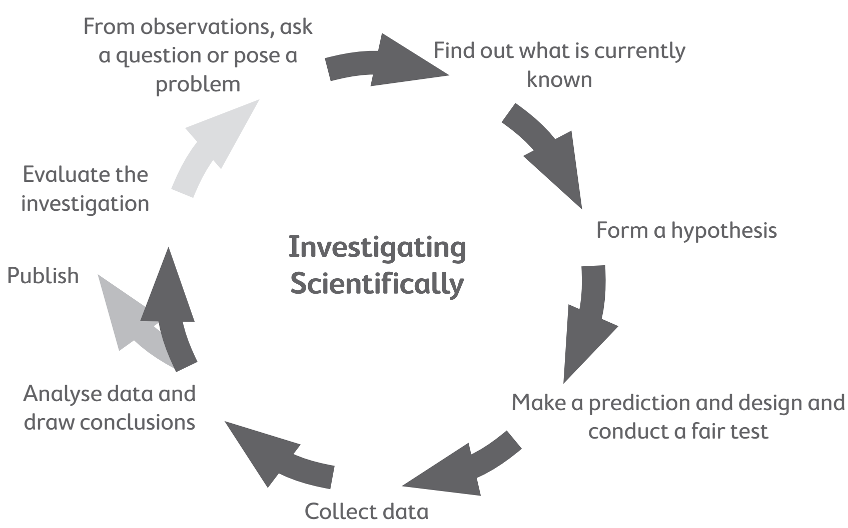
The learning process of science requires students to learn about and engage in the process of investigating scientifically.

Students engage in the process of investigating as they explore and develop their understanding of the natural and made environments.

Typically a scientific investigation:

- relates to a problem that can be formulated as an hypothesis for testing,
- collects data for analysis that can be used to draw conclusions,
- and is communicated to allow scrutiny through verification.

A diagram of the learning process of investigating is provided below.



The diagram represents a cycle of learning with various activities a student should engage in when investigating scientifically.

What distinguishes a scientific investigation from other forms of investigations?

The Science and Technology K-12 outcomes and indicators document suggests that scientific investigations include the processes of "observing, questioning, planning, predicting, testing, collecting, recording and analysing data, and drawing conclusions."

A scientific investigation is characterised by the formulation of an hypothesis and the use of fair testing to account for observations or solve problems. Research of secondary sources to identify what is already known about an area of investigation is an important part of the scientific investigation process. It is also important to note that researching secondary sources, in itself, would not constitute a scientific investigation.

Appendix 5

What is a hypothesis?

A hypothesis is a statement that describes a relationship between two or more variables that can be tested. Variables are the physical factors in an investigation that can change in some way.

Hypothesising and predicting are vital components of any scientific investigation as they lead to the design of a procedure: they identify the variable that will be observed or measured and the variable that will be manipulated. The hypothesis states the relationship between these two variables.

What is fair testing?

A fair test provides confidence in the collected data from a scientific investigation and it minimises sources of error. To do a fair test:

- control the variables.
- use an experimental control (where appropriate).
- use either repeat trials or replication.

The variables in a scientific investigation are the things that are manipulated (independent variable), measured (dependant variable) or controlled (all other variables that may influence the results).

Mark Hackling, from Edith Cowan University Western Australia, in his article Working scientifically: implementing and assessing open investigation work in science, (http://www.det.wa.edu.au/education/science/teach/workingscientificallyrevised.pdf) provides the following useful scaffold to help teachers and students when developing an hypothesis.

Cows Moo Softly

Change something (independent variable)

Measure something (dependent variable)

Keep everything else the **S**ame (all other variables)

An example of how to develop a scientific investigation from a student generated question.

Question: Does the number of batteries used make the light globe shine brighter?

Independent variable

Dependent variable
(measure something)

Hypothesis: The greater the number of batteries, placed in a series, the brighter a light globe will glow.

Controlled variables
(keep everything else the same)

When testing the above hypothesis, the number of batteries is the independent variable that will be manipulated by increasing or decreasing the number tested. The dependant variable is the brightness of the globe. All other variables that may influence the brightness of the globe are kept the same. The controlled variables would include length and width of wire used, identical connections, identical battery sizes. A suitable experimental design could involve testing:

- 1 D size battery + 5V globe.
- 2 D size batteries + 5V globe.
- 3 D size batteries + 5V globe.

To be a fair test, the investigation should be repeated a number of times. In a class situation, repetition could be achieved by having a number of groups carry out the same procedure.

As students conduct their investigation, collect observations and measurements, and then analyse the data, they should be able to state their conclusions in reference to the hypothesis. It is important to understand that an hypothesis can either be proven wrong or incorrect but rarely be proven with absolute certainty.

Stage development

How to build student skills in scientific investigation

Observing and exploring

In Early Stage 1 and Stage 1, students should have frequent access to a variety of sensory experiences as an essential component of their learning in science and technology. The teacher could use the experiences described below to build concepts and facility with the words that contain those concepts.

Sensory experiences could involve:

- feeling (hard to move – easy to move... mass and inertia, push and pull, rough – smooth – prickly, hard – soft, stiff – bendable or flexible).
- tasting (sour, bitter, sweet, neutral).
- smelling (associated with decomposition and decay, cooked food, potential danger).
- looking (colour, bright, dull, shiny, tall – short, wide – thin, fat – skinny).
- listening (sounds that are loud – soft, high pitched – low pitched, pleasing or not pleasing sounds).

The point of providing those experiences is to build understanding that science is a way of knowing about the world based on observation through the senses, in the first instance. Students should also be encouraged to find relationships between aspects of the environment they are observing and exploring such as:

- cause and effect (linear relationships like lightning causes thunder, friction causes heat).
- patterns (chains such as grass – rabbit – fox; webs, such as grass eaten by an insect and the grass seeds eaten by a mouse, a lizard eats the insect, a kookaburra eats the lizard and the mouse).
- natural cycles (like the water cycle).
- sequences (of events through time).
- similarities and differences (physical features).
- changes over time (physical features).

Appendix 5

Hypothesising and predicting

The syllabus does not define hypothesis. However, it is an essential understanding related to fair tests. It is important to understand that a hypothesis can be proven wrong or incorrect, but never be proven with absolute certainty.

By the end of Stage 1, students should, with assistance from their teacher, be able to suggest testable questions to guide investigations (what will happen if ...). By the end of Stage 2 they should know, with assistance from their teacher, how to construct hypotheses.

By the end of Stage 3, they should be able to construct their own hypotheses to guide investigations they have planned.

Devising and testing

By the end of Stage 1, students should have experienced investigations. They should be able to comment on teacher suggestions about how different kinds of investigations will be done, what equipment to use and have ideas about who would be best at doing what. By the end of Stage 2, they should be able to explain why particular procedures are done the way they are. They should have some understanding about the terms dependent and independent variable and be able to identify them in the investigations they conduct. They should be able to give reasons for repeating and replicating procedures and comment on factors that interfere with accuracy in data collection in particular settings. They will be able to give examples from previous work, of cause and effect relationships, cycles and other patterns in data and observations. At the end of Stage 3, they will be able to relate all the things they know about planning an investigation to devising a plan for their own investigations and be able to justify their decisions.

Collecting and recording

Students should be able to do the things described in the plans for investigations at each stage. They may need explicit teaching of the skills related to investigating, depending on whether they are doing things for the first time or whether it is repeating earlier experiences.

By the end of Stage 1, students should be able to distinguish between data they have collected and data collected by others and suggest when it might be better to collect the data themselves and when to use data collected by others. They should be able to identify a wide range of physical phenomena and describe it in appropriate terms (see list of experiences above). They should be able to suggest ways that data can be recorded, including using drawings (either freehand or by using the draw tools in computer software), tape recordings or video or digital camera. They should begin to use some of these methods and related equipment, either alone or with teacher (or older student) assistance.

By the end of Stage 2, students should have continued to use different data recording methods and related equipment. When asked, they should be able to give reasons related to the purpose of the investigation, for collecting particular data rather than some other data. They should be given opportunities, and guidance, to select the most appropriate fair test for different sorts of investigations and undertake those investigations, again with assistance.

By the end of Stage 3, they should be able to measure a range of physical quantities including mass, weight, time, length, temperature, rainfall, air pressure, relative humidity, wind direction, speed, area and volume. Students should be able to report the results (including the correct units) and discuss the results of their investigations. They should be able to tell you that we measure things because different people's senses are not the same. We measure things so that everyone knows what we are talking about; a centimetre is a centimetre, regardless of who measures it; 20°C is the same temperature for everyone (but for some it will feel cold, for some hot and for others it will feel comfortable).

Analysing and drawing conclusions

Once the results have been analysed and conclusions reached, they need to be communicated. The way they are communicated will need to be determined by considerations of purpose and audience. In general, science and technology provide significant opportunities to report (either verbally or in writing) using a variety of factual text types such as descriptions, explanations and procedural recounts.

Appendix 6

Questions to guide investigating tasks Questioning techniques are important in investigating and can be stimulated by a sense of curiosity, or a desire to understand or to lead to further action. Investigating scientifically involves students in asking and answering questions and comparing answers with what scientists already know about the world. Different types of questions suggest different types of scientific investigations. These may include:

- Observing and describing objects, organisms or events.
- Collecting specimens.
- Experiments seeking more information.
- Discovery of new objects and phenomena.
- Making models.

The process of investigating model below, includes questions to guide students through the process. Some questions will be for the teacher and others for the students.

Observing and questioning

Observing and exploring are interactive, foster curiosity and are closely related.

- What do you think is happening?
- How is it happening?
- Why is this 'thing' happening?
- What is different?
- Can it be different?
- Is it what you expected?
- What are you going to investigate?
- What is the problem you are investigating?
- What do you know about this topic from personal experience and from science?

Hypothesising and predicting

A proposed explanation or inference involves providing a tentative explanation for an observation or set of observations.

- What do you think will happen? Why?
- What variables may affect the phenomenon you are investigating?
- Which variable will you investigate as your independent variable?
- How will the independent variable be changed in the experiment?
- What is the dependent variable?
- How will you measure the dependent variable?
- What question are you investigating? OR
- What hypothesis are you testing? State your hypothesis as a relationship between the independent and dependent variable.

Appendix 6

Testing of a proposed explanation may:

- Support the explanation.
- Prove it false.
- Indicate that a revision of the original statement is needed.

Devising

Predicting involves making suggestions that something will happen.

- What do you want to find out?
- What are you going to do?
- What will you be looking for?
- Predict what you think will happen, explain why.
- What variables are to be controlled (kept constant) to make a fair test?
- Describe your experimental set-up using a labelled diagram and explain how you will collect your data?
- Are there any safety precautions?

Testing

Challenging and testing predictions are carried out to clarify, or identify, likely outcomes.

- How can you test what you think?
- What do you need to test your ideas?
- What variable are you going to – change – measure – keep the same?
- How will you make it a fair test?
- Carry out some preliminary trials. Were there any problems?
- How did you modify your experiment to fix the problem?

Collecting and recording

- What happened? Describe and record observations.
- Collect and record the data you need to test your hypothesis. Draw your table.
- How did you make sure your data was accurate?
- What is the best way to present your data? Is it appropriate to draw a graph? What type of graph is most suitable?

Analysing and drawing conclusions

Interpretation of your observations and drawing conclusions to explain the relationships and patterns.

- Analyse your data.
- What do the results tell you?
- Are there any patterns or trends or relationships you have identified in your data?
- What were the main sources of experimental error (sample size and selection, measurement error, poor control of variables)?
- What has happened? Why do you think it happened?
- Can you explain the relationships, patterns or trends in the results? (Students should try to use some science ideas to help explain.)
- What did you find out about the problem you investigated? Was the outcome different to your prediction? Explain.
- What difficulties did you experience?
- How could you improve this investigation? e.g. fairness, accuracy.
- How could the design of the experiment have been improved to reduce error?
- What have you learned about the topic of your investigation? Was the outcome different from your prediction? Explain.
- What have you learned about methods of investigating?
- How can I use this? What does it mean to me?
- What do I understand?
- What is your conclusion?
- How confident are you in your conclusions?

Appendix 7

Designing and making

Technology education: more than computers

Students today live in a world of unprecedented technological change. Being technologically capable is no longer about knowing a prescribed set of technical skills or processes but about being adaptable, creative, innovative and risk-taking, and being able to apply learning from one situation to a new or different context or setting.

What is technology?

Technology is about know-how and know-why. Know-how is created and applied through processes of designing and producing or making. Know-why is created through processes of investigating.

Technology is more than the objects created by technological processes such as computers, tools and other equipment. An important part of technology involves human values, skills, knowledge, techniques and processes.

Technology is concerned with the purposeful and creative use of resources in an effort to meet perceived needs or goals… (Science and Technology K–6 syllabus page 1).

Technology education aims to develop know-how and know-why through students learning to apply a design process to design and make solutions to identified needs and opportunities. In NSW primary schools the Science and Technology K-6 syllabus provides the focus for technology education.

What is design?

Design can be used as both a noun and a verb. Design (verb) can be defined as the systematic process of creating and implementing ideas to solve identified needs or opportunities. Design involves analysing needs, exploring and generating ideas, evaluating alternatives, and managing ideas to a workable solution. Design (noun) can be defined as the outcome of a systematic process of designing.

Design is future-oriented and involves students being proactive about how things can be done differently. Design is not about predetermined solutions and there is rarely, if ever, a single correct solution. Design is about making compromises and considered choices between competing needs, values, ideas and options. Most importantly design is about asking questions and testing ideas.

Design is an effective process for developing student capacity to be creative, innovative, critical thinkers and effective communicators.

What is making?

Making (verb) can be defined as the systematic process of planning and implementing a predetermined solution.

Making involves exploring and evaluating available resources including materials and equipment, practising techniques, and managing resources to a completed quality product or system.

Making is an effective process for developing student capacity to learn and refine specific techniques and manage actions to successful completion.

Typically in technology education the process of designing and making results in a product, service, system or environment; or a part of a product, service, system or environment.

How can we assist students to design effectively

A design process attempts to describe the way designers typically work to create and produce effective solutions. There are a vast array of diagrams such as cycles and models that attempt to represent the design process. In the Science and Technology K-6 syllabus the process is illustrated as a flow chart.

Regardless of the way the design process is represented, the process is not lock-step and will vary when applied in each design situation.

The syllabus describes four broad areas of design process activity. These areas of activity occur in a design process regardless of whether the designer is in kindergarten, Year 12 or a professional architect, engineer or industrial designer.

When teaching students to design the teacher takes the role of facilitator, typically guiding and structuring student work through posing questions for students to explore, generate and test ideas, regenerate and retest ideas, until a solution is reached. Knowing the types of questions a designer might ask is important.

Over a stage students should experience a number of design tasks. From task to task it is important that the learning focus of the design task varies.

Planning a design task

Here are some tips for planning a design task.

1. Identify the syllabus outcomes you want to focus student learning upon?
   For example the syllabus outcomes may be designing and making and the built environment.

2. Identify the stage students are working at and what these learning outcomes would look like? Look at the Big ideas provided on the website Supporting SciTech in the primary classroom (http://10ss.qtp.nsw.edu.au/supporting_scitech/index.html) for a better understanding of the outcomes.

3. Choose a design task that best enables you to focus on the selected outcomes and big ideas.

4. Choose authentic design tasks that students will find relevant, engaging and significant in their lives. For example a teacher had to address designing and making and the built environment in the programmed Science and Technology unit of work. At the time the SRC and P&C had been requesting sheltered play areas so the class decided together to design and model a weather protection structure for a part of the playground.

5. The more you can choose a design task that students already have a lot of experience with, the more effectively students will be able to explore the task, identify the needs of the users and establish a sound criteria for judging the effectiveness of the final solution.

6. Remember it is not that the design task be suited to Early Stage 1 or Stage 3 students. In the example of the shade structure above, students from K-12, university students studying architecture or a professional architect or engineer would be challenged by this task. The expectations about the sophistication of the response and the complexity of the considerations and the assessment criteria would however vary.

Appendix 7

7. Not all aspects of the design process need to be open-ended for students. There are many questions that can be considered in a design process. What parts of the design process do you want to leave open for the student to work through in detail and what parts will be closed or teacher-directed so that students can move through it more directly? The answer to this question relates to tip 2 and 3 above. Be clear about what you want student learning to focus upon and then allocate teaching time accordingly.

8. Allow sufficient teaching time in your program to enable the students to have a clearly established criteria for success for the design solution. How will I know that my solution is successful or not? Try doing this as a class or group brainstorming activity and then work together to negotiate priorities. Try to limit the number of success criteria to one or two in Early Stage 1 and perhaps have three or four criteria by Stage 3. For example the success criteria for Early Stage 1 might focus on the ability to provide shade to students at lunch time whereas by Stage 3 students might also be considering budget, local council building requirements and the use of environmentally sustainable materials.

9. Once your students have a clearly established success criteria all their decision making should refer back to the negotiated success criteria. For example an Early Stage 1 student asks: Should we use this material or that one for the shade cover? The teacher could reply: Which one will give better shade protection and how do you know that?

10. When students are learning a new skill they require explicit teaching so initially the skill will need to be modelled, then practised and guided before students will be capable of working independently.

11. Safety is always an important consideration for the teacher. Use risk management processes zzto identify and control risks.

12. Designing is time consuming. Allow sufficient time for students to repeatedly test, refine and retest their ideas if you want them to achieve a quality solution. A task that occurs as a one-off activity, such as design a flag in a lesson, will require little design skill and is probably more a colouring in activity than a design task. Students need to revisit their ideas over time to design effectively. Rather than doing many design tasks, do less in greater depth over the stage.

Appendix 8

Questions to guide designing and making tasks

Questioning techniques are important for assisting students to become creative, critical, innovative and enterprising as they engage with the design and make process.

Asking questions is a skill that teachers will continue to refine throughout their teaching, adapting according to the learning area or the task. Questions should not be limited to closed questions that require only a simple answer, but be more open-ended to allow a wide range of ideas to be generated and explored.

There are many models that can be used. One example is Fran Peavey's strategic questioning. She refers to 'short lever' questions that restrict options, assume solutions and hard truth and 'long lever' questions that create options, question assumptions and allow for the free flowing of ideas.

The design and make model below has questions added to help guide students through the process. Some will be questions for the teacher and others for the students.

Exploring the task

(finds out what are the requirements of the users, develop criteria and find out what is currently available)

The need or opportunity

- Is there a product, a system or an environment that is not doing its job effectively?
- Can we think of ways to do it better? (Cheaper, stronger, more attractive etc)
- Is there something we can use in a new way or for a different purpose?
- Is there a need that has no practical solution?

The user

- Who will use the design?
- How will they use the design?
- What qualities (aesthetic) will the design need for the user to appreciate it?

The client

- Who has requested the design? Why?
- What will the design have to do to meet the client's requirements? (functional and aesthetic)

Resources

- What is the budget?
- How much time is available?
- What other resources are available? (skilled people, information, materials, processes, equipment etc.)

Social and environmental considerations

- Who else might the design affect? How?
- Is there an environmental impact?
- Are there laws, rules or regulations that you need to consider?

Appendix 8

Criteria for success

- What will the design have to do to be successful?
- What are the essential success criteria and which are desirable?
- What is the priority order for the success criteria?

Defining the task

- How can we bring all these considerations together into a clear and concise statement of the design task or design brief.

Generating ideas and realising solutions

(explore and refine options, decide upon a design option, choose resources and equipment to plan and produce the design)

Generating ideas

- What design solutions exist that address similar needs, problems or opportunities?
- What are the advantages and disadvantages of these solutions?
- What creative thinking techniques can we use to generate new ideas?
- What ideas can we come up with?

Representing ideas

- What techniques can we use to represent ideas (sketching, story-boarding, drawing, modelling, flowcharts, diagrams etc.)?
- Who is the audience (me or others) and what is the purpose of the representations (rough ideas, resolving ideas, presenting ideas etc.)?
- Which techniques can we use to represent ideas as they become more resolved?
- How can we improve skills in representing ideas?

Investigating resources

- What materials, processes, equipment, etc. could be used for the design?
- What resources are available?
- What are the performance properties of the design?
- What risks (safety, cost, environmental) are associated with using the materials, processes, equipment, etc.?
- How can we test the suitability of the materials, processes, equipment?
- How can we improve our skills in using the materials, processes, equipment, etc. proficiently and safely?
- If we are unable to use the materials, processes, equipment, etc., can someone else help?
- Which materials, processes, equipment, etc. will we choose and how do they relate to the success criteria?

Resolving ideas

- What are the advantages and disadvantages of each idea in relation to the success criteria?
- Have we considered the long-term (social and environmental impact) as well as the short-term (money, time, appearance) consequences of the design?
- What do the client and user think?
- What design idea/s will we choose and why?
- Will the chosen design meet the success criteria? (essential? desirable?)
- Do we need any further modifications to the design?

Finalising the proposal

- Do we know exactly what is involved in producing the design?
- Do we need to further detail the design? (technical construction drawings, pattern pieces, layout, storyboarding, flowcharts, models)
- Which equipment and material is required?
- How much will it cost?
- What is the step-by-step sequence that will need to occur to produce the design?
- Do we have the skills needed to do each step or will we need more time to practice?
- How long is each step likely to take?
- Who is responsible for each step?
- Does our proposed time plan and budget meet the success criteria?
- Will modifications be required?

Managing safety risks

- What safety risks can we identify? (user capability and behaviour, materials, equipment, facility, teacher expertise)
- Where can we find sound advice?
- How can we eliminate or control the risks?
- If the risks cannot be controlled how will we modify the design?

Appendix 8

Managing production

- Have the necessary information, materials and equipment been acquired?
- Is the equipment set up safely and working effectively?
- How and who will manage storage and equipment maintenance issues?
- Do we need particular skills to be modelled (demonstrated) or reviewed with us or are we able to proceed independently?
- Do we need an expert to supervise our work?
- Is the production proceeding according to time plan and budget?
- Is the quality of production work appropriate to the success criteria?
- What modifications do we need to make to the planned design and production?

Evaluating products and processes

(evaluates success of the design against the criteria and considers effectiveness of the process)

Evaluating throughout the design process

- Is there a product, a system or an environment that is not doing its job effectively?
- Is there a need that has no practical solution?
- What will the design have to do to meet the users' requirements?
- What will the design have to do to meet the client's requirements?
- Who else might the design affect? How?
- Is there an environmental impact?
- What will the design have to do to be successful?
- What design solutions exist that address similar needs, problems or opportunities?
- How can we improve skills?
- What risks (safety, cost, environmental) are associated with using the materials, processes, equipment, etc.?
- What are the advantages and disadvantages of each idea in relation to the success criteria?
- Have we considered the long-term (social and environmental impact) as well as the short-term (money, time, appearance) consequences of the design?
- Will the chosen design meet the success criteria?
- What modifications do we need to make?
- Does our proposed time plan and budget meet the success criteria?
- What safety risks can we identify?
- Is the quality of production work appropriate to the success criteria?

(Note – these questions are a sample selected from the preceding Identifying, Generating and Using sections)

Reflecting on learning after the design process

Design solution

- What did we produce as a result of the design process?
- Does it work for the client and user? Do they like it?
- In what ways did our design solution achieve each success criteria?
- What aspects of the design solution did not achieve the success criteria?
- How would we do it differently next time?

Design process

- What was the design process we used?
- How could the design process be improved?
- Was our documentation processes helpful? Why or why not?
- Did we meet the requirements of the design task ? Why or why not?
- What skills did I gain or further develop?
- Did the group work well as a team?

Learning outcomes

- Which syllabus outcomes were we focusing on?
- How well have I progressed towards achieving each outcome?
- What experiences do I need to improve in my progress?

Appendix 9

How to organise cooperative learning groups

Introduction

Students need to be taught how to work cooperatively. They need to work together regularly to develop effective group learning skills.

The benefits of cooperative learning include:

- more effective learning – students learn more effectively when they work cooperatively than when they work individually or competitively, and also have a better attitude towards their school work.
- improved self-confidence – students tend to be more successful when working in groups and this builds their self-confidence.
- better classroom management – when students work in cooperative groups they take responsibility for managing much of the equipment.

Structuring cooperative learning

Use the following ideas in planning cooperative learning with your class.

- Introduce group skills and group roles before starting the unit.
- Assign students to groups rather than allowing them to choose partners.
- Vary the composition of each group. Give students the opportunity to work with others who might be of a different ability level, sex or cultural background.
- Keep groups together for two or more lessons so that students have enough time to learn to work together successfully.
- Keep a record of the students who have worked together as a group so that by the end of the year each student has worked with as many others as possible.

Group roles

Students are assigned roles within their group (see below). Each group member has a specific role, but all members share leadership responsibilities. Each member is accountable for the performance of the group and should be able to explain how the group obtained its results. Students must therefore be concerned with the performance of all group members. It is important to rotate group jobs each time a group works together so that all students have an opportunity to perform different roles.

For this unit the groups consist of four students – director, manager, speaker and safety officer. Each member of the group wears a role badge. The badges make it easier for you to identify which role each student should be doing – and easier for the students to remember what they and their group mates should be doing. Use the template at the end of this Appendix to make role badges, or create your own.

It is better to divide your students into groups of three as it is often difficult for students to work together in larger groups. If you cannot divide the class into groups of three, form two groups of two rather than a group of four.

Manager

The manager is responsible for collecting and returning the group's equipment. The manager also tells the teacher if any equipment is damaged or broken. All group members are responsible for clearing up after an activity and getting the equipment ready to return to the equipment table.

Speaker

The speaker is responsible for asking the teacher or another group's speaker for help. If the group cannot resolve a question or decide how to follow a procedure, the speaker is the only person who may leave the group and seek help. The speaker shares any information they obtain with group members. The teacher may speak to all group members, not just the speaker. The speaker is not the only person who reports to the class; each group member should be able to report on the group's results.

Director

The director is responsible for making sure that the group understands the group investigation and helps group members focus on each step. The director is also responsible for offering encouragement and support. When the group has finished, the director helps group members check that they have accomplished the investigation successfully. The director provides guidance, but is not the group leader.

Electrical Safety Officer

The Electrical safety officer is responsible for making sure the group understands and follows the safe use of materials and equipment. The safety officer should be aware of all the electrical safety messages and ensure that the investigations are undertaken in a safe manner. By the end of the unit every student should have undertaken this role and be able to pass the safety test.

Group skills

The use of cooperative groups focuses on social skills that will help students work together and communicate more effectively.

Students will practise the following five group skills throughout the year:

- move into your groups quickly and quietly.
- speak softly.
- stay with your group.
- take turns.
- perform your role.

To help reinforce these skills, display enlarged copies of the group skills chart and the group roles chart (see the end of this Appendix) in a prominent place in the classroom.

Even though the group skills seem simple, focus on one skill at a time. This will help you monitor each group's use of the skill. Encourage students to use the skill by observing them as they work and providing them with feedback – this sends the message that working together effectively is important. Leave enough time at the end of cooperative activities to help groups assess their use of the skill.

Supporting equity

In SciTech lessons there can be a tendency for boys to manipulate materials and girls to record results. Try to avoid traditional social stereotypes by encouraging all students, irrespective of their sex, to learn to the maximum of their potential. Cooperative learning encourages each student to participate in all aspects of group activities, including handling the equipment and taking intellectual risks.

Observe students when they are working in their cooperative groups and ensure that both girls and boys are participating in the hands-on activities.

Group skills

1. Move into your groups quickly and quietly
2. Speak softly
3. Stay with your group
4. Take turns
5. Perform your role

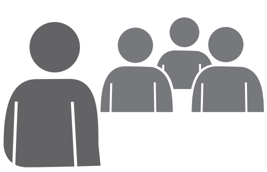
Group roles

Manager

Collects and returns all materials the group needs.

Speaker

Asks the teacher and other group speakers for help.



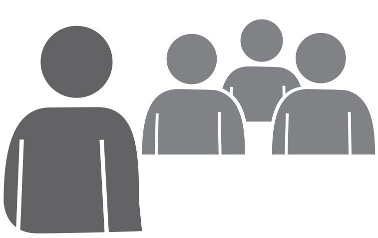
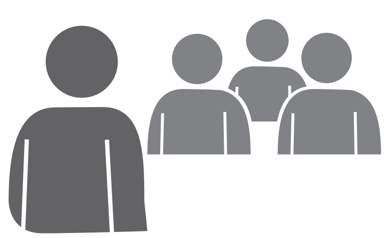
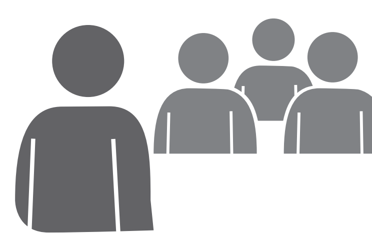
Director

Makes sure that the group understands the team investigation and completes each step.

Electrical Safety Officer

Makes sure that the group understands and follows the safe use of materials and equipment.

Role badges

 SPEAKER	 SPEAKER	 SPEAKER
 MANAGER	 MANAGER	 MANAGER
 DIRECTOR	 DIRECTOR	 DIRECTOR
 ELECTRICAL SAFETY OFFICER	 ELECTRICAL SAFETY OFFICER	 ELECTRICAL SAFETY OFFICER

Appendix 10

How to use a SciTech journal

A SciTech journal is a record of observations, experiences and reflections. It contains a series of dated, chronological entries. It may include written text, drawings, labelled diagrams, photographs, tables and graphs.

Using a SciTech journal provides an opportunity for students to be engaged in a real SciTech situation as they keep a record of their observations, ideas and thoughts about SciTech activities. The SciTech journal is a useful assessment tool. Frequent monitoring of students' journals will allow you to identify student alternative conceptions, find evidence of their understanding of the steps in the investigating and designing and making processes and see evidence of student learning for planning future learning activities in SciTech.

Using a SciTech Journal

1. At the start of the year, or before starting a SciTech unit, provide each student with a notebook or exercise book for their SciTech journal, or use an electronic format. Tailor the type of journal to fit the needs of your classroom. Explain to students that they will use their journals to keep a record of their observations, ideas and thoughts about SciTech activities. Emphasise the importance of including drawings as well as written entries.
2. Use a large project book or A3 paper to make a class SciTech journal. This can be used at all stages to model journal entries. With younger students, the class SciTech journal may be used more frequently than individual journals and may take the place of individual journals.
3. Make time to use the SciTech journal. Provide opportunities for students to plan procedures and write their predictions before an activity, to make observations during an activity and reflect on them afterwards.
4. Provide guidelines in the form of questions and headings and facilitate discussion about recording strategies, for example, note-making, lists, tables, concept maps and mind maps. Use the class SciTech journal to show students how they can modify and improve their recording strategies.
5. In SciTech journal work, you may refer students to display charts, pictures, diagrams, word walls and phrases about the topic displayed around the classroom. Revisit and revise this material during the unit. Explore the vocabulary, visual texts and ideas that have developed from the SciTech unit and encourage students to use them in their SciTech journals.
6. Review entries in the SciTech journal regularly. Give positive feedback. Write questions or comments that will clarify a student's thinking and/or improve observation. When commenting on work-in-progress, use adhesive notes instead of writing in journals so that students can make the appropriate changes themselves.
7. Combine the use of resource sheets with journal entries. After students have pasted their completed resource sheets in their journal, they may like to add their own drawings and reflections.
8. Explore the importance of entries in the SciTech journal during the steps of each process. Demonstrate how the information in the journal will help students develop and clarify their learning.
9. Use the SciTech journal to assess student learning in SciTech. For example, during the hypothesising and predicting step, use journal entries for diagnostic assessment as you determine students' prior knowledge.

Appendix 11

Alternative energy websites

http://www.seda.nsw.gov.au/renewable.asp

Links to information on renewable energy sources.

http://www.seda.nsw.gov.au/ren_wind_body.asp

Information about wind energy.

http://www.ausgrid.com.au/learningelectricity

Information and resources for teachers and students.

http://www.ausgrid.com.au/learningelectricity

Provides information on renewable energy sources.

http://www.teachers.ash.org.au/jmresources/energy/renewable.html

Provide links to sources of information on renewable energy.

http://www.science.org.au/nova/046/046key.htm

Information about meeting future energy needs.

Appendix 12

GLOSSARY

AC or alternating current:	Electric current which repeatedly changes its direction from negative to positive and back again. Alternating current is usually created by a mechanical means, such as a generator.
Amp:	The ampere or amp is a measure applied to the flow of electrons or flow of electric current.
Atom:	Primary basis of all matter. It has a nucleus consisting of protons and neutrons surrounded by orbiting electrons .
Battery:	A single electric cell for furnishing electric current or a group of such cells.
Circuit:	The complete path or part of the path of an electric current.
Charge:	The electrical property of electrons and protons that produces attraction and repulsion between them.
Conductor:	In a conductor electric current can flow freely. Simply stated, most metals are good electrical conductors, non-metals are not as good.
Current:	Is the flow of electrons. Water flowing in a pipe is similar to an electric current. You need voltage to make the current flow, just like water pressure is needed to make the water flow. It's impossible to see an electric current, but it's there – and is used to run everything from a light to your CD player.
DC or direct current:	Electric current is where the flow of electrons is always in the same direction. Direct current is most commonly found in low voltage appliances such as batteries.
Distribution system:	The poles, wires, cables, substations and other equipment required to transport electrical energy from the transmission system to people's homes.
Distribution network:	The overall network formed by the distribution system.
Electron:	The basic particle that orbits the nucleus of an atom. It can be stimulated to movement by various forces like magnetism and has a negative charge.
Energy:	The capacity to do work, or vigorous activity fuelled by various sources.
Fuse:	A safety device with a metal wire or strip that will melt, breaking the electrical circuit when the current becomes too strong.
Generator:	A machine for producing electrical current. (See Turbine)
Hydroelectricity:	In electrical generation, it is the use of the power from rushing water to push turbine blades, which turn shafts in generators that produce electricity.
Insulator:	A material (such as plastic or glass) that does not permit electricity to pass through it readily.
Kilowatt:	Equal to 1000 watts of electricity.
Kilowatt hour:	Measurement of electricity equal to one kilowatt of power produced or used in one hour.
Kinetic energy:	The energy of an object in motion.
Lightning:	The flash of light which accompanies a static electricity discharge between two clouds or between a cloud and the Earth during a thunderstorm.
Magnet:	A piece of material that has the natural ability to attract iron.
Magnetic field:	The area around a magnet that is influenced by the magnet.
Mechanical energy:	The energy of motion used to perform work.
Megawatt:	1,000,000 watts of power or 1,000 kilowatts.
Meter:	A device which measures and records the production or consumption of electrical energy.
Nuclear power:	The energy produced by splitting atoms (such as uranium) in a nuclear reactor.

Appendix 12

Off-peak power:	The amount of power generated during a period of low consumer demand.
Ohm:	A unit of electrical resistance equal to that of a conductor in which a current of one amp is produced by a potential of one volt across its terminals.
Photovoltaic cell:	A device where light energy is converted to electrical energy. Also known as a solar cell.
Solar energy:	The use of energy that reaches the Earth from the Sun.
Socket:	A hollow thing or place that receives and holds something (such as an electric light socket).
Static electricity:	A type of electrical charge that can build up when two objects rub together. Friction removes some electrons from one object and deposits them on the other.
Substation:	A facility at which two or more lines are switched for operational purposes. May include one or more transformers so that some connected lines operate at different nominal voltages to others.
Transmission lines:	The wires for getting high voltage electricity from one place to another.
Turbine or turbine generator:	An electric generator driven by a turbine; the turbine has blades that are made to rotate by the force of water, gas, steam or wind.
Volt:	The volt is the unit of measure for electro-motive force required to pass one amp through resistance of one ohm.
Watt:	A unit for measuring electric power, e.g. 1 horse power = 746 watts. One Kilowatt = 1,000 watts. One Megawatt = 1,000,000 watts.
Wind turbine:	A machine that captures the energy of the wind and transfers the motion to a generator shaft.