Unit 3
Electricity
Suggested Time: 28 Hours

Unit Overview

Introduction

Technologies based on the principles of electricity are an important part of the student's world. An understanding of the essentials of electrostatics and electric circuits will enable students to connect their learning to everyday applications. Investigations help students learn the laws of electrostatic charges and study some features and properties of electrostatics and electrical circuits.

Students should be given ample opportunity to plan, design and construct a variety of circuits as well as to explore and investigate the relationships that exist among voltage, resistance and current. Students should gather and organize their findings and communicate them in an efficient manner.

Students should also be given the chance to investigate the technologies that permit the use of electrical energy and evaluate both the technologies and their direct and indirect impacts on the environment and society in general.

Focus and Context

The world of today's student is inundated with technology that is linked to and depends on electricity for its function. The focus of this unit is inquiry and the design process with reference to technology and systems with which the student is familiar. The context revolves around electricity usage in and around the home.

Science Curriculum Links

Students investigated and explored everyday materials to produce static charges in **grade 2**. In **grade 6**, students are involved in a unit of study entitled "Electricity". The conductivity of a variety of solids and liquids as well as characteristics of static and current electricity are explored. In this unit, students also investigate simple series and parallel circuits, switches, and the relationship between electricity and magnetism when using an electromagnet. Various methods by which electricity can be generated are addressed as well as different factors that could lead to a decrease in electrical energy consumption in school and at home.

In **high school**, students have the opportunity to study electric field and Coulomb's Law. They will compare the way a motor and a generator function using the principles of electromagnetism.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

109-6 illustrate how technologies develop as a systematic trial-and error process that is constrained by cost, the availability and properties of materials, and the laws of nature.

109-7 identify different approaches taken to answer questions, solve problems, and make decisions

109-14 explain the importance of using precise language in science and technology.

110-9 compare examples of past and current technologies developed to meet a similar need.

Relationships Between Science and Technology

111-1 provide examples of scientific knowledge that have resulted in the development of technologies.

Social and Environmental Contexts of Science and Technology

112-7 provide examples of how science and technology affect their lives and their community.

112-10 provide examples of science- and technology-based careers in their province or territory.

113-2 describe possible positive and negative effects of a particular scientific or technological development, and explain how different groups in society may have different needs and desires in relation to it

113-4 analyse the design of a technology and the way it functions on the basis of its impact on their daily lives

113-5 analyze the design of a technology and the way it functions on the basis of identified criteria such as cost and impact on daily life and the community

113-6 evaluate the design of a technology and the way it functions on the basis of identified criteria such as cost and the impact on daily life and the environment.

113-9 make informed decisions about applications of science and technology, taking into account environmental and social advantages and disadvantages.

113-13 propose a course of action on social issues related to science and technology, taking into account human and environmental needs.

Skills

Students will be expected to

Initiating and Planning

208-1 rephrase questions in a testable form and clearly define practical problems.

208-5 state a prediction and a hypothesis based on background information or an observed pattern of events

Performing and Recording

209-1 carry out procedures controlling the major variables

209-3 use instruments effectively and accurately for collecting data.

209-4 organize data using a format that is appropriate to the task or experiment

209-6 use tools and apparatus safely

Analyzing and Interpreting

210-5 identify the line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit.

210-6 interpret patterns and trends in data, and infer and explain relationships among the variables

210-7 identify, and suggest explanations for, discrepancies in data.

210-8 apply given criteria for evaluating evidence and sources of information.

210-10 identify potential sources of error and determine the amount of error in measurement.

210-12 identify and evaluate potential applications of findings

210-16 identify new questions and problems that arise from what was learned

Communication and Teamwork

211-2 communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means.

211-3 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise

Knowledge

Students will be expected to

308-13 explain the production of static electrical charges in some common materials.

308-14 identify properties of static electrical charges.

308-15 compare qualitatively static electricity and electric current.

308-16 describe the flow of charge in an electrical circuit.

308-17 describe series and parallel circuits involving varying resistance, voltage, and current.

308-18 relate electrical energy to domestic power consumption costs.

308-19 determine quantitatively the efficiency of an electrical appliance that converts electrical energy to heat energy.

308-20 describe the transfer and conversion of energy from a generating station to the home.

Static Electricity

Outcomes

Students will be expected to

- explain the production of static electrical charges in some common materials (308-13)
  - recognize that electricity is an integral part of their lives
  - define static electricity
  - differentiate between static and current electricity using operational definitions

Elaborations—Strategies for Learning and Teaching

Students have experienced static electricity in their daily lives, and will have formally investigated it in the primary and elementary grades. Students will have explored static and investigated static charges as well as discussed the importance of electricity in their daily lives in Grade 6. From this and other previous study, students should have an operational definition of attraction, repulsion, electrons, positive charge, and negative charge. Given this background, teachers could begin with a K-W-L activity. Through this activity, teachers may be able to ascertain the depth of treatment required in order to cover these outcomes.

Alternatively, teachers could have students engage in a class brainstorming activity to draw upon their prior knowledge of this topic as they introduce this unit. Students could be asked to give examples of static electricity they have encountered at home or at school. Students will likely have several examples that they can contribute to the introduction of this unit.

- describe the types of charges on objects. Include:
  - (i) positive charge
  - (ii) negative charge
  - (iii) neutral
- describe how the charges on objects can change. Include:
  - (i) neutral objects can develop a positive charge
  - (ii) neutral objects can develop a negative charge
  - (iii) positively charged objects can become neutral
  - (iv) negatively charged objects can become neutral

Students should investigate the production of static electric charges with a combination of materials such as flannel, fur, wood, plastic, rubber, and metal.

By creating static charges on suspended pith balls and/or balloons, students can further investigate the properties of static electricity. Teachers could use a metal leaf electroscope to detect the presence of static charge on various objects. This activity should involve the attraction, repulsion, and neutralization of static charge. In such an investigation, teachers should clarify that identifying the type of charge on an object requires a lot more work.

This should eventually lead to the accepted scientific understanding and explanation of static charges. Students will be able to use what they have learned about the parts of atoms to create models. The models can be used to describe why some objects are considered to be neutral, positively charged, or negatively charged.

Teachers should help students make the connection between electrical charges and the components of the atom discussed in Unit 2. As a result, only negative charges transfer from one object to another since electrons are less massive and sometimes have the ability to move between atomic orbitals. Positive charges do not transfer from one object to another since they are much more massive and are found in the nucleus of the atoms.

Static Electricity

Suggested Assessment Strategies

Journal

- In a journal entry, students can reflect on how their scientific knowledge builds on what they learned in earlier grades. For example students could be asked to complete the following sentence: Two questions I would like to investigate related to electricity are…

Paper and Pencil

- Students could start to develop a mind map (See Appendix B) for electricity and continue to add to this as they work through the unit.
- Upon observation of transfer of charges to and from various materials, students could be required to complete a table to describe these interactions.

Solid Material	Soft Material	# grains of puffed rice attracted
Plastic Straw		

Presentation

- Using a poster display, students could summarize the types of charges and how objects can develop different static charges.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 228, 263
TR AC 24

ST pp. 229-231
BLM 3-6, 3-12, 3-13

Static Electricity (continued)

Outcomes

Students will be expected to

- explain the production of static electrical charges in some common materials (308-13)

  (continued)

  - define electric discharge

- identify properties of static electrical charges (308-14)
  - define the Laws of Electric Charges. Include:
    - (i) like charges repel
    - (ii) unlike charges attract
    - (iii) charged objects attract some neutral ones

- provide examples of how knowledge of static electricity has resulted in the development of technologies. Include: (111-1, 112-7)
  - (i) lightning rods
  - (ii) photocopiers
  - (iii) electrostatic air cleaners

Elaborations—Strategies for Learning and Teaching

Teachers could use a diagram to illustrate charges on objects. However, they should emphasize that the number of charges drawn in the model diagrams does not indicate the exact number of charges found on these objects. However, charges are drawn to symbolize their relative numbers. It is important for students to understand that negative charges move about readily, whereas, positive charges do not move.

Teachers could also use java applets to demonstrate the transfer and build up of charge. Examples of such applets can be found at http://phet.colorado.edu/en/simulations/category/new

Students should define electric discharge as the removal of electric charge from an object. This is a good opportunity to integrate a discussion of lightning as well as other common examples such as rubbing your feet across a carpet.

Teachers may choose to use situations or analogies to help students understand the Laws of Electric Charges. For example, to demonstrate that charged objects attract some neutral objects (i.e. outcome (iii) which is an example of induced charges), a teacher may rub a balloon on his/her head and stick it on the wall. Students could be expected to speculate on the explanation for this phenomenon, but it is not intended that teachers go into a discussion of charging by induction. Charging by induction will be covered in more detail in Physics 3204 and should not be done in any detail at this point.

Teachers could use a Role Play activity to get students to understand interactions between electric charges.

Students should investigate technologies that use static electricity in a variety of ways to perform tasks. An investigation of how the school's photocopying machine functions could begin with an invitation to the sales/repair person to explain/demonstrate how static charges are used to create copies. Students could interview a driver of a transport truck that carries flammable products to learn about the technologies and special tires used to reduce static build-up and thus prevent a potentially dangerous spark. Students could test the ability of various fabric softeners to reduce static cling by counting the number of puffed rice pieces a sock or other piece of clothing could pick up. Electrostatic precipitators/air filters, electric eels, and lightning rods are other examples of technologies and living things that could be investigated.

Static Electricity (continued)

Suggested Assessment Strategies

Performance

- Students could develop a physical model to demonstrate the transfer of charge between objects and the build-up of charge.

Journal

- Students could identify the different forces which they have discussed in science class and discuss how these forces affect their everyday lives.

Presentation

- Students could design a poster to illustrate the Laws of Electric Charges.
- Students could research other applications/examples of static electricity. They could then present their findings to the class using a variety of media such as PowerPoint Presentation, poster board, essay, cartoon, etc.

Paper and Pencil

- Prepare a table to compare the properties of the three laws of charges.

Charges	Property
+ +	
+ -	
- +	
- -	
+ neutral	
- neutral	

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST p. 244
TR PS 1
TR AC 6

ST p. 238-239
BLM 3-8

ST pp. 233-234, 241

Static Electricity (continued)

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• qualitatively compare static electricity and electric current (308-15)	Students will have had the experience of walking across a carpeted floor and getting a "shock" from the transfer of electrons when they touched a doorknob. The student can see that the rapid movement of the electrons can even light a fluorescent light bulb if it is touched against the doorknob. But, static electricity can not be harnessed as a useful energy source (i.e. you cannot use static electricity to run an electrical device.
• provide examples of careers related to electricity in their community and province. Include: (112-10) (i) photocopier technician (ii) electrician	Throughout this unit, teachers should provide students with opportunity to note and investigate some of the many careers people have that are related to electricity production, transfer and associated technologies. In addition, students should become aware of the many people and jobs associated with the production and maintenance of technologies using electricity. Teachers could invite a local tradesperson (e.g., electrician, photocopy technician, engineer, linesman, representative from Newfoundland Power) as a guest speaker. Teachers could use this as an opportunity to include a discussion of electrical safety as enrichment.

Static Electricity (continued)

Suggested Assessment Strategies

Paper and Pencil

- Students could create their own analogy to describe electric current.
- Compare and contrast static and current electricity using a Venn Diagram.

Journal

- Students could list different examples/applications of these two types of electricity they encounter daily and identify ways we control them.

Presentation

- Students could research careers that require an understanding of static electricity. They could then present their findings to the class using a variety of media such as PowerPoint Presentation, poster board, essay, cartoon, etc.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST p. 263

ST p. 312

Current Electricity

Outcomes

Students will be expected to

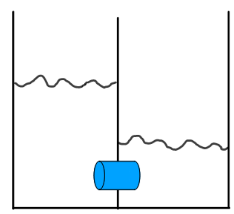
- describe the flow of charge in an electric circuit using precise language (308-16, 109-14)
  - define potential energy
  - define electric potential difference (voltage)
  - identify the volt (V) as the SI unit for electric potential difference

Elaborations—Strategies for Learning and Teaching

Students will have experience with the term voltage, likely through their use of cells and batteries. This is a good starting point for the introduction of this topic.

Students will likely have difficulty understanding some of the concepts in this section such as electric potential difference. Appropriate analogies, video clips, and diagrams will be important for students to avoid misconceptions.

Students could think about electric potential difference (voltage) as a hydroelectric dam. Water (energy) is stored behind the dam in a reservoir. The higher the dam, the more potential energy the water has.



- describe how an electrochemical cell produces a supply of electric charge. Include:
  (i) 2 electrodes of different materials
  (ii) electrolyte

Students could investigate the effect of materials used as electrodes and electrolyte on the voltage produced in an electrochemical cell. Although most electrodes are metals, there are exceptions such as carbon.

- define the coulomb (C)

Define the coulomb as the unit of electric charge. 1 coulomb of charge equates to the addition or removal of 6.25×10^{18} electrons. This will likely be very difficult for students to visualize. To put this in more concrete terms, this is about the number of electrons that pass into a 100 W light bulb per second. Discussion of the coulomb can help reinforce why the models drawn earlier representing the charges on an object are used only to show the comparative numbers of electrons and protons and not their actual numbers.

- define electric current
- identify the ampere (A) as the SI unit for current

Students could think of two rivers of equal size and volume as an analogy to understand electric current. The river that flows faster has more water molecules flowing past a given point such as a bridge. This is a higher current.

- define electric circuit

Students are introduced to electric circuits in the grade 6 curriculum. They will likely have experiences that they can bring to the introduction of electric circuits. For example, they may recall having seen their parents reset a circuit breaker or replace a fuse at home.

Current Electricity

Suggested Assessment Strategies

Journal

- Students could reflect upon how the use of the term potential in everyday language is similar to its use in "electric potential energy."
- Students could reflect upon the different types of energy they have discussed in science classes to date. Which do they feel are most important? Which do they feel are least important?
- Students could develop their own analogy to describe an electric circuit. At the end of the unit, they could reflect on their analogy and identify strength(s) and weaknesses.
- Students could reflect upon when they think about the flow of charge through an electric circuit, does it matter if they think of the electricity as flowing from positive to negative.

Paper and Pencil

- How large of a sheet of paper would you need to show a coulomb of charge? Assume each coulomb of charge requires 1 cm2 on the sheet of paper.
- Students could create their own analogy to compare voltage and current.
- Students could look at the power rating on several of the electrical devices they use and record the devices specified voltage and current.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 251-252

ST p. 232

ST p. 264

ST pp. 260-261

Current Electricity (continued)

Outcomes

Students will be expected to

- describe the flow of charge in an electric circuit using precise language (308-16, 109-14)

(continued)

- describe the parts of an electric circuit. Include:
  (i) source of electrical energy
  (ii) electrical load
  (iii) control/switch
  (iv) conductor
- identify that electric potential is provided at the source and "used" by the circuit elements (a potential or voltage drop occurs)

- organize information using a format appropriate to studying and describing current electricity (209-4)

- create circuit diagrams using appropriate circuit symbols. Include symbols for:
  (i) bulb
  (ii) cell
  (iii) battery
  (iv) wires
  (v) resistors
  (vi) ammeter
  (vii) voltmeter
  (viii) open switch
  (ix) closed switch

Elaborations—Strategies for Learning and Teaching

Electrochemical cells are one source of electric energy. Students should understand that this involves the conversion of chemical energy to electrical energy. Teachers could discuss other energy conversions that occur to create electrical energy such as generators, piezoelectric crystals and solar cells. Generation of electricity covered in more detail later in the unit.

Students should distinguish between the scientific definitions of a cell and a battery. A battery is a collection of cells. In everyday conversation, we might use these terms interchangeably and don't always draw a clear distinction between the two.

Teachers could use interactive websites to help students visualize the parts of a circuit. For example:

http://www.andythelwell.com/blobz/guide.html

http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc

http://articl319.com/shockwave/oz.htm

Current Electricity (continued)

Suggested Assessment Strategies

Presentation

- Students could research different examples of each of the four parts and identify the applications.

Paper and Pencil

- Students can compare the different uses for the many different types of switches (controls) we use. For example, toggle switch, two way switch, dimmer switch, safety switch.
- Students could draw simple diagrams to represent basic parts of a circuit. Note: Drawing of circuit diagrams with symbols is not required until later in the unit.
- Students could summarize the circuit symbols and what they represent in a poster display.
- Students could create a foldable vocabulary book in which they can store definitions for the unit.

Journal

- Students could reflect upon the necessity of using symbols instead of the circuit element sketches when drawing circuit diagrams.
- Students could think of other situations where scientists use symbols to ease their communication.
- Students could reflect upon the necessity of everyone agreeing upon a set of acceptable symbols.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 254, 262

ST p. 262-264, 275
ST p. 492 (Science Skills)
BLM 3-18, 3-19

Resistance

Outcomes

Students will be expected to

- organize information using a format appropriate to studying and describing current electricity (209-4)
  - define electrical resistance.
  - identify the ohm (Ω) as the SI unit for electrical resistance.
  - list the factors which affect the amount of resistance in a wire. Include:
    - (i) length
    - (ii) diameter
    - (iii) type
    - (iv) temperature

Elaborations—Strategies for Learning and Teaching

Teachers could use an analogy to help students understand and appreciate electrical resistance. For example, running on a sandy beach versus running in water over your knees. There is more resistance in water, which slows you down. This is analogous to current electricity flowing through various materials; each material will provide a different resistance to the electricity moving through it.

Teachers could reference that the unit for electrical resistance is named in honor of Georg Ohm who did the ground-breaking experiments and as a result, was able to define the relationships between voltage, current, and resistance. The understanding of this relationship was the true beginning of electrical circuit analysis.

The symbol for ohm, (Ω or omega), is the 24th and last letter of the Greek alphabet.

Students should be involved in activities where factors influencing resistance in a wire in an electric circuit are investigated. Students could compare and contrast the current in wires of various lengths and various diameters. Students could try blowing through straws of different lengths, diameters, and types in order to experience the varying amounts of force required to blow through the different types of straws. Students could also compare the resistance of various conductors such as copper and nichrome.

Factors that affect resistance can be explained using the analogy of a road:

(i) the further you travel down a road, the more cars you will encounter

(ii) the narrower the road, the harder it will be to drive through

(iii) a bumpy road is harder to drive on than a smooth road

(iv) if cars are going in a slow, steady rate (cooler) it is easier to drive around than if the cars are driving quickly and erratically

Resistance

Suggested Assessment Strategies

Journal

- Students could discuss how the term electrical resistance is similar to the everyday meaning of resistance.

Presentation

- Students could research what different types of materials have historically been used as electrical conductors.

Paper and Pencil

- Resistance depends on many factors. List these factors and explain why they increase or decrease resistance in a circuit.
- Students could list other examples of Greek letters we use as symbols in math/science.

Performance

- Students could perform an activity where they examine the different amount of resistance in various lengths and widths of straws by timing the amount of time it would take to drink a certain quantity of water. They could record their results in a table.

Description of Straws	Time (s)	Resistance (high or low)
Single straw		
Single straw with fold		
Etc...		

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 270-273

ST pp. 271-272
BLM 3-23

Resistance (continued)

Outcomes

Students will be expected to

- state a prediction and a hypothesis based on background information or an observed pattern of events (208-5)
- identify new questions and problems that arise from what was learned concerning voltage, current and resistance (210-16)
  - state Ohm's Law
  - given voltage drop and current through a resistor, calculate its resistance
  - given voltage drop and resistance, calculate current through a resistor
  - given current through a resistor and its resistance, calculate the voltage drop

Elaborations—Strategies for Learning and Teaching

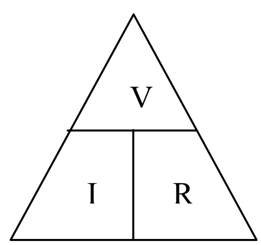
Once students have explored voltage, current, and resistance separately, a natural extension is to discuss how they are influenced by one another. This relationship is summarized by Ohm's law. Teachers could discuss the dangers of increasing the voltage supplied to the circuit in terms of its effects on current and resistance. For example, connecting too large a battery to a light bulb will blow the bulb. Similarly, teachers could discuss the dangers of exposing wet skin to electricity, even at low voltages. The lower resistance of wet skin allows for current to flow faster through the human body, which could be lethal.

Activities should demonstrate Ohm's Law quantitatively. After constructing a circuit that includes a battery, a resistor (e.g. bulb), and an ammeter, students could further explore and investigate what happens to the current as other resistors (bulb) are added to the series circuit (enrichment). Students could add batteries to the circuit to explore voltage and current readings in the circuit. Ohm's law states:

Current = Voltage/Resistance **or** Amperes = Volts/Ohms

Teachers could provide students with practice questions involving calculations of resistance, voltage, and current.

Where students experience difficulty manipulating this formula, teachers could use the triangle method to help students visualize the process. Cover the letter of the variable that you are looking for. The remaining letters represent the variables used in the calculation. A vertical line means multiplication, a horizontal line means division.



While teachers may want to provide opportunities for students to observe and experiment with situations that involve multiple sources of resistance, it is the intent of this outcome that measurements should include only those involving a single resistance. Investigations and assessments should only involve one resistance at a time. It is not intended that students solve problems for multiple resistances.

Resistance (continued)

Suggested Assessment Strategies

Presentation

- Students could create a poster display of the scientific relationships covered throughout their intermediate schooling.
- In a display, students could summarize how changing any one variable in Ohm's law affects the others.

Paper and Pencil

- Students could practice calculations using Ohm' Law.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 273-275
BLM 3-24, 3-26, 3-28

Resistance (continued)

Outcomes

Students will be expected to

- identify new questions and problems that arise from what was learned concerning voltage, current and resistance (210-16)

  (continued)

  - state Ohm's Law
  - given voltage drop and current through a resistor, calculate its resistance
  - given voltage drop and resistance, calculate current through a resistor
  - given current through a resistor and its resistance, calculate the voltage drop
  - define resistance

Elaborations—Strategies for Learning and Teaching

Teachers should ensure that students recognize that there is a direct relationship between voltage and current. As voltage increases current increases and vice versa.

Students should become familiar with the ammeter as an instrument used to quantitatively measure current. An ammeter and a bulb can be connected in a series, and students can observe that whenever the bulb is brighter, the ammeter reads a bigger current. A voltmeter can be added to the circuits so that students can measure the voltage of different batteries. Students will probably note that the data they collect from readings of ammeters and voltmeters vary due to a number of factors. Students should try to identify reasons for these different readings and suggest reasons for their data differences. Students could "feel" the resistance of a circuit if a hand-held generator is available. By adding resistance (bulbs), students would appreciate the extra energy it takes to maintain brightness.

Teachers could use a variety of interactive websites to demonstrate how the change in potential difference affects current and vice versa. Websites include:

http://www.article19.com/shockwave/oz.htm

http://phet.colorado.edu/en/simulation/circuit_construction_kit_dc

Students should understanding that color codes used on resistors indicate their calibrated resistance but should not be expected to quantify this resistance.

Resistance (continued)

Suggested Assessment Strategies

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 273-275
BLM 3-24, 3-26, 3-28

ST pp. 275-277
BLM 3-25

Resistance (continued)

Outcomes

Students will be expected to

- use an ammeter and voltmeter to measure current and voltage in a circuit (209-3)
- identify potential sources of error in ammeter and voltmeter readings (210-10)
- describe series and parallel circuits involving varying resistance and voltage (308-17)
- identify and suggest explanations for discrepancies in data collected using an ammeter and a voltmeter (210-7)
- present graphically, using a line of best fit, the data from investigation of voltage, current and resistance (210-5, 211-2)

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity: Resistors and Ohm's Law

The laboratory outcomes 210-5, 210-7, 210-10, 211-2 and, in part, 308-17 are addressed by completing CORE LAB 8-3D "Resistors and Ohm's Law."

Teachers could have students vary the resistance of the circuit. This can be accomplished by increasing or decreasing the number of light bulbs in a circuit, using conducting wires with varying resistances, or simply changing the size of a resistor in the circuit. Commercial multi-range meters should be used when doing quantitative measurements of voltage and current.

During any investigation of Ohm's law, teachers should highlight the random error associated with any measuring device and reading it. For example, one student may record a reading to be 1.12 V while another records the same measurement to be 1.13 V. This type of random error is usually minimized by taking several readings and averaging the results.

Also, when meters are added to circuits, they "change the circuit" in terms of resistance and current. Therefore, in a circuit with one 1.5 V cell and one light bulb, the potential drop of the light bulb will be 1.5 V (or a little less because of the potential drop across the conductor). However, once we add a voltmeter to measure the potential drop across the light bulb, the resistance of the circuit slightly changes, so the current in the circuit will change slightly as well. Teachers need not emphasize this point as its in depth treatment is beyond the scope of this course. However, as students conduct investigations involving the addition and removal of meters from circuits, they may observe the effects on the circuits' resistance.

Where it is possible, teachers could engage in a cross-curricular activity with Math to integrate line of best fit graphing. Students should collect data of the volatge and current, and present their findings in the form of a graph to provide an opportunity to produce a line of best fit in connection with Ohm's Law.

Resistance (continued)

Suggested Assessment Strategies

Journal

- Students could reflect upon which sources of error in their experiment are most significant.

Performance

- Students could use technology to determine the line of best fit for the data collected during an investigation and compare it to what they might have approximated.

Paper and Pencil

- Students could construct a line of best fit graph to represent the relationship between voltage and current.
- Students could create a lab report of your findings for the core activity. Include sources of error.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

Core Lab #5: Resistors and Ohm's Law
ST pp. 278-279
TR 3-34, 3-35
BLM 1-18, 3-29

ST pp. 275, 280-281

Resistance (continued)

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• describe series and parallel circuits involving varying resistance, voltage and current (308-17) - distinguish between series and parallel connections of resistors (or bulbs)	Teachers should highlight for students that resistors are often connected in manners that combine series and parallel connections. The analysis of such designs are often much more complex and are beyond the scope of this course. However, analysis of these designs remains true to the basic principles covered. That is, connecting resistors in parallel reduces total resistance and connecting resistors in series increases total resistance. Students are not expected to be able to determine or calculate the total resistance.
- describe the current and voltage at different places throughout a series and a parallel circuit	Given missing values in a circuit, students should be able to quantify voltage and current at different places. For example, current will be the same throughout a series circuit. Examples of this can be found in the review questions on p. 303 and in the BLMs.
- describe the effect on the total resistance of the circuit as resistors are added: (i) in series (ii) in parallel	Students should understand that the overall effect of adding resistors to series and parallel circuits in terms of total resistance only. The effect on voltage and current when adding resistors is not an outcome of this course.
- describe the effect on the circuit if a bulb is removed. Include: (i) If bulbs are connected in series, when one light extinguishes so must all others (ii) If bulbs are connected in parallel, when one light extinguishes, the remaining can continue to function	Students should use actual circuits, simulations and circuit diagrams to help explain why this occurs.
• give examples of situations where parallel and series connections of resistors are used. Include (113-2B): (i) Christmas lights connected in series versus parallel (ii) Household lights connected in parallel	Students could investigate Christmas tree lights that are in series as well as those that are in parallel. Note and discuss the positive and negative aspects of each.

Resistance (continued)

Suggested Assessment Strategies

Journal

- Students could reflect on the use of the term "parallel" in a mathematical sense and how its use in this sense is similar and different to its use in the context of circuit.
- Students could discuss how their daily life would change if there were only series circuits throughout your home.

Presentation

- Students could prepare a poster displaying the differences and similarities between series and parallel circuits.

Paper and Pencil

- Given a set of specifications related to series and parallel circuits students could then draw circuit diagrams. For example, draw a circuit with two bulbs where you can control each bulb individually without affecting the other.
- Students could challenge themselves or each other by creating a set of specifications and then having to draw the circuit diagram or the actual circuit to meet the specifications.
- Compare and contrast parallel and series circuits using a Venn Diagram.
- Students could be asked to develop their own analogy to illustrate how resistance depends on how resistors are connected.

Performance

- Students could build series and parallel circuits with different number of bulbs (i.e. different amounts of resistance). They could present their findings qualitatively using a scale (e.g. 1- very bright and 5 - very dim).
- Students could construct circuits similar to those shown on pages 289 and 292 and record current and voltage at various places in the circuit, recording results in an appropriate table.
- Students could complete formal lab write up/activity describing and summarizing the results of adding resistors in series and parallel circuits.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 288, 290-291
BLM 3-34, 3-35

ST pp. 288-294
ST pp. 492-494 (Science Skills)
BLM 3-20 (omit #3), 3-21, 3-31, 3-32, 3-33

ST pp. 290, 293

ST pp. 286-287
BLM 3-36

ST p. 286

Resistance (continued)

Outcomes

Students will be expected to

- give examples of situations where parallel and series connections of cells are used. Include: (113-2B)
  - (i) flashlights availing of series connections
  - (ii) powering a remote or hard to access device (e.g. lighthouse) might avail of parallel connections
- analyze the design of technologies, how they function, and how they impact our daily lives. Include: (113-4)
  - (i) fuses
  - (ii) circuit breakers
  - (iii) grounding terminals

Elaborations—Strategies for Learning and Teaching

Teachers could ask students to brainstorm possible reasons why we would connect cells in series or why we might connect them in parallel.

Teachers should make connections between the topics covered throughout this unit and the everyday experiences of the students whenever possible. Through classroom activities and/or discussions, students may inquire, "Why is there a third prong on most electrical cord plugs?" or "What do the numbers (such as 15) on circuit breakers mean?" If such questions do not arise, teachers could pose these as probing questions. In these situations, the safe use of electricity should be emphasized.

Resistance (continued)

Suggested Assessment Strategies

Paper and Pencil

- Students could evaluate their flashlight designs based on a number of predetermined criteria.
- If connecting cells in parallel increases battery life, why do we not normally connect cells in this manner for a flashlight so that we do not have to change the battery as often.
- Students could be asked the following question: A student's father cut the third prong of an electrical cord because he thought it wasn't necessary. Using what you have learnt in this section, how would you respond to him?
- Students could develop a cartoon strip, collage, or multi media project to demonstrate safety concerns with respect to fuses, breakers, and grounding terminals.

Portfolio

- Students could research and report on situations where series and parallel circuits are used and explain why each is used in that particular situation.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST p. 295
ST pp. 296-297

Resistance (continued)

Outcomes

Students will be expected to

- carry out procedures controlling the major variables (209-1)
- use instruments effectively and accurately for collecting data (209-3)
- use tools and apparatus safely (209-6)
- work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (211-3)
- describe pros and cons of parallel and series connections of cells (113-2A)
  - distinguish between series and parallel connections of cells
  - indicate that series connections of cells increase the effective voltage, but the resulting battery life is shortened
  - indicate that parallel connections maintain the effective voltage, but the resulting battery life is lengthened
  - determine the effective voltage for cells connected in series and parallel
- rephrase questions in a testable form related to series and parallel connections of cells (208-1)

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity: Resistors in Series and Parallel

The laboratory outcomes 210-7, 210-10, 210-16, 211-2 and, in part, 308-17 are addressed by completing CORE LAB 9-1F "Resistors in Series and Parallel."

Teachers could provide students with the following tables for data collection:

Circuit / Measuring Location	Predicted Current (A)	Measured Current (A)	Is there a difference in the predicted and measured current? If so, why?
Location 1			
Location 2			

Circuit / Measuring Location	Predicted Voltage (V)	Measured Voltage (V)	Is there a difference in the predicted and measured voltage? If so, why?
Location 1			
Location 2			

Teachers should highlight how series and parallel connections of cells and resistors are visually similar.

Teachers should provide students with opportunity to design and test various circuit configurations that include cells in series and parallel.

Students could investigate the different connections of cells by being challenged to design and construct a flashlight from a list of materials which meet the following criteria:

1) working switch
2) can operate with one hand
3) durability
4) has a replaceable battery or dry cell

Resistance (continued)

Suggested Assessment Strategies

Paper and Pencil

- Students could be challenged to create an analogy to describe how effective voltage is related to how cells are connected.
- Draw circuit diagrams using different combination of cells in series and parallel and determine the voltage For example, draw a circuit diagram including two 1.5 V cells and a bulb in series and in parallel, and calculate the voltage in the bulb.
- Students could be asked to compare the total resistance of two or more circuits given. For example, how does the resistance of three identical resistors connected in parallel compare to the resistance of two identical resistors connected in parallel and then connected to a third in series?

Resources

www.gov.nl.ca/edu/science_ref/main.htm

Core Lab #6: Resistors in Series and Parallel
ST pp. 300-301
TR 3-45, 3-46 ??
BLM 3-41

Power and Energy

Outcomes

Students will be expected to

- relate electrical energy to domestic power consumption costs (308-18)
  - define electrical energy

Elaborations—Strategies for Learning and Teaching

Students will likely have experiences where they were asked to change an action so as to "save energy." For example, "turn off a light when not needed" or "close the fridge door after unnecessarily opening it time after time." Teachers could use these experiences as a reference point as students investigate the cost of electrical energy.

To begin this section, teachers could ask students to guess what the cost of operating specific household devices for a set amount of time. Later in this section, students will be able to determine how accurate their "guesses" were.

Teachers could use a K-W-L Chart to have students brainstorm ideas related to electrical energy usage.

- identify the Joule (J) as the unit to measure energy
- define electrical power.
- identify the Watt (W) as the unit to measure electrical power.

The study of the uses of electrical energy provides an appropriate context in which to explore and investigate the relationships among energy, work (joule = 1 newton x 1 metre), and power (1 watt = 1 J/s). However, students are not expected to calculate energy, work and power in this course.

Students will have experience with the term "power." For example, "one truck has more power than another." Teachers should relate these experiences to what is being covered here. Power is the rate at which work is done, no matter if it is electrical power (for example how much heat an electrical hair dryer outputs per a given time interval) or mechanical power (for example, how much an engine can move per a given amount of time.)

Teachers could provide students with the opportunity to explore and experience the relationship between energy, work, and power. Explorations and discussions about the amounts of energy, work and power required to operate electric technologies would help the students gain an understanding and appreciation of these concepts. Physical activities such as lifting objects and climbing stairs could also be used.

Power and Energy

Suggested Assessment Strategies

Journal

- Students could reflect upon the different types of energy we have to pay for and what may be the consequences if the cost of these types of energies increases.
- Students could research other units used to measure power such as horsepower.

Performance

- Students could bring along, or teachers could bring samples of, home electrical bills and analyze the power consumption. How is electrical energy usage measured? How much electricity was used during the billing period? How is the cost of electricity calculated?
- Students could plan and conduct an activity investigating the power involved with a specific task. For example, how does the power dissipated by two different individuals caring different sized backpacks up a flight of stairs in school compare?

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 304-305
BLM 3-42

ST p. 306

Power and Energy (continued)

Outcomes

Students will be expected to

- relate electrical energy to domestic power consumption costs (308-18)

  (continued)

  - recognize that electrical energy cost depends on three factors. Include:
    (i) voltage drop
    (ii) electrical current
    (iii) time

- explain the importance of using precise language in evaluating electrical energy costs and relate consumption cost to electrical energy (109-14, 308-18)
  - given power rating and time, determine electrical energy used
  - identify the kWh as a more convenient unit to express electrical energy consumption
  - given electrical energy used and cost of electrical energy, determine cost to consumer

Elaborations—Strategies for Learning and Teaching

Power = Voltage x Current **or** P = V x I

Teachers should provide a variety of examples to help illustrate this relationship. For example, operating electric stoves, electrical heaters (baseboard heaters), and electric driers generally costs more because they operate using a greater voltage (220 V versus 110 V), and a greater current. Operating an electric toaster will cost more than operating a radio for equal amounts of time even though they both use the same voltage (110 V). This is because the current to the toaster is much higher than that to the radio.

At this point, students are calculating power in Watts. Teachers can then help students understand that on a household scale, kW is a more appropriate unit. This can then lead straight into the calculation of kW-h. Note that the textbook goes into much more depth than is necessary in this course.

Energy Consumption (kW-h) = Power (kW) x Time (h) **or**

E = P x t

Students should research and determine the energy consumption ratings of a variety of home appliances. In many cases, the energy consumption ratings are indicated on the "Energuide/kWh" labels.

Some time should be allotted to the study and discussion of the design and efficiency of a number of common electrical appliances, and how much it costs to operate them. The goal of such activities is for students to better appreciate the costs associated with operating certain appliances for specific periods of time. It is not intended that this be simply a drill and practice mathematical activity. Teachers should use real life examples and engage students in discussions relating to this.

Power and Energy (continued)

Suggested Assessment Strategies

Journal

- Based on each of these factors, students could reflect upon how the cost to operate different electrical devices around the home compare.

Portfolio

- Students could research the power ratings on various electrical devices used around the home.
- Over the course of a day, students could calculate an approximate cost for their electrical energy use. They could then suggest ways in which they may "save money."

Performance

- Students could conduct an interview with an electrician, appliance repair person, or some other individual employed in a profession related to the field of electricity.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST p. 307

ST pp. 307-310
BLM 3-46, 3-47, 3-48

Power and Energy (continued)

Outcomes

Students will be expected to

- identify and evaluate potential applications of findings (210-12)
  - recognize that electrical energy is converted to many other forms. Include:
    (i) light
    (ii) heat
    (iii) sound
- evaluate the design of electrical devices in terms of their efficiency. This should include incandescent lighting versus fluorescent lighting: (113-6)
- determine quantitatively the efficiency of an electrical appliance that converts electrical energy to heat energy (308-19)
  - given useful output energy and input energy, calculate efficiency of an electrical device

Elaborations—Strategies for Learning and Teaching

Teachers should ensure that students understand that not all the electrical energy that is used to make a stove element hot is transferred directly to the water in a cooking pot. Some of the electrical energy is converted to heat energy, some is converted to other forms such as light energy, which are lost to the surroundings. As an example of the energy being converted to sound, teachers could reference the "cracking" sound of the pot or electric burner as it expands while being heated.

Students should come to realize that energy exists in a variety of forms and can be converted to a variety of forms.

Students should associate the use and efficiency of electrical appliances with their impact on our environment and our way of life.

Students should be able to determine the efficiency of an electrical appliance given the energy used and the energy of the system. The textbook uses the formula E(J) = P(W) x t(s). In order to reduce the number of formulae students are expected to use in this unit, teachers should continue to use examples using energy in kW. In equation form, E(kW-h) = P(kW) x t(h).

For example, an incandescent lighbulb left on for 10.0 h/week uses 7.0 kW-h of energy to supply 0.4 kW-h of light. A compact fluorescent bulb uses 2.0 kW-h in the same amount of time to supply the same amount of light.

$$\% \text{ efficiency} = \frac{\text{Energy output}}{\text{Energy input}} \times 100\%$$

$$\text{Incandescent: } \frac{0.4 \text{ kW-h}}{7.0 \text{ kW-h}} \times 100\% = 6\% \text{ efficiency}$$

$$\text{Compact fluorescent: } \frac{0.4 \text{ kW-h}}{2.0 \text{ kW-h}} \times 100\% = 20\% \text{ efficiency}$$

Power and Energy (continued)

Suggested Assessment Strategies

Performance

- Students could predict which are the least and which are the most electrical energy efficient devices around the home. They could then conduct research to test their predictions.

Presentation

- Students could prepare a poster/display of the different bulb wattages available and their common uses.
- Students could use a poster display to concretely represent the energy transformations that occur during a selected process.

Paper and Pencil

- Students could create a table to compare incandescent and fluorescent lighting.

	Incandescent	**Fluorescent**
Power Rating		
Initial Temperature		
Final Temperature		
Brightness		

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST p. 314-316
BLM 3-50

ST pp. 316-317

ST pp. 318-319
BLM 3-51

Power and Energy (continued)

Outcomes

Students will be expected to

- compare examples of past and current technologies that used current electricity to meet similar needs (110-9)
  - recognize that Energuide labels are used to aid customers

Elaborations—Strategies for Learning and Teaching

Students could compare and contrast various electrical appliances that convert electrical energy to heat energy. Students could compare and contrast old and new models of irons and toasters, for example, and suggest reasons for differences in efficiencies.

Teachers could refer to the Natural Resources Canada website for further information on energuide labels.

http://oee.nrcan.gc.ca/residential/personal/ appliances/energuide.cfm?attr=4#household

- propose a course of action that reduces the consumption of electrical energy. Include: (113-13)
  - (i) for homes heated by electricity, improve insulating factors
  - (ii) turn off lights when not required
  - (iii) use energy-efficient light bulbs
  - (iv) air dry clothes when possible

Students could compare monthly electric utility bills and suggest reasons for differences in kWh used (season, types of appliances used, time appliances are used, etc.)

Students should identify and propose a course of action that reduces electrical energy consumption either at home or in society in general. Students should be able to substantiate their course of action with evidence gathered or constructed throughout the course of study of this unit. Note whether students modify their behaviour with regard to energy usage and consumption as this is related to the attitudinal outcome of stewardship.

Teachers could use a Think-Pair-Share cooperative learning activity to promote discussion on this topic.

- identify different approaches taken to answer questions, solve problems, and make decisions (109-7)
- analyse the design of a technology and the way it functions on the basis of identified criteria such as cost and impact on daily life and the community (113-5)
- make informed decisions about applications of science and technology, taking into account environmental and social advantages and disadvantages (113-9)

The CORE STSE component of this unit incorporates a broad range of Grade 9 outcomes. More specifically, it targets (in whole or in part) 109-7, 113-5, and 113-9. The STSE component "Electricity Conservation: The New Trend" can be found in Appendix A.

Power and Energy (continued)

Suggested Assessment Strategies

Performance

- Students could contact an appliance manufacturer requesting information on what practices they have incorporated to make their products energy efficient.

Paper and Pencil

- Students could create a table to compare the information found on some appliances that have Energuide labels.

Energuide Info:	Appliance 1	Appliance 2
Average annual energy consumption		
Annual energy consumption range for models of this type and size.		
Energy efficiency of the appliance relative to similar models		
Type and size of the model		
Model number		

- Students could use the Natural Resources Canada website and do a search for Energuide information such as:
  - •What is energy state?
  - •Efficiency of Appliances
  - •Energy Cost calculator
  - •Energy efficiency tips

  www.nrcan-rncan.gc.ca/com/index-eng.php
- Students could investigate the electrical energy consumption at their school (or other public building).
- Students could create a Mind Map (See Appendix B) of the ways electricity is used and how it can be reduced.

Presentation

- Students could prepare a poster to illustrate consumption of electrical energy in a typical home.
- Using their findings from the above study, they could make recommendations to how energy consumption and costs could be reduced.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST p. 320

ST p. 320-322

Core STSE #3: "Electricity Conservation: The New Trend," Appendix A

Energy Generators

Outcomes

Students will be expected to

- describe the transfer and conversion of energy from a generating station to the home (308-20)

The electrical energy that is used by homes and industry originates in electric generators in which a revolving magnet generates the electrical energy. Students investigated the link between magnets and electricity in Grade 6. Students have the chance to investigate this relationship further in senior high. At this level, students need only be aware that this relationship exists (generator-electricity; electricity-motor). Students would be expected to be able to trace the path of energy conversion and transfer from source to use. For example, wind energy - windmill generator - utility lines - porch light.

- identify the components of an electrical generator. Include:
  (i) coil of wire
  (ii) magnets

Students should be given the opportunity to examine examples of electric generators to observe the parts and how they interact. For example, generators are designed such that either the coil of wire or magnets move in relation to the other. This motion is achieved through a number of sources. For example, the motion of water and steam will be discussed in the next outcome. Portable gasoline generators use mechanical energy.

- describe different types of electrical generating stations. Include:
  (i) hydroelectric
  (ii) thermal
  (iii) nuclear

This is an excellent opportunity to incorporate a NL example with Churchill Falls and the proposed lower Churchill development. However, even given our provincial wealth of hydroelectric, we continue to generate a significant portion of our electricity through the burning of fossil fuels at Holyrood.

Teachers could provide students with reading material on each of the types of generating stations and have students do a Jig Saw activity to relay all the information to the other students in the class.

- explain that electrical energy is transmitted over large distances at high voltage and low current

Teachers could arrange for someone from the local power utility company to explain how electrical energy is provided to their community.

Energy Generators

Suggested Assessment Strategies

Journal

- Students could reflect upon our dependence on electricity and its generation and how much this has changed over the last 60 years.

Presentation

- Students could research how electricity was first provided to the community they live in and compare it to the situation today.
- Students could prepare a display showing the various uses for gas powered electrical generators.
- Students could research the Chernobyl nuclear accident. What are the long term consequences of this incident?
- Students could create a poster of one of the types of electrical generating stations and present to the class.

Performance

- Students could design and test a simple generator using a coil of wire and a magnet.
- Teachers could use the following questions to probe student understanding of the factors that affect the electrical output of generators: How would the size / strength of a magnet affect the production of electricity? How would the number of turns in a coil of wire affect the production of electricity? How would the motion between the magnet and the coil of wire affect the production of electricity?

Paper and Pencil

- Students could create a flow chart to illustrate how energy gets transferred and converted from generating station to home.
- Students could create a table to compare hydroelectric, thermal, and nuclear generating stations.

Source	Energy Transfer	Method	Pros	Cons
Hydro				
Thermal				
Nuclear				

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST pp. 324-326
BLM 3-53

ST pp. 326-328

ST pp. 327-328

Energy Generators and Alternative Sources of Energy

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• describe the transfer and conversion of energy from a generating station to the home (308-20) **(continued)** - define transformer	Teachers should indicate that transformers GENERALLY do one of two functions. They either step up (increase) the voltage or step down (decrease) the voltage. Teachers should provide examples of transformers such as power adaptors for various electric devices such as electric games. Hence, the importance of using a specific adaptor for a specific device can be illustrated. The wrong adaptor may not step down the voltage by the correct amount. While there is a third type of transformer (isolation transformer) that is sometimes used, students are not expected to know this and teachers do not need to address this type of transformer.
- recognize that voltage is provided at 120 V and 240 V for domestic use	Referencing Ohm's law, teachers could highlight the importance of supplying electrical energy at a relatively constant voltage for the consumer's safety as well as for the safe operation of electrical devices.
• apply criteria for evaluating environmental problems associated with electrical energy production. Include: (210-8) i) safety ii) cost of production iii) degree of environmental impact	Students could investigate how electrical energy is produced and transported to their community. If there are a number of ways electricity is generated, they could be compared and contrasted.
• give examples of alternative sources of electrical energy. Include: (109-6A) (i) wind generator (ii) solar energy (iii) fuel cell • explain the development of alternative sources of energy as constrained by several factors. Include: (109-6B) (i) cost (ii) availability of materials (iii) properties of materials	Examples of alternative sources of energy such as windmills, solar panels, and wood chips could be highlighted and discussed when investigating and exploring sources of electrical energy. These could be compared and contrasted in terms of cost, efficiency, and impact on the environment. Students should come to realize that the availability of energy resources in a region usually dictates the types of energy used in that region. Teachers could use a jig saw activity (see Appendix B) to promote sharing and understanding of ideas. Students should examine and discuss the positions of groups who support, and groups that are against, certain technologies that produce electrical energy. The damming of rivers in Labrador and coal-fired generators in New Brunswick could be used, for example, to evaluate evidence and sources of information from a variety of sources.

Energy Generators and Alternative Sources of Energy

Suggested Assessment Strategies

Performance

- Students could examine various electrical adaptors used around the home to determine the input and output specifications.
- Students could debate as to which alternate source of electrical energy is the best for our provincial government to actively support/pursue.

Journal

- Students could address the question, why do we need transformers?
- Is the lifestyle of the people in the community affected by the source of electrical energy?

Portfolio

- Students could research the domestic electricity specifications used in other countries.

Presentation

- Students could research a remote/isolated community in Newfoundland and Labrador, and determine how electrical energy is provided to the community.

Resources

www.gov.nl.ca/edu/science_ref/main.htm

ST p. 327

ST p. 328

ST pp. 329-334

ST pp. 329- 334