EXPLORING ELECTRICITY PRODUCTION

OPG GRADE 6 TEACHER GUIDE

ONTARIO POWER GENERATION

EXPLORING ELECTRICITY PRODUCTION:
GRADE 6 TEACHER GUIDE

This Teacher Guide, which accompanies the ***EXPLORING ELECTRICITY PRODUCTION – OPG GRADE 6 EDUCATION KIT***, is intended for teachers of Grade 6 students in Ontario and aligns to selected curriculum expectations in ***The Ontario Curriculum: Grades 1-8 Science and Technology (2007)***, ***The Ontario Curriculum: Grades 1-8 Language (2006)*** and ***The Ontario Curriculum: Grades 1-8 Mathematics (2005).***

Ontario Power Generation (OPG) is an Ontario-based electricity generation company whose principal business is the generation and sale of electricity in Ontario. OPG's focus is on the efficient production and sale of electricity while operating in a safe, open and environmentally responsible manner.

OPG is committed to helping Ontario teachers and students learn more about the amazing world of electricity and power generation in Ontario. Please contact us if you have questions or comments about this Teacher Guide or the Education Kit. For more information, please visit: www.opg.com/learningzone.

RESOURCE OVERVIEW

The ***EXPLORING ELECTRICITY PRODUCTION*** Teacher Guide contains five lessons that examine electricity generation on both the macro and micro levels.

At a macro level, students will learn about the different types of electricity generation used by OPG that help to supply Ontario's homes and businesses. At a micro level, students will investigate and use technological problem-solving skills to explore and construct devices that generate electricity. Students will also have the opportunity to identify and assess the short- and long-term environmental effects of the different ways in which electricity is generated in Ontario.

LESSONS AT A GLANCE

LESSON	NAME	FOCUS	OVERVIEW	SUGGESTED TIMING
1	Electricity Generation Close to Home	Understanding Concepts	Students will brainstorm devices which use electricity, locate OPG generating stations on a map of Ontario and graph OPG's generating stations by type.	2 x 40 minutes (Science, Mathematics, Language, Social Studies)
2	How Does Large-Scale Electricity Generation Work?	Understanding Concepts	Students will explore how various forms of energy are transformed into electrical energy at generating stations and will record their learning using graphic organizers.	2 x 40 minutes (Science, Language)
3	What Is a Generator?	Investigation	Students will read and discuss a comic about Michael Faraday's discoveries in electricity generation and will create and test a simple generator.	2 x 40 minutes (Science, Language)
4	Generate Your Own Electricity	Investigation	Students will use a technological problem-solving process to create a miniature generating station (wind turbine) which employs a turbine and a generator.	2 x 40 minutes (Science, Language)
5	Electricity Generation and the Environment	STSE	Students will identify and assess the short- and long-term environmental effects of the different ways in which electricity is generated in Ontario using consequence maps.	2 x 40 minutes (Science, Language)
			Total Suggested Time	10 X 40 minutes

ONTARIO GRADE 6 CURRICULUM ALIGNMENT

THE ONTARIO CURRICULUM: GRADES 1-8 SCIENCE AND TECHNOLOGY (2007)

Strand: Understanding Matter and Energy

Topic: Electricity and Electrical Devices

Fundamental Concepts: Energy, Systems and Interactions, Sustainability and Stewardship

Big Ideas:
- Electrical energy can be transformed into other forms of energy
- Other forms of energy can be transformed into electrical energy
- Electrical energy plays a significant role in society, and its production has an impact on the environment

OVERALL AND SPECIFIC EXPECTATIONS		LESSON				
		1	2	3	4	5
1.	**Relating Science and Technology to Society and the Environment**					
1.	**Evaluate the impact of the use of electricity on both the way we live and the environment**					✓
1.1	assess the short- and long-term environmental effects of the different ways in which electricity is generated in Canada *(e.g., hydro, thermal, nuclear, wind, solar)*, including the effect of each method on natural resources and living things in the environment					✓
2.	**Developing Investigation and Communication Skills**					
2.	**Investigate the characteristics of static and current electricity, and construct simple circuits**	✓	✓	✓	✓	✓
2.1	follow established safety procedures for working with electricity			✓	✓	
2.2	design and build series and parallel circuits, draw labelled diagrams identifying the components used in each, and describe the role of each component in the circuit				✓	
2.4	design, build, and test a device that produces electricity *(e.g., a wind turbine)*				✓	
2.6	use appropriate science and technology vocabulary, including current, battery, circuit, transform and energy, in oral and written communication	✓	✓	✓	✓	✓
2.7	use a variety of forms *(e.g., oral, written, graphic, multimedia)* to communicate with different audiences and for a variety of purposes	✓	✓	✓	✓	✓
3.	**Understanding Basic Concepts**					
3.	**Demonstrate an understanding of the principles of electrical energy and its transformations into and from other forms of energy**	✓	✓	✓	✓	
3.4	describe how various forms of energy can be transformed into electrical energy *(e.g., hydroelectric plants use water power; nuclear generating stations use nuclear energy; wind turbines use wind power)*		✓	✓	✓	
3.5	identify ways in which electrical energy is transformed into other forms of energy	✓				✓
3.6	explain the functions of the components of a simple electrical circuit				✓	

THE ONTARIO CURRICULUM: GRADES 1-8 LANGUAGE (2006)

Strand: Reading

OVERALL AND SPECIFIC EXPECTATIONS		LESSON				
		1	2	3	4	5
Reading for Meaning						
1.	**Read and demonstrate an understanding of a variety of literary, graphic, and informational texts, using a range of strategies to construct meaning**	✓	✓	✓	✓	✓
1.1	read a wide variety of texts from diverse cultures, including literary texts, graphic texts *(e.g., graphic novels, atlases, graphic organizers, charts and tables)*, and informational texts *(e.g., non-fiction materials)*	✓	✓	✓	✓	✓
1.4	demonstrate understanding of increasingly complex texts by summarizing and explaining important ideas and citing relevant supporting details *(e.g., general idea and related facts in tables and charts, concept maps)*	✓	✓	✓		✓
1.5	develop interpretations about texts using stated and implied ideas to support their interpretations	✓	✓	✓		✓

THE ONTARIO CURRICULUM: GRADES 1-8 MATHEMATICS (2005)					
Strand: Data Management and Probability					
OVERALL AND SPECIFIC EXPECTATIONS	LESSON				
	1	2	3	4	5
Collection and Organization of Data					
Collect and organize discrete or continuous primary data and secondary data and display the data using charts and graphs, including continuous line graphs	✓				
Collect and organize discrete or continuous primary data and secondary data and display the data in charts, tables, and graphs that have appropriate titles, labels and scales that suit the range and distribution of the data, using a variety of tools	✓				
Select an appropriate type of graph to represent a set of data, graph the data using technology, and justify the choice of graph	✓				
Data Relationships					
Read, describe, and interpret data, and explain relationships between sets of data	✓				
Read, interpret, and draw conclusions from primary data and from secondary data, presented in charts, tables, and graphs	✓				

TEACHER NOTES

Below are some suggestions to help facilitate the implementation of this resource.

TEACHING AND LEARNING

- This resource is not a full teaching unit, but rather a mini-unit about electricity generation. Prior knowledge and skills are identified for each lesson. You can do as many or as few of the lessons as you wish.
- The lessons address the overall expectations and some specific expectations from the **Electricity and Electrical Devices** topic in the **Understanding Matter and Energy** strand. The lessons do not address specific curriculum expectations related to static electricity, electrical conductivity or electricity consumption.
- The lessons provide cross-curricular learning opportunities with Language and Mathematics.
- In order to address the learning needs of all students, *Differentiated Instruction* suggestions are provided in the lessons.
- Assessment strategies and tools are provided with each lesson. Teachers may choose to use the ones provided or assessment strategies and tools of their choice.

STUDENT PRIOR LEARNING

- The lessons in this resource are not designed to be an introduction to electricity and electrical energy. Students will need some familiarity with constructing simple series circuits, including how to draw circuit diagrams and construct circuits using light bulbs, wires and motors.
- Students are required to have skills in research, investigation and technological problem-solving as well as experience in several different modes of communication (e.g., labelled diagrams, graphic organizers, graphs, etc.).
- Students should be familiar with the safe and proper operation of electrical equipment, including light bulbs, wires and DC motors.
- Students should have some prior experience working in cooperative small groups and using the Internet for research.

LOGISTICS

- Students will need access to LED and incandescent light bulbs, copper wire, bar magnets, DC motors and other materials to build the devices in Lessons 3 and 4. These materials are available from an educational supply house such as Boreal Northwest (www.boreal.com), an electronics store such as The Source (www.thesource.ca), local surplus stores, toy stores and dollar stores. You may also want to contact your school board's lending library, parents and local utilities for additional resources.
- Access to the Internet is recommended for Lessons 1, 4 and 5. You may choose to have students use the Internet during class time, during computer lab time or outside of class time.

LESSON #1: ELECTRICITY GENERATION CLOSE TO HOME

SUGGESTED TIMING:
2 x 40 minutes (Science, Mathematics, Language, Social Studies)

LESSON OVERVIEW:

Ontario gets its electricity from diverse sources of energy supplied by a large number of generating stations located across the province. In this lesson, students will learn about Ontario's "energy mix," create a graph of OPG's generating stations and locate the generating station closest to their school or town.

KEY QUESTION:
How is electricity generated in Ontario and where is the generating station closest to our school or town?

CURRICULUM CONNECTIONS

BIG IDEAS:
Electrical energy can be transformed into other forms of energy.
Other forms of energy can be transformed into electrical energy.

OVERALL AND SPECIFIC EXPECTATIONS:
See charts on pages 3 and 4

FYI

*Currently, OPG's **THERMAL** stations burn coal, oil or natural gas.*

ASSESSMENT *for* LEARNING and *as* LEARNING

LEARNING GOALS:

- Becomes familiar with the major types of electricity generation in Ontario, identify where generating stations are located geographically and graph generating stations by type

SUCCESS CRITERIA:

Knowledge and Understanding

- Understands that there are many ways to generate electricity in Ontario and that these generating stations are located near necessary resources (e.g., falling water, lakes, etc.)

Thinking and Investigation

- Brainstorms ways in which electrical energy is transformed into other forms of energy
- Collects and represents graphically data from a map

Communication

- Uses appropriate science and technology vocabulary (i.e., *electricity, generation, hydroelectric, nuclear, thermal, wind,* etc.) in oral and written communication
- Collects and communicates data using appropriate types of graphs

Application

- Makes connections between technology and society

ASSESSMENT STRATEGIES:

- The students' graphs could be assessed in terms of data management outcomes from the Mathematics curriculum.
- The students could assess the suitability of their choice of graphing method (e.g., from types of graphs already studied, such as pictographs, bar graphs, broken-line graphs and continuous line graphs).

MATERIALS

MATERIALS AND RESOURCES:

- OPG Grade 6 Student Guides (pages 2-3) – 1/student (provided with kit)
- Science notebooks – 1/student
- Coloured pencils or markers
- Graph paper or graphing software

PREPARATION:

- None

PRIOR LEARNING

Prior to this lesson, students will have:

- familiarity with various types of graphs and their uses
- experience reading maps
- experience using the Internet for research

DIFFERENTIATED INSTRUCTION - ***INTELLIGENCES***

This activity could be done together as a whole class or individually, in pairs or in small groups using a THINK-PAIR-SHARE strategy.

MINDS-ON

WHOLE CLASS

Begin the lesson by having students brainstorm a list of devices that use electricity. For each device, have the students describe what form of energy the electrical energy is transformed into (e.g., heat, light, sound, etc.) and identify the source of electrical energy (dry cells vs. electrical outlets). On the list, have the students circle devices that use dry cells (batteries) with one colour and the devices that use electrical outlets with a different colour and tally the totals.

- *Do more devices use dry cells or electrical outlets?*

Discuss where the electricity in electrical sockets originates (i.e., generating stations).

DIFFERENTIATED INSTRUCTION - ***INTELLIGENCES***

Students can also see an interactive map showing the locations of the 75 electricity-generating stations operated by OPG at www.mypowercareer.com/Content/WhyOPG/OurWork/Map/Index.html (English only).

ACTION

WHOLE CLASS – SOCIAL STUDIES FOCUS

Students will use the map of Ontario on pages 2 and 3 of the OPG Student Guide to identify four types of generating stations (nuclear, hydroelectric, thermal and wind) and observe where the stations are located geographically.

After reading, questions for discussion can include:

- *What are the four types of generating stations?*
- *What do you notice about the locations of the various types of stations? Do you notice any patterns?*
- *Which generating station generates the most electricity (in MW)? Which generates the least?*

INDIVIDUAL – MATHEMATICS FOCUS

Students will create two graphs. The first will be a graph of OPG's generating stations by type (e.g., a bar graph or pictograph) and the second will be a graph of the four types according to production (e.g., stacked bar graph, percentages shaded on a 10 x 10 grid, etc.).

After graphing, questions for discussion can include:

- *What inferences can you draw from each of the graphs?*
- *Did any of the data surprise you? How so?*
- *Is the type of generating station with the most sites the type that can generate the most electricity?*
- *How might someone use this data?*

MATH MATTERS

Each student could choose the graphical formats he/she would like to use for the two graphs. Students could be assessed on their choice of an appropriate style of graph.

MISCONCEPTION ALERT

The map in the Student Guide does not show all of the generating stations in Ontario, only those operated by OPG. There may be other generating stations close to you operated by other utility companies.

CONSOLIDATION AND CONNECTION

WHOLE CLASS, SMALL GROUP, INDIVIDUAL

Individually, or in small groups, the students could find the generating station(s) nearest to their school or town. They could use the map on pages 2 and 3 of the OPG Student Guide as a start and then refine their search by going to www.opg.com and clicking on the **Power Generation** button at the top of the page. From there, they can choose HYDRO, NUCLEAR or THERMAL from the menu on the left to find the nearest plant group (Hydro only) and plant/station. For the closest station/plant, have the students find out **three facts** about the site, such as:

- *River or lake it is located on/near (if any)*
- *When it first came into service*
- *How many people it employs*
- *What company built it*

Have the groups share what they learned with the whole class.

DIFFERENTIATED INSTRUCTION - ***INTELLIGENCES***

Students could present the information about the closest generating station in the form of a poster, brochure, rap, etc.

EXTENSIONS:

Students could choose another generating station to find out more about.

BACKGROUND INFORMATION

On the map, students will see that each power station/plant has a number in MW (megawatts). This is the **Maximum Continuous Rating** (MCR), the maximum output of a generating station under normal operating conditions, rounded to MW.

Students may be familiar with the term **kilowatt** (as in kilowatt-hours for electricity consumption), but may not be familiar with the term **megawatt**. A megawatt **(MW)** is one million watts. A **watt (W)** is a unit of **power** (measure of the rate of energy conversion).

LESSON #2: HOW DOES LARGE-SCALE ELECTRICITY GENERATION WORK?

SUGGESTED TIMING:
2 x 40 minutes
(Science, Language)

LESSON OVERVIEW:

Most generating stations, whether they are nuclear, thermal (coal, oil or natural gas), hydroelectric or wind, do essentially the same job - transform kinetic energy into electrical energy. In this lesson, students will explore similarities and differences among generating stations and create flow charts showing how these generating stations transform energy.

KEY QUESTION:
How are various forms of energy transformed into electrical energy at generating stations?

CURRICULUM CONNECTIONS

BIG IDEA:

Other forms of energy can be transformed into electrical energy.

OVERALL AND SPECIFIC EXPECTATIONS:

See chart on pages 3 and 4

FYI

Ontario's nuclear reactors use fuel pellets that are made from naturally occurring uranium that is mined in Saskatchewan.

ASSESSMENT *for* LEARNING and *as* LEARNING

LEARNING GOALS:

- Understands that kinetic energy derived from moving air, moving water or steam is transformed into electrical energy by the turbine and generator in a generating station
- Compares and contrasts two types of generating stations using an appropriate graphic organizer
- Creates flow charts which explain the energy transformation processes in generating stations

SUCCESS CRITERIA:

Knowledge and Understanding

- Understands how different types of generating stations transform various types of energy into electrical energy

Communication

- Demonstrates understanding of increasingly complex texts by summarizing and explaining important ideas and citing relevant supporting details using graphic organizers such as T-charts and Venn diagrams
- Uses appropriate science and technology vocabulary (i.e., *electrical energy, generator, kinetic energy, transform, turbine, etc.*) in oral and written communication

ASSESSMENT STRATEGIES:

- Pairs of students could review each other's T-charts for accuracy and completeness.
- Graphic organizers could allow students to demonstrate understanding of increasingly complex texts by summarizing and explaining important ideas and citing relevant supporting details.

MATERIALS

MATERIALS AND RESOURCES:

- OPG Student Guides (pages 4-7) – 1/student (provided with kit)
- Student notebooks or sheets of paper
- PDFs of each of the four types of generating stations (optional, available at www.opg.com/learningzone)
- SMART Board™ (optional)

PREPARATION:

- Download PDFs if you plan to use them with the SMART Board™.

PRIOR LEARNING

Prior to this lesson, students will have:

- familiarity with different types of energy (e.g., chemical, thermal, nuclear, gravitational potential, etc.)
- experience using a variety of graphic organizers including Venn diagrams, T-charts and flow charts

MINDS-ON

INDIVIDUAL, WHOLE CLASS - LITERACY FOCUS

Introduce the question, ***"How does a generating station work?"*** Have each student create a T-chart in his/her notebook or on a piece of paper with the headings "What Is Interesting" and "What Is Important."

Next, have the students individually or with a partner read pages 4-7 of the OPG Student Guide and, keeping in mind the question, have the students fill in the T-chart using information found on pages 4-7. Students could discuss their responses with an elbow partner before sharing with the whole class.

DIFFERENTIATED INSTRUCTION -
INTELLIGENCES

Visual learners would benefit from watching the ***HOW IT WORKS: ELECTRICITY GENERATION*** *videos, which show and explain three of the four types of generating stations (available in the kit and online at www.opg.com) (English only).*

LINKS TO LITERACY

This strategy helps students to think critically about a text and sort out what is important from what is simply interesting.

ACTION

INDIVIDUAL, SMALL GROUP, WHOLE CLASS - LITERACY FOCUS

Using the "What is Important" information from the previous activity and pages 4-7 of the OPG Student Guide, have each student (or small groups of students) compare and contrast two of the four types of generating stations (hydroelectric, thermal, nuclear, wind) using a Venn diagram.

The diagrams should include:

- the energy source that creates the kinetic energy (i.e., moving air, moving water, burning of fuel, fission);
- what turns the turbine (i.e., air, water, steam);
- the major parts (e.g., turbine, generator, boiler, burner, reactor, dam);
- whether cooling water is used (thermal, nuclear); and
- waste products (if any).

DIFFERENTIATED INSTRUCTION –
PREFERENCES

Instead of Venn diagrams, students could be given a choice of graphic organizers (e.g., comparison matrix, double-cell diagram, etc.). For more information, visit www.graphic.org (English only).

LINKS TO LITERACY

Students can create their own glossaries of the bold words from the Student Guide, that could include use of first language, symbols, graphic representations, etc.

Upon completion of the diagrams, individuals or groups of students could present their diagrams orally to the class using compare and contrast statements such as "hydroelectric stations generate electricity using water but nuclear stations generate electricity using uranium," etc. Based on this information, summarize what all four types of generating stations have in common (all have turbines and generators and involve some form of energy which is transformed into kinetic energy which turns the turbine and is then transformed into electrical energy).

CONSOLIDATION AND CONNECTION

INDIVIDUAL, SMALL GROUP

Once students are familiar with the parts of generating stations, they will create diagrams (e.g., flow charts) which show the energy transformation process for each type of generating station. This could be done using energy words on small pieces of paper. For example, for coal you would have:

> *DIFFERENTIATED INSTRUCTION –* ***READINESS***
>
> *If necessary, review types of energy and energy transformation from the Grade 5* ***Conservation of Energy and Resources*** *topic in the* ***Understanding Earth and Space Systems*** *strand.*

CHEMICAL ENERGY —BURN→ ***THERMAL ENERGY*** —STEAM→ ***KINETIC ENERGY*** —TURBINE→ ***MECHANICAL ENERGY*** —GENERATOR→ ***ELECTRICAL ENERGY***

IMPLEMENTATION OPTIONS:

- Cut and laminate the energy words. Have the students post the words in the correct order on a chalkboard, white board, etc., for each type of generating station and describe what happens as the energy is transformed.
- In their OPG Student Guides, the students could write the energy words and draw arrows for the energy transformation in the appropriate locations on the diagrams on pages 4-7.
- Project the PDFs of each of the four cut-away diagrams on a SMART Board™ and have the students take turns writing the energy words and drawing arrows for the energy transformation on the diagrams.

BACKGROUND INFORMATION

Most hydroelectric stations use the natural drop of a river (such as a waterfall or rapids) or a dam built across a river to provide the change in height (**gravitational potential energy**) needed to produce **kinetic energy** (energy of movement). Water is collected in the **forebay**, then channelled via the station's intake into a pipe called a **penstock** that carries the water down to the **turbine** (see Lesson #4). As the water flows down the penstock, the water pressure increases. This pressure causes the turbine to spin, which in turn spins a **generator** (see Lesson #3).

Wind turbines work much like hydroelectric stations; instead of moving water, they use **wind energy** (energy of moving air) to create kinetic energy. Wind causes the turbine to spin, which is connected via gears to a generator.

Thermal generating stations convert the **chemical energy** (energy held in chemical bonds) in coal, oil or natural gas into kinetic energy. Thermal generating stations use steam to spin their turbines. To create the steam, water is heated in **boiler** tubes that surround a large industrial furnace that burns coal, oil or natural gas, depending on the type of generating station. The steam is transferred under pressure to the turbine, causing the turbine to spin and in turn spinning the generator. The steam from the turbine condenses back to a liquid, using cooling water from a lake, and is pumped back to the boiler where it is reheated to continue the process.

Instead of burning coal, oil or natural gas, Canada's CANDU® nuclear reactors use the **fission** of natural **uranium** (a radioactive metallic element) to convert **nuclear energy** (energy the holds the nucleus together in an atom) into kinetic energy. Unlike the other fuels, uranium is not burned. Uranium atoms release large amounts of heat through a process called fission (splitting of atoms). In a CANDU® reactor, the fission process heats up heavy water (water with hydrogen replaced by one of its isotopes called **deuterium**), which in turn heats up ordinary water in a boiler. The steam is piped over to the turbine hall, where it drives the huge turbine and generator that produce the electricity we use.

LESSON #3: WHAT IS A GENERATOR?

SUGGESTED TIMING:
2 x 40 minutes (Science, Language)

LESSON OVERVIEW:

At a generating station, a large generator converts kinetic energy from the turbine into electrical energy. Inside the generator, a huge magnet called a **rotor** spins inside coils of copper wire called a **stator**. This causes a flow of electrons (known as **electricity**) inside the copper wires. In this lesson, students will read about the discovery of this phenomenon by Michael Faraday as well as build and investigate simple generators made from magnets and copper wire.

KEY QUESTION:
How does a generator work?

CURRICULUM CONNECTIONS

BIG IDEA:
Other forms of energy can be transformed into electrical energy.

OVERALL AND SPECIFIC EXPECTATIONS:
See charts on pages 3 and 4

ASSESSMENT *for* LEARNING and *as* LEARNING

LEARNING GOALS:

- Understands the structure and function of a generator by building a simple generator

SUCCESS CRITERIA:

Knowledge and Understanding

- Understands how a generator transforms kinetic energy into electrical energy

Thinking and Investigation

- Follows established safety procedures for working with electricity
- Builds a series circuit which includes a generator

Communication

- Describes the role of each component in the circuit
- Uses appropriate science and technology vocabulary (i.e., *circuit, current, energy, magnet, transform, wire, etc.*) in oral and written communication
- Collects and communicates data and observations from investigation of their generator
- Demonstrates understanding of increasingly complex texts by summarizing and explaining important ideas during a class discussion

ASSESSMENT STRATEGIES:

- Data collected and results recorded during the group investigation could be collected as student work samples.
- Students could individually assess their participation in the small group investigation using the Group Self-Assessment (BLM 4.3).

MATERIALS

IMPLEMENTATION OPTION

If you are unable to purchase enough supplies for each group to make a generator, purchase enough to make one generator and allow each group to use it for their investigation.

MATERIALS AND RESOURCES:

- OPG Grade 6 Student Guides (pages 8-9) – 1/student (provided with kit)
- Strong bar magnets – 4/group
- Thin copper wire (coated, preferably 30 gauge) ~ 30 m/group
- Metal knitting needle or 15 cm piece of straight metal coat hanger wire – 1/group
- Cup hooks (or large nails) – 4/group
- Masking tape – 1 roll/group
- Scissors – 1 pair/group
- Cardboard strips – 8 short (5 cm x 14 cm) and 8 long (5 cm x 18 cm) – 1 set/group
- LED light bulb with wires attached – 1/group
- BLM 3.1 How to Build a Generator – 1/student (optional)

IMPLEMENTATION OPTION

Instead of using cardboard, you could nail together two long and two short strips of wood.

PREPARATION:

- Gather all of the required materials. Bar magnets, thin copper wire and LED light bulbs can be purchased from an educational supply house such as Boreal Northwest (www.boreal.com) or from The Source (www.thesource.ca). Alternately, bar magnets might be borrowed from a Grade 3 teacher or purchased from a toy store.

PRIOR LEARNING

Prior to this lesson, students will have:

- experience setting up series circuits
- experience working in cooperative small groups

LINKS TO LITERACY

Students could use a similar comic book format to create biographies of famous Canadian scientists.

MINDS-ON

INDIVIDUAL, WHOLE CLASS – LITERACY FOCUS

Students will begin by reading a comic about scientist and inventor Michael Faraday on pages 8 and 9 of the OPG Student Guide. In this comic, students will learn that Faraday is credited as the first person to create an electric current by passing a magnet in and out of a wire coil.

After reading, questions for discussion can include:

- *What is the main idea of this comic?*
- *Do you agree with Faraday that in science "the process is as important as the product"?*
- *Whose picture would you put up for inspiration?*

LINKS TO LITERACY

Students could present a dramatic retelling of the story of Michael Faraday's life to the class.

ACTION

SMALL GROUP

Explain to the students that they will be creating generators based on the principles discovered by Michael Faraday. Students will follow the written directions and images on BLM 3.1 to make a simple generator out of the materials provided.

Each group of students will test their generator by placing the generator in a series circuit with a LED light bulb to determine if their generator produces electricity. *Note: the light from an LED light bulb is very faint, so generators are best tested in a darkened area.*

DIFFERENTIATED INSTRUCTION - **READINESS**

If necessary, review the parts of a circuit and the requirements for a series circuit.

DIFFERENTIATED INSTRUCTION -
PREFERENCES

If groups wish, they could come up with a question of their own to investigate, rather than choosing one of the pre-determined questions.

Alternately, make the generator yourself (without the light bulb) and have the students put the generator into a series circuit with a light bulb and proceed to the next step.

Each group of students will also choose one of the questions below to investigate.

- ***Is there a relationship between the number of coils of wire and the brightness of the light bulb?***
- ***Is there a relationship between the number of coils of wire and the speed at which you have to spin the magnets?***
- ***How fast must the magnets be spun if using two magnets instead of four?***
- ***How fast must the magnets be spun if using two light bulbs instead of one?***

The students should collect data and record observations that will help them to answer their question.

TROUBLESHOOTING:

If students are unable to get their light bulbs to light up, check the suggestions below:

- *Were the ends of the wires cleaned off?* Bare copper wire needs to be connected to the leads of the light bulb. Plastic or other coatings on the wire can be scraped off with the side of a pair of scissors.
- *Are the wires securely connected?* The copper wires may not be firmly secured to the leads of the light bulb.
- *Are the magnets being turned fast enough?* Speed is important here. The fewer the coils of wires, the faster the magnets need to be spun.
- *Are there enough turns of the wire?* If there is insufficient wire, a current will not be generated.
- *Are the magnets strong enough?* If the magnets are weak or have been demagnetized, there will not be enough of a magnetic field to induce a current in the wires.

MISCONCEPTION ALERT

*The **electrical energy** that is referred to in these lessons is **electric potential energy.** In the case of a generator, this energy forces electrons to flow through the copper wire.*

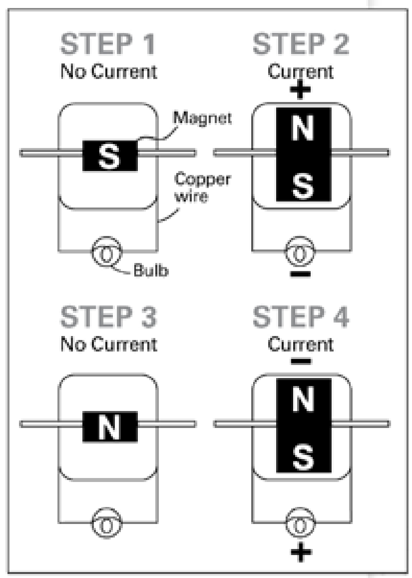
CONSOLIDATION AND CONNECTION

SMALL GROUP, WHOLE CLASS

Students will show and share the results of their investigations with the other groups. Using the diagram at the bottom of page 9 of the OPG Student Guide, have the students compare the workings of their miniature generators to the interior of a large-scale generator.

Questions for discussion can include:

- ***How easy was it to turn the magnets by hand?***
- ***What could make this task easier?***
- ***What turns the magnets in the large generators at a generating station?***



EXTENSIONS:

An alternative to having students build the generators on BLM 3.1 would be to have students create their own designs or research designs on the Internet and replicate one of the designs they find.

BACKGROUND INFORMATION

Electricity produced by magnetism is called **induced voltage**. It is by **induction** - the passage of a magnetic field across a **conductor** (e.g., copper wire) - that a voltage will be induced in that conductor. The magnitude of the induced voltage depends on two factors: the number of turns of the wire and how fast the magnetic lines of force, or **flux**, pass across the wire.

LESSON #4: GENERATE YOUR OWN ELECTRICITY

SUGGESTED TIMING:
2 X 40 minutes (Science, Language)

LESSON OVERVIEW:

A key component of electricity generation at a generating station is the **turbine**. This device causes the rotor to spin. Turbines at generating stations are spun using moving fluids such as steam, water or air. In this lesson, students will use technological problem-solving skills to create a simple turbine that will be connected to a generator – a commercial toy DC motor - in order to build a miniature GENERATING STATION.

KEY QUESTION:
How can we generate enough electricity to power a light bulb using moving air?

CURRICULUM CONNECTIONS

BIG IDEA:
Other forms of energy can be transformed into electrical energy.

OVERALL AND SPECIFIC EXPECTATIONS:

See chart on pages 3 and 4

ASSESSMENT *for* LEARNING and *as* LEARNING

LEARNING GOALS:

- Understands how turbines and generators are used to convert kinetic energy into electrical energy
- Plans, builds and tests a device that transforms energy from moving air into kinetic energy and then into electrical energy

SUCCESS CRITERIA:

Knowledge and Understanding

- Understands that a turbine makes the task of turning the magnets in a generator easier and more efficient than turning the magnets by hand

Thinking and Investigation

- Follows established safety procedures for working with electricity
- Selects and uses appropriate tools, materials and techniques
- Develops and implements a plan for the construction and testing of the GENERATING STATION

Communication

- Draws a labelled circuit diagram identifying and explaining the components used in the GENERATING STATION
- Uses appropriate science and technology vocabulary (i.e., *circuit, electrical energy, generator, kinetic energy, magnet, transform, turbine, wire, etc.*) in oral and written communication

ASSESSMENT STRATEGIES:

- Students can monitor their progress using the Generating Station Checklist (BLM 4.1).
- The Generating Station Rubric (BLM 4.2) could be used for Assessment of Learning.
- Students can assess their participation in the group using the Group Self-Assessment (BLM 4.3).

MATERIALS

MATERIALS AND RESOURCES:

- OPG Grade 6 Student Guides (pages 4-7) – 1/student (provided with kit)
- Windmill Generator (Green Science series) from KidzLabs® (~$15) <u>or</u>
  - ◊ small toy DC motor (~$6) – 1
  - ◊ miniature incandescent bulb (1.5 V, 25 mA) with wires attached (~$8) – 1
  - ◊ copper wire (for creating a circuit) – 30 cm
- Plastic spoons, craft sticks, cardstock, etc.
- Narrow drinking straws – 1/group
- Scissors – 1 pair/group
- Tape (masking, duct, electrical)
- Electric fan - 1
- BLM 4.1 Generating Station Checklist – 1/student (optional)
- BLM 4.2 Generating Station Rubric – 1/student (optional)
- BLM 4.3 Generating Station Self-Assessment – 1/student (optional)

> ***IMPLEMENTATION OPTION***
>
> *Instead of, or in addition to, making wind turbines, students could make water wheels. As water wheels need to spin very quickly in order to generate electricity, water wheels are best tested with water from an outdoor hose.*

PREPARATION:

- The Windmill Generator (Green Science series) from KidzLabs® can be found at many toy stores. For alternate sources of materials, see the Logistics section on page 4 of this Teacher Guide.

> ***FYI***
>
> *A DC motor can also act as a generator. Normally, people use motors to transform electrical energy (e.g., from a dry cell) into kinetic energy. The opposite is also possible. People can use motors to transform kinetic energy (e.g., from a turbine) into electrical energy.*

PRIOR LEARNING

Prior to this lesson, students will have:

- technological problem-solving skills
- experience using the Internet for research
- experience setting up series circuits
- experience working in cooperative small groups

> *DIFFERENTIATED INSTRUCTION - **READINESS***
>
> *It would be beneficial if this particular lesson followed the teaching of the **Flight** topic of the **Understanding Structures and Mechanisms** strand as knowledge of wings and propellers can be applied to the design of the turbine.*

MINDS-ON

SMALL GROUP

Divide the class into small groups. Explain to the students that they will be designing and building a turbine to connect to a generator (from the windmill generator kit or a commercial toy DC motor). The challenge will be to create enough current to keep the light from a small light bulb on steadily and as brightly as possible. *Note: if using the windmill generator kit, a narrow drinking straw can be used as an adaptor to enable students to attach their turbine to a shaft connected to the motor.*

Distribute a copy of BLM 4.1, 4.2 and 4.3 to each student (optional). Have the students use technological problem-solving skills to plan, build and test their GENERATING STATIONS.

Initiating and Planning

Stage 1: *Identify the problem to solve.* In this case, the students will be finding a way to create a turbine to attach to a generator (the GENERATING STATION).

Stage 2: *Brainstorm ideas.* Students will brainstorm a number of solutions to the problem, ideally four or more, and determine which are realistic in the classroom.

Stage 3: *Choose a solution.* Students should consider the strengths and weaknesses of their initial ideas and then choose a design for further development.

Stage 4: *Make a plan.* Students will outline the steps of a plan, including labelled drawings, to solve the problem. These drawings should include measurements and labelling of materials, fasteners, etc. They should also identify any required tools.

Stage 5: *Establish criteria for evaluating the device.* This should include the device's ability to keep the light on steadily and brightly, but could also include aesthetic and environmental considerations.

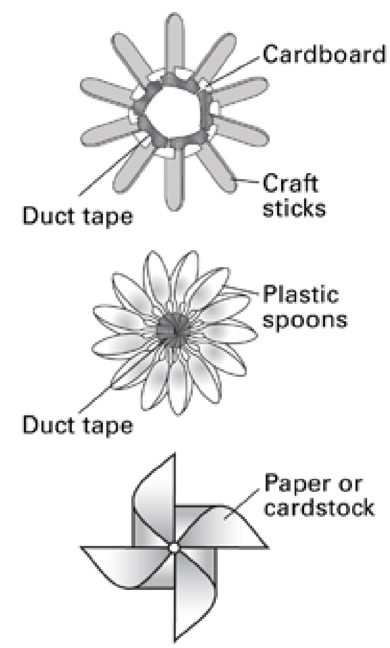
ACTION

SMALL GROUP

Performing and Recording

Stage 6: *Build, test and evaluate the device.* Students will construct their turbines based on their plans and working drawings and adjust the plans as necessary. Students will then attach the turbines to the generators and test their GENERATING STATIONS, with moving air from an electric fan, and reflect on the suitability of their designs. If the GENERATING STATIONS do not meet the criteria, the students will make changes to the original designs and retest as necessary. Modifications should be recorded.

Stage 7: *Record results.* Students will record their results using labelled circuit diagrams that identify and explain the components used in the GENERATING STATIONS.



IDEAS FOR STUDENT TURBINES

CONSOLIDATION AND CONNECTION

WHOLE CLASS

Analyzing and Interpreting

Stage 8: *Explain how the solution solved the problem.* Students will explain how they solved the problem using the pre-determined criteria.

Stage 9: *Suggest changes.* Students will identify and explain what changes could be made to their plans and how to improve their solutions as well as give reasons for the changes.

If you wish, you can use BLM 4.2 - Generating Station Rubric for assessing the GENERATING STATIONS and students could use BLM 4.3 - Group Self-Assessment to assess their contribution as a group member.

BACKGROUND INFORMATION

Turbines used in **wind farms** for commercial production of electricity are usually three-bladed and pointed into the wind by computer-controlled motors. The tubular steel towers range from 60 to 90 metres tall. Like the kit wind generator, commercial wind turbines often use a **gear box** to step up the speed of the generator. OPG runs two wind turbines, one in Tiverton and one in Pickering.

FYI

The word "turbine" was introduced by the French engineer Claude Bourdin in the early 19th century and is derived from the Latin word for "whirling" or a "vortex."

LESSON #5: ELECTRICITY GENERATION AND THE ENVIRONMENT

SUGGESTED TIMING:
2 x 40 minutes (Science, Language) plus time outside of class for students to research and complete the consequence map assignment.

LESSON OVERVIEW:

Ontario is fortunate to have many methods of generating electricity to make up our "energy mix," but as the environmental impact of energy consumption becomes more important, Ontarians will have to decide on the way forward for electricity generation. In this lesson, students will explore, analyze and evaluate the environmental impact of different types of electricity generation over time using a consequence map instructional strategy.

KEY QUESTION:
What are the potential environmental impacts of different types of electricity production in Ontario over the next 50 years?

CURRICULUM CONNECTIONS

BIG IDEA:
Electrical energy plays a significant role in society, and its production has an impact on the environment.

OVERALL AND SPECIFIC EXPECTATIONS:
See charts on pages 3 and 4

FYI

Ontario has been using water to make electricity for over a century. In fact, some of Ontario's hydroelectric generating stations are over 100 years old and still generating electricity for us today.

ASSESSMENT *for* LEARNING and *as* LEARNING

LEARNING GOALS:

- Identifies and assesses the short- and long-term environmental effects of the different ways in which electricity is generated in Ontario

SUCCESS CRITERIA:

Knowledge and Understanding

- Understands that each method of electricity generation has different impacts on the environment

Thinking and Investigation

- Locates information relevant to research questions
- Draws conclusions based on research findings and justifies conclusions

Communication

- Uses appropriate science and technology vocabulary (i.e., *consumption, environment, habitat, impact, production, waste, etc.*) in oral and written communication
- Uses a variety of forms (e.g., oral, written and graphic – consequence map) to communicate for a variety of purposes

Application

- Makes connections between science, technology, society and the environment

ASSESSMENT STRATEGIES:

- Students could assess their participation in the creation of the consequence map using the Group Self-Assessment (BLM 4.3).
- The Consequence Map Rubric (BLM 5.1) could be used to assess students' consequence maps.

MATERIALS

MATERIALS AND RESOURCES:

- OPG Grade 6 Student Guides (pages 4-7, 10-11) – 1/student (provided with kit)
- BLM 5.1 Consequence Map Rubric – 1/student (optional)
- BLM 4.3 Group Self-Assessment – 1/student (optional)
- Chart paper
- www.opg.com/greenlight/
- www.powerauthority.on.ca/electron/

PREPARATION:

- Access to the Internet is recommended for this lesson. You may choose to have students use the Internet during class time, during computer lab time or outside of class time.
- Have a blackboard or chart paper available to draw consequence maps. Optionally, a computer and LCD projector or SMART Board™ could be used.

PRIOR LEARNING

Prior to this lesson, students will have:

- experience locating information using Internet sources
- experience working in cooperative small groups

DIFFERENTIATED INSTRUCTION - ***READINESS***

Have the students watch the video at www.opg.com/greenlight/future.asp to introduce the issues related to the future of electricity generation in Ontario (English only).

MINDS-ON

INDIVIDUAL, SMALL GROUP, WHOLE CLASS

The students will begin by examining pages 10-11 of the OPG Student Guide. Have the students identify and list all of the items pictured. Examine the list.

- ***How many of those items would have been used by the students' parents when they were in Grade 6?***

Next, have the students examine pages 10-11 of the OPG Student Guide to see how Ontario's electricity needs have changed over the past 100 years.

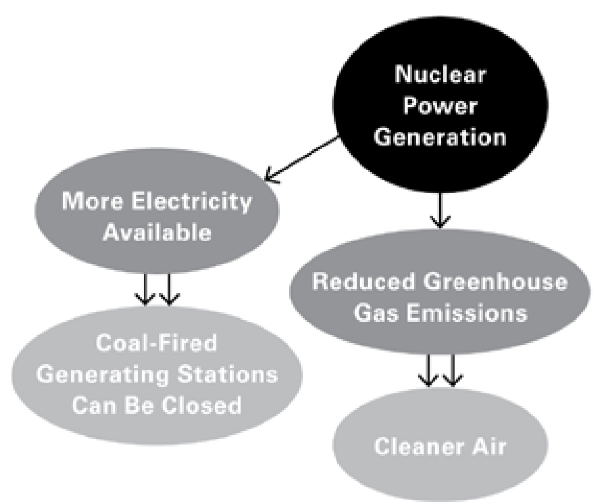
- ***Given the increases in demand for electricity and the concerns about the environmental impact of generating electricity, how will future demand be met?***

Introduce the concept of a consequence map as a focused type of brainstorming. Pose the key question, "What environmental impact will different types of electricity generation have in Ontario over the next 50 years?"

ACTION

WHOLE CLASS

Do a sample consequence map with the students to demonstrate the strategy. Begin with the key question, "What impact has the introduction of nuclear power generation had on Ontario over the past 50 years?"



SMALL GROUP

Divide the class into small groups. Assign each group a method of electricity generation for which they must think of primary and secondary environmental consequences of its operation (including potential impact of accidents). Distribute a copy of BLM 5.1 to each student.

Students will create consequence maps of the short- and long-term environmental effects of electricity generation (operating impact and potential impact of accidents only). Each small group will focus on one method of electricity generation – consequence maps could be done on paper or digitally.

As well as using pages 4-7 and 10-11 of the OPG Student Guide, students are encouraged to use secondary sources such as the Greenlight section of the OPG website (www.opg.com/greenlight/).

CONSEQUENCE MAPS

A consequence map is a strategy in which students think about the long-term impact of an event, trend or new technology and present that information visually. A consequence map begins with a question (e.g., "What impact has the introduction of nuclear power generation had on Ontario over the past 50 years?"). Write a phrase based on the question in a central oval, then brainstorm what the direct (primary) consequences of that event were and write them in ovals around the central oval.

Make sure that students list consequences, such as "public concerns about nuclear safety" or "reduced greenhouse gas emissions," rather than just saying "safety" or "greenhouse gases," which are simply factors. Once a number of primary consequences have been written, choose one to develop further by considering the secondary consequences that result from that primary consequence.

CONSOLIDATION AND CONNECTION

SMALL GROUP, WHOLE CLASS

Groups will take turns presenting the primary and secondary consequences of the method of electricity generation that they researched, along with their analysis of the environmental impact of that method of electricity generation.

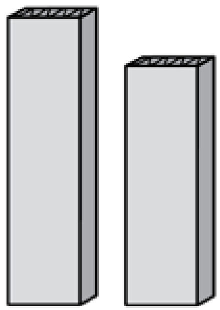
After all of the presentations have been completed, make a consolidated consequence map poster with all of the groups' analyses on it (place "What Are the Environmental Consequences of Electricity Generation in Ontario?" in the centre, with each type of electricity generation coming from that and the primary and secondary consequences coming from those). As a class, analyze the environmental consequences of the different types of electricity generation and discuss what would be an ideal energy mix for Ontario in the future. What other factors should be taken into account (e.g., cost, reliability, safety, etc.) when deciding what Ontario's energy mix should be?

BACKGROUND INFORMATION

All methods of generating electricity have an impact on the environment. Hydroelectric plants, for instance produce almost no **greenhouse gases** (e.g., carbon dioxide) but construction may have required flooding of land and disruption of animal and human habitats. Nuclear plants produce almost no greenhouse gases, but the question of disposal of **spent nuclear fuel** (uranium involved in fission) has yet to be resolved. Thermal plants, particularly coal-fired ones, produce significant greenhouse gas emissions. Wind turbines produce almost no greenhouse gases, but they require large amounts of land and significantly impact bird migration routes. Also, since wind turbines have a poor **operating efficiency** (percentage of time in which they run), large numbers of them are needed to produce meaningful amounts of electricity. For example, wind turbines can only generate electricity when the wind is the right speed, which in Ontario is only about 20 percent of the time. To accurately assess the environmental impact of different types of electricity generation, their **life-cycle impact** should be examined, from the construction of the plant through its operation (including the extraction, production and transportation of fuel) and eventual dismantling and disposal of the plant itself.

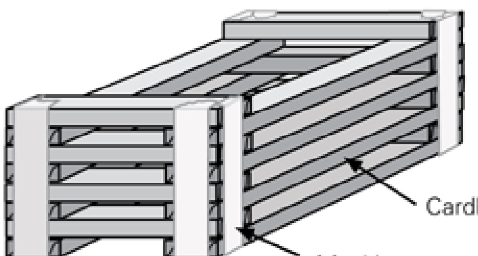
BLM 3.1 – BUILD A GENERATOR

1.

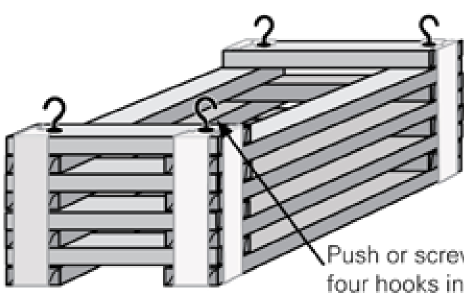


Measure and cut 8 short pieces of cardboard (5 cm x 14 cm) and 8 long pieces of cardboard (5 cm x 18 cm).

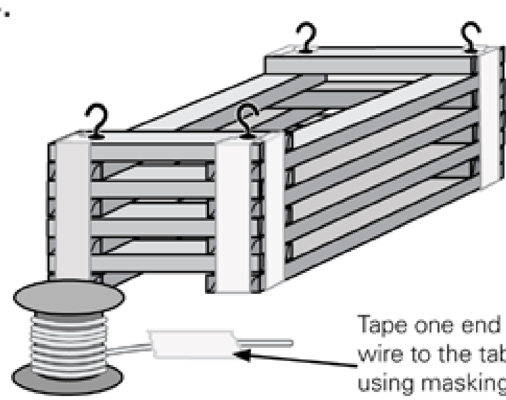
2. Stack pairs of cardboard, alternating short and long pieces. Leave a hole 4 cm X 8 cm in the centre. Tape together using the masking tape.



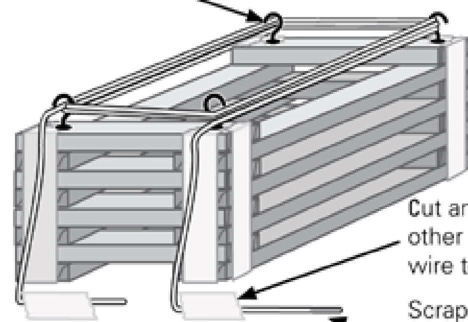
3.



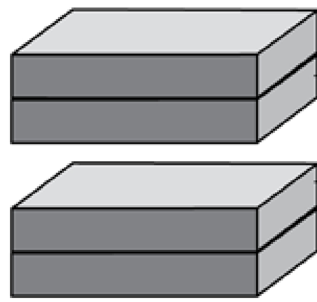
4.



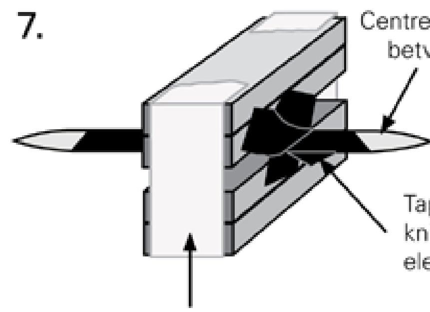
5.



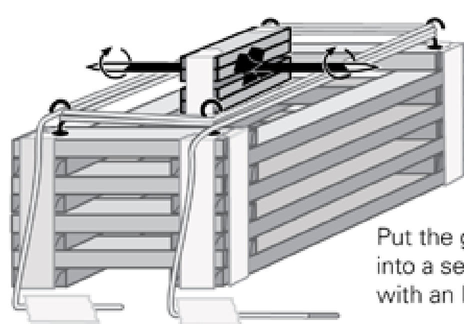
6.



7.



8.



Spin the knitting needle really fast and find out if you are generating electricity.

BLM 4.1 GENERATING STATION CHECKLIST Name: ____________________

		COMPLETE
1.	Have we completed our research?	
2.	Is our research well-organized and well-documented?	
3.	Have we brainstormed and recorded at least four different ideas?	
4.	Have we thought about what the turbine must do and evaluated each possible solution?	
5.	Have we chosen the best solution and described why we chose it?	
6.	Have we made precise and labelled scale drawings of the generating station?	
7.	Have we followed our plan for the construction of the generating station?	
8.	Have we tested our generating station and recorded our observations?	
9.	If our generating station failed the test, have we recorded our recommended modifications?	
10.	Have we gone back to our generating station based on our recommended modifications and retested our generating station if it was necessary?	
11.	Are we prepared to present our generating station to the class?	
12.	Have we prepared a labelled circuit diagram identifying and explaining the components used in our generating station?	
13.	Is our work complete, neat and precise?	

BLM 4.3 GROUP SELF-ASSESSMENT Name: ____________________

LEARNING SKILLS AND WORK HABITS: COLLABORATION	NOT VERY WELL	SOME-WHAT	VERY WELL
How well did I do my share of the work? **Comment:**			
How well did I respond to the ideas and opinions of others? **Comment:**			
How well did I make sure that my group worked effectively together? **Comment:**			
How well did I make sure that my group met our group goals? **Comment:**			
How well did I share information, resources and expertise with my group? **Comment:**			
How well did I work with my group members to solve problems and make decisions? **Comment:**			
What can I do to improve?			

BLM 4.2 GENERATING STATION RUBRIC

NAME: ______________________________ DATE: ____________

	LEVEL 1 THE STUDENT:	LEVEL 2 THE STUDENT:	LEVEL 3 THE STUDENT:	LEVEL 4 THE STUDENT:
Knowledge and Understanding				
Understanding of electricity generation	Demonstrates limited understanding of how turbines and generators are used to convert kinetic energy into electrical energy	Demonstrates some understanding of how turbines and generators are used to convert kinetic energy into electrical energy	Demonstrates considerable understanding of how turbines and generators are used to convert kinetic energy into electrical energy	Demonstrates thorough understanding of how turbines and generators are used to convert kinetic energy into electrical energy
Thinking and Investigation				
Brainstorming and planning	Brainstorms ideas, chooses a solution and makes a plan with limited effectiveness	Brainstorms ideas, chooses a solution and makes a plan with some effectiveness	Brainstorms ideas, chooses a solution and makes a plan with considerable effectiveness	Brainstorms ideas, chooses a solution and makes a plan with a high degree of effectiveness
Construction, testing, observation and evaluation	Constructs, tests, observes and evaluates the generating station with limited effectiveness	Constructs, tests, observes and evaluates the generating station with some effectiveness	Constructs, tests, observes and evaluates the generating station with considerable effectiveness	Constructs, tests, observes and evaluates the generating station with a high degree of effectiveness
Safety	Follows safety procedures with limited effectiveness	Follows safety procedures with some effectiveness	Follows safety procedures with considerable effectiveness	Follows safety procedures with a high degree of effectiveness
Communication				
Diagrams	Expresses ideas through diagrams with limited effectiveness	Expresses ideas through diagrams with some effectiveness	Expresses ideas through diagrams with considerable effectiveness	Expresses ideas through diagrams with a high degree of effectiveness
Use of electricity vocabulary	Uses vocabulary with limited effectiveness	Uses vocabulary with some effectiveness	Uses vocabulary with considerable effectiveness	Uses vocabulary with a high degree of effectiveness

BLM 5.1 CONSEQUENCE MAP RUBRIC

NAME: ______________________________ DATE: ______________

	LEVEL 1 THE STUDENT:	LEVEL 2 THE STUDENT:	LEVEL 3 THE STUDENT:	LEVEL 4 THE STUDENT:
Knowledge and Understanding				
Understands ways in which the environment can be impacted by electricity generation	Demonstrates limited understanding of ways in which the environment can be impacted by electricity generation	Demonstrates some understanding of ways in which the environment can be impacted by electricity generation	Demonstrates considerable understanding of ways in which the environment can be impacted by electricity generation	Demonstrates thorough and insightful understanding of ways in which the environment can be impacted by electricity generation
Thinking and Investigation				
Gathers evidence	Gathers evidence about environmental impact with limited effectiveness	Gathers evidence about environmental impact with some effectiveness	Gathers evidence about environmental impact with considerable effectiveness	Gathers evidence about environmental impact with a high degree of effectiveness
Communication				
Organizes and expresses information	Organizes and expresses primary and secondary consequences with limited effectiveness	Organizes and expresses primary and secondary consequences with some effectiveness	Organizes and expresses primary and secondary consequences with considerable effectiveness	Organizes and expresses primary and secondary consequences with a high degree of effectiveness
Uses appropriate vocabulary and terminology	Uses language related to electricity generation and the environment with limited effectiveness	Uses language related to electricity generation and the environment with some effectiveness	Uses language related to electricity generation and the environment with considerable effectiveness	Uses language related to electricity generation and the environment with a high degree of effectiveness
Application				
Makes connections between science, technology and society	Assesses environmental impact of electricity generation in Ontario with limited effectiveness	Assesses environmental impact of electricity generation in Ontario with some effectiveness	Assesses environmental impact of electricity generation in Ontario with considerable effectiveness	Assesses environmental impact of electricity generation in Ontario with a high degree of effectiveness

ACKNOWLEDGEMENTS:

OPG is grateful to the Grade 6 teachers who contributed their time and expertise to the development of this resource.

Ce guide est également disponible en français (format PDF) sur le site Web d'Ontario Power Generation.

For more information, please visit:

www.opg.com/learningzone

Developed by Let's Talk Science