Topic 4.7
How can we conserve electrical energy at home?

Overview

In this topic, students will learn how electricity is measured and explore ways to conserve energy. They will read EnerGuide labels to compare similar appliances and become informed electrical energy consumers. The Case Study gives students the opportunity to reflect on past and future uses of energy, and how they might help reduce our use of electricity today.

Common Misconceptions

- **Some students confuse the terms *power* and *energy*, and use them interchangeably.** For example, students may describe the power/energy produced by a generating plant, or the power/energy of the electrical device being used. Have students look up the terms in the glossary to compare their definitions and units of measurement. You might also use an analogy: Power : Energy = Speed : Distance. Both power and speed are rates. To calculate energy or distance, you need to multiply by a unit of time.

Background Knowledge

Electric meters outside the home keep track of the amount of electricity that enters the home through the power lines from a nearby transformer. Every time a load is turned on, current is drawn through the meter, causing the dials to turn. Until recently, an employee from the power company would come about every two months to read the numbers on the dial, and determine the electrical energy used during that period by calculating the difference between the current and previous readings.

By 2010, Ontario power companies plan to have all homes outfitted with smart meters. These meters will be able to record the total electricity used hour-by-hour, and send the information to the utility company automatically. The cost for the electricity will be based on time-of-use pricing. Customers pay according to *when* they use their electricity during the day. For example, they may pay 4.0¢/kW•h during off-peak hours, 8.8¢/kW•h during on-peak hours, and 7.2¢/kW•h during mid-peak hours.

The cost for the electricity is calculated by multiplying the amount of electrical energy used (in kW•h) by the unit rate charged by the utility company (in $/kW•h). Notice that the time-of-use pricing offers customers an incentive to monitor their electricity consumption.

EnerGuide labels are found on all new electrical appliances. These labels tell how much energy an appliance is likely to use in one year. They also compare each appliance with similar models on the market. This information enables consumers to make informed choices when deciding which appliance to buy.

Literacy Strategies

Before Reading

- ELL Many English language learners, especially those coming from refugee cimcumstances, may find the idea to measuring usage and plans to reduce this usage very new. Explain the problem that exists in Canada and some of the strategies that have been implemented or are in the process of being implemented. Use this time to introduce key vocabulary and terms that may confuse English language learners, like pool of electrical energy, sustainable energy, kilowatts, time of use prices, smart meters, peak hours, cost calculations, incentives, and EnerGuide. This summary of the big ideas can then be consolidated by the activities with other students that follow.
- Preview the contents of the topic by skimming the headings and subheadings in this topic. Rewrite the titles into questions that can be answered. For example, "What is the unit of measurement for electrical energy?", "How are meters used to measure home energy use?", "What are time-of-use prices?"

Specific Expectations

- **E1.2** propose a plan of action to decrease household energy costs by applying their knowledge of the energy consumption of different types of appliances
- **E2.7** calculate the costs of running common household electrical devices, and compare their efficiency
- **E2.8** graph and interpret electricity consumption data collected over a period of time from electrical meters at home or in the community

Skills

- communicate ideas, plans, procedures, results, and conclusions using a variety of formats
- express the results of calculations accurately and precisely

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-51 for a summary of the materials required in this topic.

During Reading

- "Chunk" the reading for English language learners by directing them to the text that answers each question. Have students make summary notes to answer the questions they wrote before reading. Ask them to include a labelled drawing of an Energuide label (shown on page 318).

After Reading

- Have students draw a T-chart to compare the old-style meters and the new smart meters. Ask, "What advantages or disadvantages do the new-style meters have?" Ensure that English language learners understand the terms *advantage* and *disadvantage* by using familiar examples, such as the advantages and disadvantages of taking transit.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Learning Check questions, page 317 Activity 4.14, page 317	Students explain how energy use is measured in Ontario.	• Analyze Figure 4.40 with students. Ask questions such as "Between what hours is energy use the heaviest/lightest in winter?" • Create similar axes on the chalkboard, paper bars to represent heavy energy use. Invite students to move them to represent summer energy use or weekend energy use, and justify their placement.
Learning Check questions, page 319 Activity 4.15, page 319	Students desribe several ways to conserve energy.	• Have students identify key words in each question in the activity and find which callout on Figure 4.41 those words correspond to, to help them interpret the EnerGuide label.

Topic 4.7 (Student textbook pages 314–325)

Using the Topic Opener (Student textbook pages 314–315)

- Read aloud the opening paragraph and then have students look at the numbers for Ontario's electricity demand on May 3, 2009. Ask students how consumers can use the information to help them use energy more wisely. (One possible answer: To avoid a possible blackout, consumers should try using less electrical energy during the peak hour.) English language learners may have little knowledge of blackouts.
- Have students work in pairs to consider the Topic Question: How can we conserve electrical energy at home? Some English language learners might benefit from reviewing ways in which energy is used in the home and then being given an example of how they might conserve energy. Ask them to list ways they think this can be done, then share their ideas with the rest of the class.
- Assign the Starting Point Activity.

Starting Point Activity (Student textbook page 315)

Pedagogical Purpose

Students will use an inquiry approach to assess social, economic, and environmental costs and benefits of using electrical energy in a sustainable or an unsustainable way.

Planning	
Materials	Students may review the meaning of sustainable on page 65.
Time	10–15 min in class

Skills Focus

- analyze and interpret qualitative data
- make decisions based on evidence

Background Knowledge

Sustainable energy is the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their needs. A broader interpretation may allow inclusion of fossil fuels and nuclear fission as transitional sources while technology develops, as long as new sources are developed for future generations to use. A narrower interpretation includes only energy sources that are not expected to be depleted in a time frame relevant to the human race. In this activity, students will also consider sustainable uses of electricity. Students may interpret these to be uses that are necessary to ensure basic needs are met, or uses that are not easy to power in another way, for example, using hand tools instead of power tools.

Activity Notes and Troubleshooting

- Using energy in a sustainable manner implies using energy in a responsible manner that avoids waste. The example photographs could provide starting points for class discussions; each example depicts a use and potential misuse of electrical energy.
- Focus students' attention on minimizing unnecessary use of electrical energy.
- Two examples of rechargeable batteries are shown: these batteries have the capability to provide energy again and again, but have drawbacks as well. For example, they do not last for more than a few years, and disposal of them presents serious issues related to disposal of hazardous wastes.

Additional Support

- ELL The use of graphic cues in this activity provides additional support for students. Consider having a class discussion before beginning the activity to identify what is going on in each photograph. Keep in mind that the families of some English language learners may not have access or knowledge of some of these items.
- ELL Match English language learners with students who have strong English communication skills to help them participate fully in group discussions. Ensure these students understand some of the obstacles English language learners might experience and they have strategies to support them.
- DI Bodily-kinesthetic learners may enjoy acting out sustainable or unsustainable uses of electricity, while others guess what they are illustrating.

Answers

1. Answers will vary. Use of the rechargeable drill and the rechargeable batteries are good examples of sustainable uses of electrical energy. In addition, accept answers that include an explanation of how any or all of these examples could be used in a way that will meet the needs of today without compromising our ability to meet the needs of tomorrow.
2. Answers will vary. Unsustainable uses include all wasteful practices.

Instructional Strategies for Topic 4.7

Conserving energy at home requires an understanding of how energy is measured. (Student textbook pages 316–317)

- Read the information about electrical units, smart meters, and time of use pricing on pages 316 to 317. What advantage does this type of billing have? (It encourages conservation by making consumers think about the amount of, and times they use, electrical energy.)

- Have students examine the graph shown in Figure 4.40. The axes look like axes of other bar graphs they have seen, but the information on the graph is shown somewhat differently. Discuss with students what information they can learn from the graph.
- Assign Activity 4.14.
  - Enrichment—As a mini-project, ask students to monitor their electrical consumption at home for a week, and to present the data in a graph format.

Learning Check Answers (Student textbook page 317)

1. kilowatt hours (kWh)
2. Answers may vary, e.g., A kilowatt is one thousand watts. It is used to measure the rate at which energy is consumed. For example, a light bulb may use 1000 J of energy to stay on for 10 s. So, it is consuming energy at a rate of 1000 J per 10 s, or 100 J/s. One J/s is the unit of a watt, so the light bulb is consuming energy at a rate of 100 W or 0.1 kW.
3. Answers may vary, e.g., Using the examples from Figure 4.37 as a guide, I would estimate using around 30 kWh per day.

Activity 4.14 Best Time to Use (Student textbook page 317)

Pedagogical Purpose

Students will consider how energy use varies during a day and during a year, and how time-of-use pricing encourages efficient use of energy.

Planning	
Time	15–20 min in class

Skills Focus

- analyze and interpret quantitative data
- make decisions based on evidence

Background Knowledge

Use of the smart meter lets power-supply companies charge different prices for electrical energy that is used at different times of the day. Prices will be highest when the most electrical energy is being used. This is referred to as on-peak use. Prices will be lowest when the least electrical energy is being used. This is referred to as off-peak use. Periods between on-peak use and off-peak use are called mid-peak hours.

The graph in Figure 4.40 compares on-peak, mid-peak, and off-peak periods during winter. The schedule is different for winter and summer because people use electrical energy at different times and in different ways for those seasons. For example, people are more likely to use air conditioning in the summer than in the winter.

Since the inception of electricity deregulation and market-driven pricing throughout the world, government regulators have been looking for a means to match consumption with generation. Traditional electrical meters only measure how much energy is consumed, not when it was consumed. Smart meters provide an economical way of measuring this information, allowing price setting agencies to introduce different prices for consumption based on the time of day and the season.

Electricity pricing usually peaks at certain predictable times of the day and the season. In particular, if generation is constrained, prices can rise significantly during these times as more expensive sources of power are purchased from other jurisdictions or more costly generation is brought online. It is believed that billing customers by how much is consumed and at what time of day it is consumed will ecourage consumers to adjust their consumption habits to be more responsive to market prices. Regulatory

and market design agencies hope these "price signals" will delay the construction of additional generation or at least the purchase of energy from higher priced sources, thereby controlling the steady and rapid increase of electricity prices. The world's largest smart meter deployment was undertaken between 2000 and 2005 by the dominant utility company in Italy with over 27 million customers.

Activity Notes and Troubleshooting

- Focus students on their actual use of electrical energy in a day. For example, ask students what home lighting, heating, or cooling appliances they used during the previous day and when they used them. When would large amounts of energy be used in their home? When would almost no energy be used?
- Ask students how they could use electricity in different ways to save energy and money.

Additional Support

- ELL Match English language learners with students who have strong communication skills and understand the issues language learners face to ensure understanding.
- If possible, make a large copy of Figure 4.40 to share with students. This could be drawn on the chalkboard or on an overhead, and bars could be created for students to place to represent different patterns of energy use. Analyze Figure 4.40 with students before they begin to ensure they understand what the graph shows. The axes look like a bar graph, but the data is not shown the way it would be on a bar graph.

Answers

1. During summer, the dominant energy use is usually for air conditioning, which peaks during the late afternoon, but still operates at high levels during the overnight hours, and drops to its lowest level in the early morning.
2. Different pricing structures are used during the different seasons to ensure that periods of peak price coincide with periods of peak use. Utilities, with the support of government, are encouraging people to reduce use of energy with financial incentives.
3. Answers will vary. Examples include the following:
   – delay use of the dishwasher until times of reduced energy
   – lower thermostat in winter
   – raise thermostat in summer
   – use a programmable thermostat

People can conserve energy by making informed choices.

(Student textbook pages 318–319)

- Preview new vocabulary by writing the terms *power*, *energy*, *efficiency*, and *phantom loads* on the chalkboard. Ask students to brainstorm what these terms mean. Have students read the explanation of phantom loads on pages 318–319. Provide examples and non-examples with English language learners, and then have students decide if a situation is an example of a phantom load or not.
- Refer to Figure 4.41 and explain the main parts of an EnerGuide label. Assign Activity 4.15.
- Enrichment—As an extension activity, have students make a list of all the ap pliances in their home that have an EnerGuide label. Ask them to analyze which appliance uses the most energy in one year.

Activity 4.15 Reading EnerGuide Labels (Student textbook page 319)

Pedagogical Purpose

Students will learn to read the information on EnerGuide labels to compare the energy use of similar types of appliances.

Planning	
Materials	Bring in examples of other EnerGuide labels, at least four, and photocopy these for student use. Each student will need at least three different EnerGuide labels; download EnerGuide labels in pdf at **www.scienceontario.ca**.
Time	20–30 min in class

Skills Focus

- analyze and interpret quantitative data
- make decisions based on evidence

Background Knowledge

EnerGuide is a Government of Canada initiative that rates the energy consumption and efficiency of household appliances, heating equipment, cooling equipment, ventilating equipment, new houses, and personal vehicles. You can use the EnerGuide label to make informed buying decisions by comparing the energy performance of different products.

Activity Notes and Troubleshooting

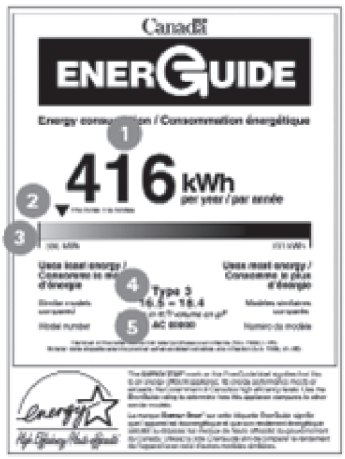
- Ask senior physics students to act as peer helpers during this activity to help keep students on task and to assist students who struggle with numeracy.
- Focus students' attention on their personal use of energy efficient and inefficient appliances.
- Remind students that energy savings can amount to a significant saving that could be used for alternatives.

Additional Support

- If possible, make a large copy of an EnerGuide label to share with students during discussions. English language learners may not understand what role the government plays here. Explain that the government often uses strategies like this to encourage wise choices. Explain what a standard means. Point out that there are two languages on the label and invite English language learners to redraw the label using their own first language.
- ELL Match English language learners with students who have strong communication skills to ensure understanding of the questions.
- Students with visual challenges will find this activity difficult. Allow these students to look at the images on-line where they can change the resolution and size of the images. Alternatively, have a classmate with excellent communication skills assist them.

Answers

(for the EnerGuide label pictured)
Source: http://oee.nrcan.gc.ca/residential/personal/appliances/energuide.cfm?attr=4



1. 1130 kWh
2. 350 kWh
3. 416 kWh
4. This model is much closer to the most efficient appliance in the category.
5. Answers will vary depending on label. For the EnerGuide label on the preceding page, I would recommend buying this appliance because it is very efficient in use of energy.

Using the Case Study Investigation

People Power (Student textbook pages 320–321)

Pedagogical Purpose

Students will use a case study approach to assess social, economic, and environmental costs and benefits of using renewable and non-renewable sources of electrical energy in an energy efficient manner.

Literacy Support

Before Reading

- Have students view episodes of *That 70s Show* to get an image of what the 70s looked like and to hear about some of the issues from that decade. Students could write a brief description of what a typical household might have. Images from the Internet could be presented.
- Students could research the Internet to understand what precipitated the oil crisis. [The 1979 (or second) oil crisis occurred in the wake of the Iranian Revolution. Massive political protests in Iran had a devastating effect on the Iranian oil sector. While the new regime resumed oil exports, it was inconsistent and at a lower volume and prices increased. Saudi Arabia and other OPEC nations increased production to offset the decline, but the overall loss in production was about 4 percent. A widespread panic resulted, driving the price far higher than would be expected under normal circumstances.]
- Students may find out that there were in fact two oil crises during the 70s. One in 1973 due to OAPEC's embargo on oil in protest to the financial support by the U.S. of the Israeli military. They could compare the effects of the 1973 crisis with the one in 1979.

During Reading

- Have students examine the letter and search the Internet for images from the 1970s to help them visualize what it might have been like during this decade. Students could also watch television episodes of *That 70s Show* for examples.
- Have students research details about the cars from the 70s—their weight, fuel efficiency, and materials. Compare these cars with cars from this decade. What changes were made and why?

ELL Have English language learners work with students who have strong English language skills. Strong students can summarize and simplify the information found during their research above.

ELL As you read through the case study with students, have English language learners highlight words they do not understand. On the board, write synonyms for each of these words.

After Reading

- Provide graphic organizers such as **BLM G-32** through **BLM G-39** to help students organize and consolidate their notes. If necessary, fill in part of the organizer before you photocopy it, and have students complete it.

Activity Notes

- Remind students that oil crises have occurred several times in the recent past and that the response has always been an increase in prices for fossil fuels.
- This activity is intended to focus students on reading to obtain information. English language learners may be competent at this skill in their first language but need support with vocabulary and the syntax or organization of English along with unfamiliar cultural references.
- Students are not expected to actually construct a pedal powered machine, but this could be an extension.
- ELL If possible, match English language learners with peers who have demonstrated strong English communication ability and a willingness to help. English language learners and others may need help understanding some of the cultural references and the idioms and slang terms used in the diary entry and supporting text (everyone jumped on the bandwagon) on page 320.
- DI Some bodily-kinesthetic learners may want to build the machine they design and demonstrate it for the class, instead of describing it.

Answers

Pause and Reflect

1. Answers will vary. Attempts to improve energy efficiency included improved fuel economy in cars and other government strategies, some of which extend to this day, for example, EnerGuide.
2. The Bionic Energy Harvester is a device that when worn on the leg while walking generates electricity which can be used to power small electrical devices like cell phones or charge batteries that could be used by other electrical devices.
3. The Bionice Energy Harvester recovers energy spent by our leg muscles during walking.

Inquire Further

4. The energy crises of the 1970s were caused initially by shortages in supplies of fossil fuels due to war or insurrection in and around the oil-producing countries of the Middle East.

5. Students can begin their search for additional information at the McGraw-Hill Ryerson website: **www.scienceontario.ca**.

6. Answers will vary. Students should design an application that converts the rotational energy from the chain or bicycle wheel to power a device that rotates.

Using Making a Difference (Student textbook page 322)

Literacy Support

Before Reading

- Have students skim the two stories to make a list of terms they are not familiar with. These may include: grey water, recycled, electric field, particulates, fluorescent tubes, landfill, contaminate, and leachate. Clarify these together before reading.
- ELL English language learners could use **BLM G-31 English Word Study** to record meanings for each of the terms listed above.

During Reading

- ELL Have English language learners read the first story to find out what Katie observed and what she wondered and then what she found out from her project. Have them skim the paragraph to find these verbs and the information that answers the questions. Ask them to read the second story to find out what Patrick learned about tubes containing mercury.
- Invite a volunteer to summarize the key ideas in each story in one sentence. Write this on the chalkboard and invite others to add to or refine it.

After Reading

- Make connections with prior knowledge. Ask students how these stories connect to what they have learned about electricity. For example, "introducing an electric field to grey water" fits into Topic 4.1 about electrical energy generation and Topic 4.7 about ways to conserve energy.

Instructional Strategies

- The first story in this feature can be used to help students realize that electricity can be used in many ways; not just to power electrical devices. In this case, the electricity is used to clean household wastewater, called grey water. Have students answer the question in the blue box: "What other uses for grey water can you think of?" (For more information about grey water recycling, see www.scienceontario.ca.) Students can present their findings using a method of their choice (oral presentation, Bristol board, poster, pamphlet, Powerpoint presentation, etc.)
- After reading the second story, students can research the different types of light bulbs on the market and compare them using a graphic organizer of their choice.

Answers

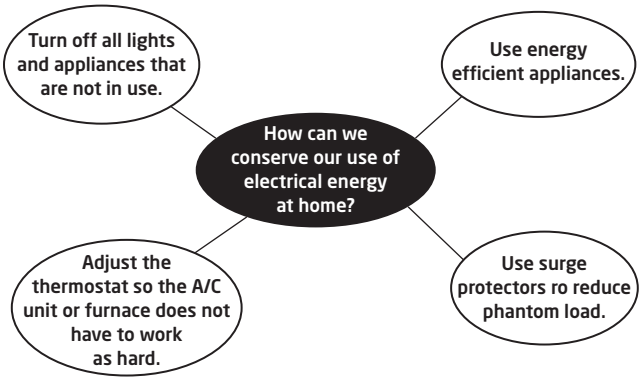
What other uses for grey water can you think of?
Answers may vary but may include, reusing as toilet water, hot water heat recycling, and ice rinks.
How could you help raise your community's awareness of the hazards linked with throwing away fluorescent tubes?
Answers may vary but may include: talking to your friends and family about the issue, making posters to put around your neighborhood or school, and writing letters to local officials.

Topic 4.7 Review (Student textbook page 323)

Please see also **BLM 4-29 Topic 4.7 Review (Alternative Format)**.

Answers

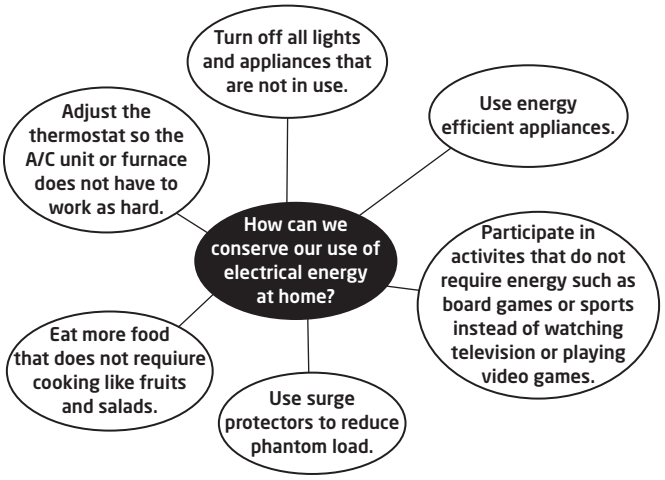
1. Answers may vary. For example:



2. a) Answers may vary. For example: An EnerGuide label shows the energy the appliance will use in a year of normal use and where this number falls in the range of the most efficient and inefficient appliances of the same type.

b) Answers may vary. For example: I would want to choose an appliance with the lowest energy usage. I could check to ensure that the energy consumption was efficient by seeing where it lied on the shaded line as well as comparing it to the most efficient and most inefficient products.

3. Answers may vary. For example:



4. Model A:

Annual Cost = Energy Use × Price of Electricity
= 400 × 0.08
= 32

Model A will cost \$32 a year to operate. Over the long term, this model will cost \$32/year × 17 years = \$544 to operate.

Model B:

Annual Cost = Energy Use × Price of Electricity
= 460 × 0.08
= 36.8

Model B will cost \$36.8 a year to operate. Over the long term, this model will cost \$36.8/year × 17 years = \$625.6 to operate.

The difference in operation costs is \$625.6 – \$544 = \$81.6 over the life of the refrigerator, which is more than 4 times the initial difference in price. So, you will save more money in the long run if you bought Model A.

5. The total amount of energy used by all the televisions in Canada is:

Phantom Load per TV × Number of TVs
= 100 × 21 000 000
= 2 100 000 000

So, 2.1 billion kWh was wasted in 2003.

The cost of this wasted energy is:

Energy Used × Price of Electricity
= 2 100 000 000 × 0.08
= 168 000 000

About \$168 million was wasted in 2003 by Canadians on phantom load alone!

6. Answers may vary. For example: Modern appliances are more efficient than older appliances with respect to energy consumption. Energy prices are steadily increasing so by reducing the usage of electricity, you could save more and more money each year. Many harmful by-products are created from power plants such as greenhouse gas emissions. In addition to the financial benefits of replacing your old appliance, you will help reduce the energy usage around the world which will greatly help the environment by reducing the amount of emissions from power plants.

7. a) Answers may vary. For example: Office buildings use a large amount of light bulbs and thus lots of energy. Convincing offices to participate in Earth Hour could greatly reduce electricity consumption. This is normally difficult because many companies cannot afford to keep the lights off because this would probably halt production. To get around this obstacle, perhaps Earth Hour could occur during a lunch hour so offices could participate and not worry about worker production. If Earth Hour became a festivity providing an outdoor lunch, this could encourage many people to leave their light-dependent workplaces and participate. For the lunch to be successful, the date would probably need to be changed to a warmer day, possibly in June.

b) Answers may vary. For example: I think many people are unaware of how easy it can be to reduce energy usage. Simple things like surge protectors and turning off the furnace or the air conditioning unit when people are not home could save an immense amount of energy with very little work. If the organizers for Earth Hour focused on more of these simple energy saving tips and showed how much energy these things waste, it could inspire many people to make these simple, but effective changes.

Using Science at Work (Student textbook page 324)

Literacy Support

Before Reading

- Ask students to brainstorm a list of all the careers they can think of that involve the field of electricity. As they do, list the careers using a wheel like the one on page 325 and explain each so English language learners understand. Introduce the term *electrical instrumentation technicians* and have students predict what those people might do in their careers. List these predictions and then have the students read to find out if they were correct.

During Reading

- As students read, have them make notes to answer the questions: "What do electrical instrumentation technicians do?" "What educational background and skills do they need?"
- Read aloud, and talk about where the important information is found in each paragraph.

After Reading

- Ask students to compare the career wheel shown on page 325 with the list of careers they made earlier. Can they suggest a way to organize or group the different careers together? (for example, by skills or training needed, by responsibilities and duties to carry out)

Instructional Strategies

- Ask students if they know anybody who works in the field of electricity. If possible, arrange for someone who works in this field to visit the school and talk to the class about their career.
- If possible, provide students with brochures about different careers related to electricity. Alternatively, students could look for this information on the Internet. They can summarize the information and make posters about the different careers to post around the science room.

Answers

1. Electronic instrumentation technicians typically work in industrial plants.
2. Answers may vary, for example, A powerline technician can come in three types: a journeyman/woman technician, a trouble technician, or a cable splicer. I will further investigate the requirements and duties of a journeyman/woman powerline technician.

   To be a successful powerline technician, one needs to have trade qualifications as a Journeyman Powerline Technician (PLT) with an interprovincial red seal certificate, a full driver's license, the ability to work independently or as a team, and good communication skills. A person must be physically fit with a strong cardiovascular system. He or she would also be required to have technical and safety skills pertaining to working with power lines.

   The job would entail safely performing activities related to the construction, maintenance, repair, or testing of various electrical systems. A powerline technician would also be expected to undertake live line work and perform helicopter patrols. Additionally, if there are any customer service calls pertaining to power interruption, it would be the duty of a powerline technician to attempt to trouble shoot and solve the problem.