HOW IT WORKS
ELECTRICITY GENERATION

GRADE 9 TEACHER'S GUIDE

ONTARIO POWER GENERATION

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ELECTRICITY GENERATION

TEACHER'S RESOURCE KIT – GRADE 9

This **Teacher's Guide**, which accompanies the **HOW IT WORKS: ELECTRICITY GENERATION Teacher's Resource Kit – Grade 9**, is intended for teachers in Ontario teaching **Science, Grade 9 Academic (SNC1D)** and **Science, Grade 9 Applied (SNC1P)** and aligns to the curriculum expectations in *The Ontario Curriculum Grades 9 and 10 Science (2008)*.

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 one of the largest power generators in North America, with a total capacity of over 21 000 megawatts (MW). Each year OPG's 65 hydroelectric stations, 3 nuclear stations, 5 thermal stations, 2 co-owned gas-fired stations and 2 wind power turbines produce 70% of Ontario's electricity needs.

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 Teacher's Resource Kit. For more information, please visit www.opg.com/learningzone.

RESOURCE OVERVIEW

THE HOW IT WORKS: ELECTRICITY GENERATION Teacher's Guide contains five lessons for teachers of Grade 9 students in Ontario that examine electricity supply and demand on both the macro and micro levels.

At the macro level, students will learn about the different sources of electricity which help to supply Ontario's homes and businesses and also explore the demand side of the equation by looking at the concepts of baseload and peak demand. At the micro level, electrical supply and demand are investigated using hands-on/minds-on strategies as students construct a variety of series and parallel circuits and examine how changes in supply and demand affect the behaviour of electrical devices in those circuits. Students will also have the opportunity to think about their future occupations through an exploration of some of the careers at OPG.

LESSONS AT A GLANCE

LESSON	NAME	FOCUS	OVERVIEW	SUGGESTED TIMING	
				minutes	classes
1	Electricity Generation In Ontario	STSE	Students will research the various sources of energy used to generate electricity in Ontario and complete a cost-benefit analysis of these sources.	60 min.	2
2	Understanding Electrical Supply	Investigation	Students will solve problems related to power as well as explore how changing the energy source in series and parallel circuits affects the power, potential difference and current in those circuits given a fixed load.	75 min.	1
3	Baseload vs. Peak Demand	STSE	Students will gather data on their classroom's and home's electricity consumption to find patterns, then devise an action plan to flatten their family's electrical consumption curve and minimize their impact on peak demand.	60-70 min.	2
4	Understanding Electrical Demand	Investigation	Students will challenge each other to find out whether it is possible for demand to exceed supply in a circuit and relate this to the real world.	75 min.	1
5	Careers in Electricity Generation	Careers	Students will explore OPG's mypowercareer.com web site to read about the many different types of careers in electricity generation, then each create a job posting based on one of the careers.	60 min.	2
			Total Suggested Time	330-340 min.	8 classes

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

Teaching and Learning

- The lessons in this resource address all of the overall expectations in Strand A: Scientific Investigation Skills and Career Exploration and Strand E: Physics for both SNC1D and SNC1P. The lessons do not, however, address specific curriculum expectations related to static electricity or conductivity.
- The lessons in this resource provide opportunities for students to work in cooperative small groups. Teachers should be familiar with a variety of cooperative small group learning strategies.
- In order to address the learning needs of all students, Differentiated Instruction suggestions are provided in the lessons. Additional Differentiated Instruction resources can be found on the EDU GAINS web site (edugains.ca).
- Assessment strategies and tools are provided with the lessons. Teachers may choose to use the tools provided or the assessment tools of their choice.

Student Prior Learning

- The lessons in this resource are not designed as an introduction to electricity, but rather are designed to provide students with opportunities to extend and apply their knowledge of electricity to new situations.
- Students are required to have inquiry skills for research and experimentation as well as experience in several different modes of communication (e.g., oral presentations, written reports, diagrams, persuasive writing, etc.).
- Students are required to have background knowledge about series and parallel circuits, including how to draw schematic diagrams and construct circuits using bulbs, wires and primary cells.
- Students should be familiar with the safe and proper operation of electrical equipment, including primary cells (1.5 V), ammeters and voltmeters (or multimeters), for Lessons 2 and 4.
- Students should have some prior experience working in cooperative small groups.
- Students should have some prior experience using the internet for research.

Logistics

- Students will need time outside of class to do research and complete group and individual assignments for Lessons 1, 3 and 5. Time outside of class may also be required for Lesson 2.
- Students will need access to primary cells (1.5 V only), alligator leads, miniature 1.2 V light bulbs ideally with sockets, switches, ammeters and voltmeters (or multimeters) for Lessons 2 and 4.
- Access to the internet is required for Lessons 1 and 5. You may choose to have students use the internet during class time, or students could do their internet research outside of class time.
- It would be beneficial to acquire a Kill-A-Watt Power Monitor for Lesson 3. The Kill-A-Watt Power Monitor, which measures electricity consumed by individual electrical devices, is available from the GreenGadgets.ca web site or scientific supply stores. Many public libraries also have Kill-A-Watt Power Monitors available for borrowing.
- For Lesson 5, it would be useful to have an LCD projector or SMART Board™.
- These lessons are not appropriate for leaving with a supply teacher, as they require teachers to observe students and provide feedback.

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Curriculum Alignment: Science, Grade 9 Academic SNC1D

The following are expectations from *The Ontario Curriculum Grades 9 and 10 Science (2008)*.

		Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
A1	demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analyzing and interpreting, and communicating)	•	•	•	•	•
A1.1	formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research		•		•	
A1.2	select appropriate instruments and materials for particular inquiries		•		•	
A1.3	identify and locate print, electronic, and human sources that are relevant to research questions	•				•
A1.4	apply knowledge and understanding of safe practices and procedures when planning investigations with the aid of appropriate support materials		•		•	
A1.5	conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data		•		•	
A1.6	gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams		•	•	•	
A1.7	select, organize, and record relevant information on research topics from various sources, including electronic, print, and/or human sources using recommended formats and an accepted form of academic documentation	•		•		•
A1.8	analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty	•	•		•	
A1.10	draw conclusions based on inquiry results and research findings, and justify their conclusions	•	•	•	•	
A1.11	communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats	•	•	•	•	
A1.12	use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement		•	•	•	
A1.13	express the results of any calculations involving data accurately and precisely		•	•	•	
A2	identify and describe a variety of careers related to the fields of science under study, and identify scientists, including Canadians, who have made contributions to those fields					•
A2.1	identify and describe a variety of careers related to the fields of science under study and the education and training necessary for these careers					•
E1	assess some of the costs and benefits associated with the production of electrical energy from renewable and non-renewable sources, and analyse how electrical efficiencies and savings can be achieved, through both the design of technological devices and practices in the home	•		•		
E1.2	assess some of the social, economic, and environmental implications of the production of electrical energy in Canada from renewable and non-renewable sources (e.g., wind, solar, hydro, coal, oil, natural gas, nuclear)	•				
E1.3	produce a plan of action to reduce electrical energy consumption at home and outline the roles and responsibilities of various groups in this endeavour			•		
E2	investigate, through inquiry, various aspects of electricity, including the properties of static and current electricity, and the quantitative relationships between potential difference, current, and resistance in electrical circuits		•		•	
E2.1	use appropriate terminology related to electricity, including, but not limited to: ammeter, amperes, battery, current, fuse, kilowatt hours, load, ohms, potential difference, resistance, switch, voltmeter, and volts	•	•	•	•	
E2.5	design, draw circuit diagrams of, and construct series and parallel circuits, and measure electric current I, potential difference V, and resistance R at various points in the circuits, using appropriate instruments and SI units		•		•	
E2.6	analyse and interpret the effects of adding an identical load in series and in parallel in a simple circuit		•			
E2.7	investigate the quantitative relationships between current, potential difference, and resistance in a simple series circuit		•		•	
E3	demonstrate an understanding of the principles of static and current electricity		•		•	
E3.5	explain the characteristics of electric current, potential difference, and resistance in simple series and parallel circuits, noting how the quantities differ in the two circuits		•		•	
E3.6	describe, qualitatively, the interrelationships between resistance, potential difference, and electric current		•		•	

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Curriculum Alignment: Science, Grade 9 Applied SNC1P

The following are expectations from *The Ontario Curriculum Grades 9 and 10 Science (2008)*.

		Lesson				
		1	2	3	4	5
A1	demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating)	•	•	•	•	•
A1.1	formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research		•		•	
A1.2	select appropriate instruments and materials for particular inquiries		•		•	
A1.3	identify and locate print, electronic, and human sources that are relevant to research questions	•				•
A1.4	apply knowledge and understanding of safe practices and procedures when planning investigations with the aid of appropriate support materials		•		•	
A1.5	conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data		•		•	
A1.6	gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams		•	•	•	
A1.7	select, organize, and record relevant information on research topics from various sources, including electronic, print, and/or human sources using recommended formats and an accepted form of academic documentation	•		•		•
A1.8	analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty	•	•		•	
A1.10	draw conclusions based on inquiry results and research findings, and justify their conclusions	•	•	•	•	
A1.11	communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats	•	•	•	•	
A1.12	use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement		•	•	•	
A1.13	express the results of any calculations involving data accurately and precisely		•	•	•	
A2	identify and describe a variety of careers related to the fields of science under study, and identify scientists, including Canadians, who have made contributions to those fields					•
A2.1	identify and describe a variety of careers related to the fields of science under study and the education and training necessary for these careers					•
E1	assess some of the costs and benefits associated with the production of electrical energy from renewable and non-renewable sources, and analyse how electrical efficiencies and savings can be achieved, through both the design of technological devices and practices in the home	•		•		
E1.1	assess social, economic, and environmental costs and benefits of using a renewable and a non-renewable source of electrical energy (e.g., solar, wind, hydro, nuclear, coal, oil, natural gas), taking the issue of sustainability into account	•				
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	investigate, through inquiry, the properties of static and current electricity and the cost of the consumption of electrical energy		•		•	
E2.1	use appropriate terminology related to static and current electricity, including, but not limited to: ammeter, ampere, battery, conductivity, current, energy consumption, fuse, kilowatt hours, load, ohm, potential difference, resistance, switch, voltmeter, and volts	•	•	•	•	
E2.4	design, draw circuit diagrams of, and construct simple series and parallel circuits		•		•	
E2.5	compare, on the basis of observation, the differences between series and parallel circuits		•		•	
E2.6	use an inquiry process to investigate the effects that changing resistance and changing potential difference have on current in a simple series circuit		•		•	
E3	demonstrate an understanding of the concepts and principles of static and current electricity		•		•	
E3.5	explain the characteristics of electric current, potential difference, and resistance, in simple series and parallel circuits		•		•	
E3.6	describe, qualitatively, the interrelationships between resistance, potential difference, and electric current, in a series circuit		•		•	

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LESSON 1: ELECTRICITY GENERATION IN ONTARIO

LESSON OVERVIEW

Ontario gets its electricity from a mix of energy sources - some renewable (e.g., wind, solar, hydro) and some non-renewable (e.g., coal, oil, natural gas and nuclear). However, there are concerns about some of the energy sources used to generate electricity. Concerns can be social (e.g., having power stations or transmission lines nearby), economic (e.g., the cost of building new generating plants), environmental (e.g., carbon emissions from a coal-fired generating station) or, in some cases, all three. In this lesson, students will research the various sources of energy used to generate electricity in Ontario and complete a cost-benefit analysis of one of these sources.

KEY QUESTION:
Which source of energy used in electricity generation in Ontario would you choose to best address Ontario's electrical energy needs, taking into consideration costs and benefits to society, the economy and the environment?

SUGGESTED TIMING:
60 minutes (three 20 minute blocks) plus time outside of class for completing the group assignment

CURRICULUM CONNECTIONS

BIG IDEA:
A responsible and effective energy strategy for electricity generation involves diverse energy sources, each with its own unique set of social, economic and environmental implications.

EXPECTATIONS: (see charts on pages 3 and 4 for detailed descriptions)
- SNC1D: A1, A1.3, A1.7, A1.8, A1.10, A1.11, E1, E1.2, E2.1
- SNC1P: A1, A1.3, A1.7, A1.8, A1.10, A1.11, E1, E1.1, E2.1

LEARNING GOALS:
- Assess the social, economic, and environmental costs and benefits of renewable and non-renewable sources of energy used in electricity generation

ASSESSMENT AND EVALUATION

ASSESSMENT/SUCCESS CRITERIA:

Knowledge and Understanding
- Understands that each method of electricity generation has both costs and benefits

Thinking and Investigation
- Locates electronic sources relevant to research questions
- Draws conclusions based on research findings and justifies conclusions

Communication
- Information is well organized and calculations are done accurately

ASSESSMENT TOOLS:
- Energy Source Cost-Benefit Analysis Self-Assessment

FYI

Nameplate Capacities

Large coal-fired generating station = ~500 MW
(e.g., Nanticoke Generating Station, 3 964 MW for eight units)
Large natural gas-fired plant = ~500 MW
(e.g., Lennox Generating Station, 2120 MW for four units)
Medium nuclear reactor = ~500 MW
(e.g., Pickering B-5, 540 MW)
Large hydroelectric generating station = ~500 MW
(e.g., Sir Adam Beck I, 498 MW)
Wind turbine = ~2 MW
(e.g., Huron Wind, 1.8 MW)
Solar panels = ~95W
(e.g., First Light Solar Park, 200 000 panels used to generate 19 MW)

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MATERIALS AND RESOURCES

- **BLM 1-1:** Internet Resources – 1/student
- **BLM 1-2**: Energy Source Cost-Benefit Analysis Template – 1/group of 2-3 students
- **BLM 1-3:** Energy Source Cost-Benefit Analysis Self-Assessment– 1/student
- **HOW IT WORKS: ELECTRICITY GENERATION** Student Guides (pages 1, 5-13) – 1/student (provided with kit)
- Student notebooks

INTERNET RESOURCES:
- For more information about Ontario's energy needs, go to www.ieso.ca. For more information about how electricity generation works and various types of energy used in the generation of electricity, go to opg.com.

RESOURCES:
- **HOW IT WORKS: ELECTRICITY GENERATION** DVD (optional) (provided with kit)

PREPARATION:
1. Make copies of the BLM pages for each student (available in the **BLACK LINE MASTERS** section at the end of this Teacher's Guide).
2. Students will need access to computers for internet research. This could be during class time or outside of class time.

Differentiated Instruction - READINESS
This brainstorming exercise will help to assess student knowledge of energy sources.

PRIOR LEARNING

Prior to this lesson, students will have:
- Awareness of energy sources
- Experience locating information using internet sources
- Experience doing cost-benefit analyses
- Experience working in small cooperative groups

Differentiated Instruction - PREFERENCES
An alternative to assigning student groups would be to let students choose their groups and choose their topics.

MINDS-ON

DAY 1 - WHOLE CLASS

Brainstorm a list of energy sources used to generate electricity in Ontario. Students should record these energy sources in their science notebooks. This list should include renewable (hydro, wind) and non-renewable (nuclear, natural gas, coal) energy sources. Discuss where they have seen examples of each (e.g., hydro generating station on the Niagara River, nuclear generating station in Pickering or coal-fuelled generating station in Thunder Bay).

ACTION

WHOLE CLASS

Students will be completing a cost-benefit analysis of one energy source from a given point of view. Assign students in groups of 2 or 3 to each of the topics on the chart below.

ENERGY TYPE	SOCIAL	ECONOMIC	ENVIRONMENTAL
Coal	Group 1	Group 7	Group 13
Hydro	Group 2	Group 8	Group 14
Natural Gas	Group 3	Group 9	Group 15
Nuclear	Group 4	Group 10	Group 16
Wind	Group 5	Group 11	Group 17
Solar	Group 6	Group 12	Group 18

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Provide each group with a copy of **BLM 1-2**: Energy Source Cost-Benefit Analysis Template. To make the comparison of energy sources fair, each group will calculate the number of plants or units (e.g., wind turbines, nuclear power plants, dams, etc.) which would be required to produce 500 MW of power. Students will make this calculation using the ***nameplate capacity*** of each electricity generation technology from the FYI box. Provide the students with this data and explain that nameplate capacity is the maximum amount of energy that a given electricity generation technology can produce under optimal conditions.

For most groups this will be simple. For 500 MW you would need:

1 – Medium nuclear reactor

1 – Large coal-fired generating station

1 – Large natural gas-fired plant

1 – Large hydroelectric generating station

The groups who will analyze wind and solar technologies will have to do some calculating. For 500 MW you would need:

500 MW ÷ 2 MW/wind turbine = 250 wind turbines

500 MW ÷ 95W/solar panel = 5 263 158 solar panels

These values will need to be recorded on **BLM 1-2**: Energy Source Cost-Benefit Analysis Template.

For their cost-benefit analyses, the students will need to take into consideration the fact that no technology which produces electricity runs at its nameplate capacity 100% of the time. The percentage of time that a given technology produces its nameplate capacity is called its ***capacity factor***. For example, if an energy source produces electricity 50% of the time then its capacity factor is 50%. Discuss the following questions:

- Why do you think coal, hydro, nuclear and natural gas power plants only run at their nameplate capacity 90% of the time? **Power plants are sometimes shut down for routine maintenance, upgrades, etc.**

- Why do you think wind turbines have a 25% capacity factor? **Wind turbines can only run when the wind is at the right speed (cannot run if the wind is too strong or not strong enough, or not blowing), turbines can also be shut down for maintenance, upgrades, cleaning, etc.**

- Why do you think solar panels only have a 10-15% capacity factor? **Solar panels only run on sunny days and cannot run at night. They also need to be cleaned on a regular basis.**

As a class, review the process of completing a cost-benefit analysis (see the sidebar for how to use the chart).

Cost-Benefit Analysis

A cost-benefit analysis is a method of organizing information for the purpose of making a decision. People often use this method informally to make decisions about their own lives.

Students first think and list the positive aspects (benefits) as well as negative aspects (costs) of a given item, scenario, etc. This may require research.

Next, students sort and list the costs and benefits in the appropriate columns of the cost-benefit chart. If they are unsure if a given item, scenario, etc. is a cost or a benefit, it can go in the “Unsure” column.

After they have entered the costs and benefits, the students need to weight the strengths of each, from +5 for the greatest benefit to -5 for the greatest cost. These numbers will be entered into the chart beside the cost or benefit.

Finally, each column of weights is totalled, and the totals from the columns are entered into the equation at the bottom of the page. A descriptive conclusion is then written based on the evidence.

For other examples of cost-benefit lesson plans, visit lessonplanet.com and type “cost benefit analysis” into the search engine.

Determine criteria that could be used by each group's perspective to assess the benefits and costs.

Criteria could include:

- **Social Perspective**: location (living near a nuclear plant, having a wind turbine on your property), emissions, lights, noise, effects on recreation and aesthetics, etc.
- **Economic Perspective**: operating costs (cost of fuel, maintenance, staff, waste disposal, carbon tax), capital costs (cost to construct), life cycle, etc.
- **Environmental Perspective**: air quality, habitat impact, possibility of failure, management of waste, impact of failure, availability of raw materials, procurement of raw materials, transportation of raw materials, etc.

> **Differentiated Instruction - READINESS**
> If students have not previously done a cost-benefit analysis, they could do a practice one with a scenario such as, if you were given the opportunity to go on a summer exchange to Japan, would you go? For an exemplar cost-benefit analysis of this scenario, see the Lesson Plan "How Green is Canada's Electricity?" on the Canadian Nuclear Association (CNA) web site (see BLM 1-1 for the link).

Students should write the criteria specific to their perspective on their template in the appropriate column. Do not discuss whether the criteria are costs or benefits at this point. Students need to decide about each criterion themselves based on their research evidence. If students are unsure whether the criterion is a benefit or a cost, they may use the unsure column. For each criterion, students will need to describe the specific benefits or costs for their energy source. They will also need to provide justification for the weighting of each cost or benefit; this will be based on their research evidence. Provide students with **BLM 1-3**: Energy Source Cost-Benefit Analysis Self-Assessment and review the criteria. This is a self-assessment which provides criteria for the task.

SMALL GROUP

Students will research their energy source from their perspective either in the computer lab during class time or using the internet outside of class. There are sources of information for students on **BLM 1-1:** Internet Resources; they may also choose to locate other sources through web searches. Students should also be encouraged to use the **HOW IT WORKS: ELECTRICITY GENERATION** Student Guide (pages 1, 5-13) (provided with kit).

> **Differentiated Instruction - INTELLIGENCES**
> As part of their research, students could watch the **HOW IT WORKS: ELECTRICITY GENERATION** DVD provided with the kit or online at www.opg.com/learningzone.

Completion of cost-benefit analyses by small groups could take place <u>outside of class</u> between Day 1 and Day 2.

CONSOLIDATION AND CONNECTION

DAY 2 - WHOLE CLASS

Provide each of the groups with the opportunity to present the findings from their cost-benefit analyses to the class. Record the overall totals as a class on a chart such as the one in the ACTION section (e.g., use blackboard, whiteboard, overhead, computer). Discuss the data in the chart both horizontally and vertically. Questions for discussion can include:

- Is a cost-benefit analysis objective or subjective?
- Is there any definitive 'best' form of energy for electricity generation?
- If you were in a position of authority, how could you use this information?
- How does ***capacity factor*** affect your analysis?
- Where would your energy come from at night if you based an energy system on solar energy?
- Where would your energy come from on a calm day if you based an energy system on wind energy?
- Why would a responsible and effective energy strategy involve using different energy sources?

BACKGROUND INFORMATION:

For more information about Canada's energy needs, how electricity generation works and various types of energy used in the generation of electricity, see the web links on **BLM 1-1**: Internet Resources in the **BLACK LINE MASTERS** section at the end of this Teacher's Guide.

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LESSON 2: UNDERSTANDING ELECTRICAL SUPPLY

LESSON OVERVIEW

In Ontario, electrical energy is supplied by nuclear, hydroelectric, wind and thermal power plants. In everyday life, electrical energy is also supplied by primary cells (e.g., AAA, D, watch batteries, etc.) and secondary cells (e.g., car batteries, Li-H computer batteries, etc.). In this lesson, students will solve problems related to power as well as explore how changing the energy source in series and parallel circuits affects the power, potential difference and current in those circuits given a fixed load.

KEY QUESTION:
How does the energy supply (number of primary cells) affect the potential difference, current and power in a series circuit and a parallel circuit given a constant load?

SUGGESTED TIMING:
75 minutes (some time outside of class may be necessary)

CURRICULUM CONNECTIONS

BIG IDEA:
Current electricity has distinct properties that determine how it is used.

EXPECTATIONS: (see charts on pages 3 and 4 for detailed descriptions)

- SNC1D: A1, A1.1, A1.2, A1.4, A1.5, A1.6, A1.8, A1.10, A1.11, A1.12, A1.13, E2, E2.1, E2.5, E2.6, E2.7, E3, E3.5, E3.6
- SNC1P: A1, A1.1, A1.2, A1.4, A1.5, A1.6, A1.8, A1.10, A1.11, A1.12, A1.13, E2, E2.1, E2.4, E2.5, E2.6, E3, E3.5, E3.6

LEARNING GOALS:

- Solves word problems involving current, potential difference and power
- Carries out an inquiry involving current, potential difference and power

ASSESSMENT AND EVALUATION

ASSESSMENT/SUCCESS CRITERIA:

Knowledge and Understanding

- Understands the relationship between current, potential difference and power in parallel and series circuits in which the load is kept constant

Thinking and Investigation

- Uses processing skills and strategies (e.g., gathering data, observing, manipulating materials and equipment safely, solving equations)

Communication

- Written plans, observations and conclusions are clear and logical and use appropriate vocabulary and SI units

ASSESSMENT TOOLS:

- Inquiry Checklist

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MATERIALS AND RESOURCES

- Alligator leads – at least 10/group
- Miniature 1.2 V light bulbs – 3/group
- Light bulb sockets (to fit bulbs above) – 3/group
- 1.5 V (AA, C or D) primary cells (ideally with holders) – several/group
- Ammeter and voltmeter (or multimeter) – 1/group
- Student notebooks
- **BLM 2-1**: Inquiry Checklist – 1/student
- Calculators

INTERNET RESOURCES:

- You can see an up to the minute total of exactly how many MW of electricity OPG is producing by going to opg.com and clicking on Power Generation. You can also see how much is produced by OPG's nuclear, hydro-electric and thermal generating plants.

RESOURCES:

- HOW IT WORKS: ELECTRICITY GENERATION DVD (optional) (provided with kit)

PREPARATION:

1. Make copies of **BLM 2-1:** Inquiry Checklist (page 27) for each student (available in the **BLACK LINE MASTERS** section at the end of this Teacher's Guide).

PRIOR LEARNING

Prior to this lesson, students will have:

- Awareness of relationship between energy, voltage and current
- Experience setting up series and parallel circuits
- Experience with correct use of voltmeters and ammeters
- Experience solving simple equations in word problems
- Experience working in cooperative small groups

Differentiated Instruction - READINESS

You may need to review the prefix mega (1 000 000) and have students practice doing conversions involving watts and megawatts.

Unitconversion.org has a Universal Power Converter which can do this calculation as well as many other power conversions.

MINDS-ON

WHOLE CLASS

OPG has the capacity to produce more than 21 000 MW of electricity (go to opg.com to find out exactly how many MW of electricity OPG is currently generating for the province of Ontario). How many electrical devices could be powered with this much energy?

Provide the students with the power of common devices from the chart below. Have each student choose one device and calculate how many of their devices could run on 21 000 MW of electricity. Students will need calculators.

DEVICE	POWER	NUMBER OF DEVICES	DEVICE	POWER	NUMBER OF DEVICES
CFL light bulb	18 W	1 166 666 666	Xbox 360®	185 W	113 513 513
Electric clothes dryer	4 400 W	4 772 727	Microwave oven	1 440 W	14 583 333
50-56" Plasma television	340 W	61 764 706	Clock-radio	4 W	5 250 000 000
Electric furnace	26 500 W	792 453	Air conditioner, medium	900 W	23 333 333

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Explain that watts (W) and megawatts (MW) are a measure of ELECTRIC POWER (P). Electrical power can be defined as the amount of electrical energy that is converted to light, heat, sound, etc. every second (P = E/t). Energy is measured in joules (J) and time in seconds (s). 1W = 1J/s.

Power is more commonly expressed in terms of POTENTIAL DIFFERENCE and CURRENT. Have students recall that: P = E/t and P = VI.

Have students answer questions 1-3 below.

1. A toaster is connected to a 110 V wall outlet. What is the power of the toaster?
2. An electric clothes dryer is plugged into a 220 V wall socket. How much current passes through the dryer?
3. Create your own word problem using the values in the chart (provide students with values from the chart below). Give the problem to someone else in the class to solve (and solve his/her problem in return).

ELECTRICAL DEVICE	CURRENT (A)	SOURCE OF ELECTRIC POTENTIAL	POTENTIAL DIFFERENCE (V)	ELECTRICAL DEVICE	POWER (W)
Electric drill	4.5	Portable generators	24, 120, 240	Electric clothes dryer	4400
Vacuum cleaner	6.5	Wall outlets in house	120, 240	Clock-radio	4
Toaster	13.6	Generators in power stations	550	32" LCD television	125

Answers:

1. P = 1469 W
2. I = 20 A
3. Answers will vary. Check for accuracy.

Differentiated Instruction - READINESS

Provide students with strategies for solving word problems, such as:
G – what are the givens?
U – what are the unknowns?
E – write the equation (this includes any manipulation of the equation depending on the unknowns)
S – substitute the givens
S – solve

ACTION

SMALL GROUP

Differentiated Instruction - PREFERENCE

Help students to form groups which will work well together and which will foster an environment of inclusion.

In this investigation, students will explore how potential difference, current and power are affected by changing the energy source in parallel and series circuits when the load is kept constant.

Have students form small groups. Present the students with the Key Question and have them reword the question to make a prediction. For this investigation, each group will be given 3 light bulbs and several 1.5 V batteries (ideally with holders). Students will also need access to ammeters, voltmeters, alligator leads and calculators.

Students will be asked to set up an inquiry to investigate their predictions. Students will need to understand what is variable (the power source – voltage of primary cell) and what is constant (load, number and types of connecting wires).

In their notebooks, have students record:

1. Prediction (expected observations)
2. Materials (what they used)
3. Procedure (what they did)
4. Observations (data chart and labelled circuit schematic diagrams as well as qualitative comments)
5. Analysis (computations for V, I and P)
6. Conclusions (how did observations compare to prediction?)

Differentiated Instruction - READINESS

Assess students' readiness to set up and conduct an inquiry independently. If necessary, provide support such as determining the method as a class, providing charts for organizing data or providing a template for completing a lab report.

HOW IT WORKS
ELECTRICITY GENERATION

Provide students with **BLM 2-1**: Inquiry Checklist. These are the assessment criteria for the inquiry. Have students hand this in with their notebooks.

As students conduct the inquiries, provide support and observe how safely, accurately and effectively students are using the materials and equipment. Make comments on the Inquiry Checklist.

If necessary, allow students to complete the analysis and conclusions outside of class time.

Differentiated Instruction - READINESS

You may choose to have students complete a formal lab report, or do a more informal report in their notebooks. The reports could be done individually, or as a group.

CONSOLIDATION AND CONNECTION

WHOLE CLASS

After the investigation, discuss the results as a class. Questions for discussion could include:

- What is the relationship between potential difference, current and power?
- What trends did you see in the data?
- How did observations and calculations differ for series and parallel circuits?
- How much power is produced by each type of cell?
- How much power is consumed by each light bulb?

BACKGROUND INFORMATION:

Electricity leaving a generating plant is not at a high voltage; the voltage is actually relatively low. Electricity is produced at less than 25 000 V, then “stepped up” to 735 kV on long-distance transmission wires. From there, voltage is lowered, or “stepped down,” by transformers to reach customers in a safe, low-voltage form along distribution lines.

To see how electrical power is generated in Ontario, watch the **HOW IT WORKS: ELECTRICITY GENERATION** DVD included in the Teacher’s Resource Kit, or go to opg.com.

TEACHER’S NOTES:

LESSON 3: BASELOAD VS. PEAK DEMAND

LESSON OVERVIEW

Ontario's electricity consumption has two major components: baseload (constant, steady demand) and peak demand (surges in electricity consumption). In this lesson, students will gather data on their classroom's and their home's electricity consumption to find patterns, then devise an action plan to flatten their family's electrical consumption curve and minimize their impact on peak demand.

KEY QUESTION:
How do patterns of electricity consumption affect the electrical grid and the environment and how can those patterns be altered to minimize negative impact on the environment?

SUGGESTED TIMING:
60-70 minutes (one 40 minute block and one 20-30 minute block) plus time outside of class for completing the individual assignment

CURRICULUM CONNECTIONS

BIG IDEA:
Altering patterns of electricity consumption can ease strains on the electrical grid and reduce the environmental impact of energy production.

EXPECTATIONS: (see charts on pages 3 and 4 for detailed descriptions)

- SNC1D: A1, A1.6, A1.7, A1.10, A1.11, A1.12, A1.13, E1, E1.3, E2.1
- SNC1P: A1, A1.6, A1.7, A1.10, A1.11, A1.12, A1.13, E1, E1.2, E2.1

LEARNING GOALS:

- Collects data on electricity consumption patterns and devises an action plan to modify electricity consumption so that it is more evenly distributed over time

ASSESSMENT AND EVALUATION

ASSESSMENT/SUCCESS CRITERIA:

Knowledge and Understanding

- Understands basic concepts related to electricity generation and consumption in Ontario

Thinking and Investigation

- Gathers and organizes data using appropriate formats, including tables and graphs

Communication

- Expresses plans, observations and conclusions using appropriate vocabulary and SI units in a written or electronic format

Application

- Produces a plan of action to modify electrical energy consumption at home

ASSESSMENT TOOLS:

- Assignment Rubric

HOW IT WORKS
ELECTRICITY GENERATION

FYI
The greatest recorded electrical consumption in Ontario was reached on August 1, 2006, when 27 005 MW of electricity was drawn from the grid.

MATERIALS AND RESOURCES

MATERIALS

- **BLM 1-1**: Internet Resources – 1/student
- **BLM 3-1**: Home Electricity Consumption Chart – 1/student
- **BLM 3-2**: Baseload vs. Peak Demand Assignment Rubric – 1/student
- Kill-A-Watt Power Monitor* (optional) – 1/student
- **HOW IT WORKS: ELECTRICITY GENERATION** Student Guides (pages 1, 3, 4, 13) – 1/student (provided with kit)

  *The Kill-A-Watt Power Monitor, which measures electricity consumed by individual electrical devices, is available from the GreenGadgets.ca web site or scientific supply stores. Many public libraries also have Kill-A-Watt Power Monitors available for borrowing.

INTERNET RESOURCES:

- The Weather Network's (theweathernetwork.com) Ontario Power Consumption page (accessible under the "Home and Garden" menu) has hourly, daily, monthly and seasonal demand and supply information for Ontario.

PREPARATION:

1. Make copies of the BLM pages for each student (available in the **BLACK LINE MASTERS** section at the end of this Teacher's Guide).

Implementation Option
Create an electronic spreadsheet for the students to input their data into and post this on a class portal to supplement the paper data collection tool.

PRIOR LEARNING

Prior to this lesson, students will have:
- Awareness of energy sources and their environmental impact (ideally, students will have done Lesson 1, Electricity Generation in Ontario, and have familiarity with the costs and benefits of different types of electricity generation in Ontario)
- Experience charting data and making graphs

MINDS-ON

DAY 1 - WHOLE CLASS

Examine the graph on p. 4 of the **HOW IT WORKS: ELECTRICITY GENERATION** Student Guide. Discuss the differences between baseload electricity demand and peak demand, particularly the different types of generators which supply baseload and peak demand and the environmental impact of each type (see p. 13 of the **HOW IT WORKS: ELECTRICITY GENERATION** Student Guide). Brainstorm reasons why demand for electricity fluctuates throughout the day and also throughout the year. When would the greatest consumption be expected? Why do peak electricity consumption periods have a disproportionately high impact on the environment?

Implementation Option
If you have access to a Kill-A-Watt Power Monitor, you can plug an electrical device into it and find out the device's power consumption.

ACTION

WHOLE CLASS

Conduct an energy audit of the classroom for one class period. Begin by finding every electrical device in the classroom that draws electricity from the grid (not battery-powered devices, but including devices wired directly to the school's electrical system, such as overhead lighting, PA system, etc.). Determine each device's consumption in kilowatt-hours, either through examination of the device (many devices have placards on them which list power consumption and light bulbs are rated in terms of power consumption – i.e., a 60 W light bulb consumes 60 watt-hours of power if it is on continuously for one hour) or through research.

Record which electrical devices are operating in the classroom, and how many minutes each device was operating, including start and stop times.

HOW IT WORKS
ELECTRICITY GENERATION

Students can determine how much power a device has used by multiplying its power rating by how long it was running: for instance, a 1 000 W microwave oven that ran for 15 minutes would have consumed 250 watt-hours of electricity.

Students will also have to make sure that devices which draw “Phantom Load” are also included in data gathering.

Phantom Load

“Phantom Load” (or standby power) is the electricity consumed by electrical appliances that are switched off. Many electronic devices, such as televisions and DVD players, consume 10-15 W to power remote control functions and digital clocks. AC power adapters also consume standby power.

Graph the results to show how much power was consumed in the classroom and at which times, along with total electricity consumption (in watt-hours) for the period.

If desired, the class electricity consumption could be recorded on other days to compare results, or results from different classes could be compared. An electricity audit of the entire school could also be conducted over one day or an entire week.

Implementation Option

An alternative to having students complete individual Home Electricity Consumption charts is to have each student or the entire class devise an action plan to modify the classroom’s electricity consumption pattern.

INDIVIDUAL

Provide each student with a copy of **BLM 3-1**: Home Electricity Consumption Chart and **BLM 3-2**: Baseload vs. Peak Demand Assignment Rubric. Students will be charting their home electricity consumption over a 24-hour period.

This assignment is best completed on a weekend, preferably when at least one family member will be home for the entire time. Students will use the Home Electricity Consumption chart to keep track of which electrical devices in the home are turned on and off over a 24 hour period. It would be best to post the Home Electricity Consumption chart in a common area, such as on the refrigerator, so that all family members can help to compile the data.

Students will conduct an inventory of all electrical devices in the home that are plugged in, then determine which ones run constantly and keep track of which devices are turned on and for how long for the duration of the investigation. Students will also calculate how much power each of the devices used, and as well as the total household consumption for each hour, taking into account “Phantom Load” (see note above).

After the data has been compiled, students will calculate the hourly consumption in their homes, as well as determine average hourly consumption and peak and lowest hours of consumption. Students will then convert the hourly data into a graph. Finally, students will write action plans that list at least three ways their families could shift some of their electrical consumption from the peak demand times to lower demand times.

Each student must hand in:

- A completed Home Electrical Consumption Chart;
- A graph showing the student’s home electrical consumption over the 24 hour period when data was collected;
- An Action Plan that proposes at least three behaviours which could be modified to shift home electricity consumption away from peak demand times; and
- The assignment rubric.

Implementation Option

Tally each student’s hourly consumption to create a class graph for electricity consumption. Compare students’ individual consumption graphs to the class graph. How similar are the consumption patterns?

HOW IT WORKS
ELECTRICITY GENERATION

Review the assignment requirements and the rubric with the students.

CONSOLIDATION AND CONNECTION

DAY 2 - WHOLE CLASS

Provide each student with the opportunity to present his/her consumption data to the class. Each student should discuss whether he/she considers the data collected as representative of a typical day in his/her home. If not, what was unusual about the day?

Tally each student's peak consumption hour and lowest consumption hour. Which hours showed the greatest consumption? Which hours showed the lowest consumption?

Differentiated Instruction - INTERESTS
Time permitting, students could do independent research projects in which they explore and discuss different efforts to manage electricity consumption, such as smart meters. Information about smart meters can be found at smartmetersontario.ca.

EXTENSIONS:

Students can compare their personal consumption patterns to the province's consumption pattern. When does their home's peak load occur compared to that of the province as a whole?

How would large-scale adoption of electric cars affect power consumption and peak load in Ontario? If 10% of the cars in Ontario were replaced with electric cars, what impact would that have on electrical consumption, gasoline consumption and greenhouse gas emissions?

How have electrical consumption patterns changed over the past 30 years in Ontario? How might they change over the next 30 years?

BACKGROUND INFORMATION:

In Ontario, baseload is met primarily by nuclear and hydroelectric power plants, which operate cleanly and reliably and are more efficient to operate continuously. Peak demand is met primarily by thermal generating plants, which can be turned on and off relatively quickly to meet high demands. These plants are generally more expensive to operate and have a greater environmental impact. When peak demand exceeds the total capacity of Ontario's electrical generators, electricity must be imported.

TEACHER'S NOTES:

LESSON 4: UNDERSTANDING ELECTRICAL DEMAND

LESSON OVERVIEW

Our society has a constant demand for electricity. In this lesson, students will explore how increasing the load (light bulbs) in series and parallel circuits affects the current in those circuits given a constant energy source (three 1.5V D cell batteries). Students will challenge each other to find out whether it is possible for demand to exceed supply in a circuit and relate this to the real world.

KEY QUESTION:
Is it possible for demand (the load, i.e., number of light bulbs) to exceed supply (current) in a series or a parallel circuit, given a constant source of energy?

SUGGESTED TIMING:
75 minutes (some time outside of class may be necessary)

CURRICULUM CONNECTIONS

BIG IDEA:
Current electricity has distinct properties that determine how it is used.

EXPECTATIONS: (see charts on pages 3 and 4 for detailed descriptions)
- SNC1D: A1, A1.1, A1.2, A1.4, A1.5, A1.6, A1.8, A1.10, A1.11, A1.12, A1.13, E2, E2.1, E2.5, E2.7, E3, E3.5, E3.6
- SNC1P: A1, A1.1, A1.2, A1.4, A1.5, A1.6, A1.8, A1.10, A1.11, A1.12, A1.13, E2, E2.1, E2.4, E2.5, E2.6, E3, E3.5, E3.6

LEARNING GOALS:
- Carries out an inquiry involving current and resistance
- Understands real-world applications of electrical energy supply

ASSESSMENT AND EVALUATION

ASSESSMENT/SUCCESS CRITERIA:

Knowledge and Understanding
- Understands relationship between current and resistance in parallel and series circuits

Thinking and Investigation
- Tests, observes, gathers data and manipulates materials safely

Communication
- Writes observations and conclusions clearly and logically and uses appropriate vocabulary

Application
- Applies knowledge of circuits to the supply and demand of electrical energy

ASSESSMENT TOOLS:
- Student self-assessment questions

HOW IT WORKS
ELECTRICITY GENERATION

MATERIALS AND RESOURCES

MATERIALS

- Beam balance with variety of weights
- Alligator leads
- Miniature 1.2 V light bulbs
- Light bulb sockets (to fit bulbs above)
- Switches
- 3 D cell batteries, ideally with holders – 1 set/ group
- Cardboard boxes painted black on the inside (optional)
- **HOW IT WORKS: ELECTRICITY GENERATION** Student Guides (page 3) – 1/student (provided with kit)
- Student notebooks

INTERNET RESOURCES:

- The Weather Network's (theweathernetwork.com) Ontario Power Consumption page (accessible under the "Home and Garden" menu) has hourly, daily, monthly and seasonal demand and supply information for Ontario.

PREPARATION:

1. If you wish, gather several medium-sized cardboard boxes and paint the insides of the boxes with black paint. Students may wish to test their circuits inside the boxes, in order to more clearly observe dimly lit bulbs.

PRIOR LEARNING

Prior to this lesson, students will have:

- Experience setting up series and parallel circuits
- Experience working in cooperative small groups

Differentiated Instruction - STYLES

As students read page 3 of the Student Guide, they could **annolight** the text. In this strategy, students highlight key words and phrases and then **annotate** those **highlights** with notes in the margin. Several web sites have descriptions of this strategy.

MINDS-ON

WHOLE CLASS

Have students read page 3 of the **HOW IT WORKS: ELECTRICITY GENERATION** Student Guide.

As large quantities of electricity cannot be stored, supply and demand for electricity must be kept in constant balance. As demand increases, so must supply. In fact, electric power is consumed less than a second after being produced. This balance of supply and demand can be demonstrated using a beam balance and weights.

Invite one student up to assist you. Designate one side of the balance as the SUPPLY side and the other the DEMAND side. Place one weight on the DEMAND side. The student must then put enough weight on the SUPPLY side to balance your weight. Place another two weights and repeat the process. Explain that this is like BASELOAD demand. Next, pretend that the weather turns hot and you turn on an air conditioner. Add another heavy weight to the DEMAND side and repeat. Explain that this is like PEAK demand. Finally, pretend that it is late in the evening and it has become cooler; take off a weight from the DEMAND side and repeat the process.

ACTION

SMALL GROUP

Ask the students the key question, "Is it possible for demand (the load - number of light bulbs) to exceed supply (current) in a series or a parallel circuit given a constant source of energy?" Put those students who say "yes" into small groups and put students who say "no" into small groups (if the whole class says either yes or no, split them into YES groups and NO groups). Discuss how they will know that supply has exceeded demand with the light bulbs (i.e., the bulbs no longer produce light).

HOW IT WORKS
ELECTRICITY GENERATION

Differentiated Instruction - READINESS

Assess students' readiness to set up and conduct an inquiry independently. More experienced students could be grouped with less experienced students.

The groups that answered YES will try to prove that it is possible for demand to exceed supply, while the groups that answered NO will try to prove that it is not possible. The groups may choose to build either parallel or series circuits to support their arguments. All groups will use 3 D cells and have access to alligator leads, switches and light bulbs. Groups may also choose to test their circuits inside a box (to better see dimly lit bulbs).

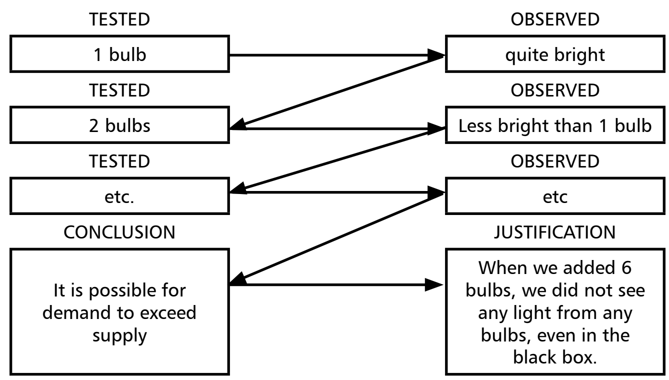
Instead of completing a lab report, students could use a graphic organizer, such as the Cause and Effect Graphic Organizer described below, to organize and record their observations and conclusions.

Students should continue testing until they have enough evidence to support their prediction. As the students are investigating, circulate and provide guidance and support as necessary.

Cause and Effect Graphic Organizer

Demonstrate how students could record their predictions, their tests and observations, using a chart similar to the one at right. Students should continue to add boxes until they feel that they can draw a conclusion. What they write in the justification box should be supported by their observations.

Prediction: I think it is possible for demand to exceed supply in a series circuit given a constant source of energy.



CONSOLIDATION AND CONNECTION

WHOLE CLASS

After the investigation, have each group present their findings and the evidence that supports their prediction. If some groups had similar approaches, then have them only contribute any new information.

Members of the opposing groups should be encouraged to challenge the evidence and ask questions. As well, the teacher should ask questions of both groups, such as:

- What criteria did you use to determine if demand was exceeding supply?
- Does your conclusion relate in any way to the type of circuit you constructed?
- How can you explain your findings in terms of the load (resistance)?
- How can you explain your findings in terms of current?
- What is the relationship between current and resistance?

At this time, you can also have students answer the following self-assessment questions in their notebooks.

1. What do I understand about the relationship between current and resistance in series and parallel circuits?
2. What is the "supply" and what is the "demand" in a circuit?
3. Did a graphic organizer help me to plan and record information? Why or why not?
4. Under what circumstances could demand exceed supply in real life? What might the consequences of this be?

EXTENSIONS

Students could do research on blackouts (the total loss of power to an area). A particularly noteworthy blackout was the Northeast Blackout of 2003, when a massive electrical power outage occurred throughout much of Ontario and parts of the northeast and midwest United States as a result of a problem that originated in Ohio. At the time, it was the most widespread electrical blackout in history, affecting an estimated 10 million people in Ontario alone.

Differentiated Instruction - INTERESTS

Time permitting, students could do independent research projects in which they explore and discuss future energy demand issues.

Students could do research on how OPG plans to meet demand in the future, such as the construction of the Niagara Tunnel, which will increase the output from the Sir Adam Beck hydroelectric complex by 14%.

BACKGROUND INFORMATION:

In a **series** circuit, the current passing through the loads and entering and leaving the source are the same ($I_t = I_1 = I_2 = I_3$). The total resistance of the circuit is the sum of the resistances of the loads ($R_t = R_1 + R_2 + R_3$). Therefore, with more bulbs there is less current for each bulb. The bulbs will appear dimmer with each bulb added. Eventually, enough bulbs can be added so that the bulbs are no longer able to produce light.

In a **parallel** circuit, the sum of the current passing through the loads is equal to the current entering and leaving the source ($I_t = I_1 + I_2 + I_3$). The total resistance of the circuit is less than the resistance of an individual load ($1/R_t = 1/R_1 + 1/R_2 + 1/R_3$). Therefore, even as bulbs are added, each bulb remains very bright.

What is important for students to realize is that primary cells are not analogous to electricity generating stations. Primary cells, which transform chemical energy to electrical energy, have a finite supply of reactants that eventually become exhausted. Generating stations, which transform various sources of energy into electrical energy, are constantly resupplied and will continue to generate electricity as long as there is demand or until they are shut down.

An analogy could be useful here. Imagine that a primary cell is like a pool filled with water (available energy). If you wanted to water your garden, you set up a hose that draws water from the pool. If you ran 5 sprinklers off a single hose (analogous to a series circuit), none of the sprinklers would spray very high and it would take a long time to drain the water from the pool. On the other hand, if you had 5 sprinklers, each on a separate hose (analogous to a parallel circuit), then each would spray up high and the pool would drain five times as fast.

The electricity from an operating generating station is more like water that flows through a faucet than from a pool. Once the faucet is turned on, the water will run until the faucet is turned off. As long as there is water to supply the faucet, a faucet that is left on could run indefinitely.

TEACHER'S NOTES:

LESSON 5: CAREERS IN ELECTRICITY GENERATION

LESSON OVERVIEW

For students starting to think about what to do after high school and wanting a job they will enjoy, there are opportunities at OPG in many diverse fields. In this lesson, students will explore OPG's mypowercareer.com web site to read about the many different types of careers in electricity generation, then will each create a job posting based on one of the careers.

KEY QUESTION:
What career possibilities are there in the electricity generation sector in Ontario and what education and training are required for those careers?

SUGGESTED TIMING:
60 minutes over 2 days in class, plus time outside of class for research and writing

CURRICULUM CONNECTIONS

BIG IDEA:
There are many career possibilities in the field of electricity generation, each with its own unique set of education and training requirements.

EXPECTATIONS: (see charts on pages 3 and 4 for detailed descriptions)
- SNC1D: A1, A1.3, A1.7, A2, A2.1
- SNC1P: A1, A1.3, A1.7, A2, A2.1

LEARNING GOALS:
- Gathers information on careers in electricity generation and determines which skills and education would be relevant to those careers

ASSESSMENT AND EVALUATION

ASSESSMENT/SUCCESS CRITERIA:

Knowledge and Understanding
- Identifies which careers are available in the electricity generation sector in Ontario

Communication
- Communicates for different audiences and purposes in written form using vocabulary and terminology specific to careers in electricity generation

Application
- Transfers knowledge of careers to context of an employment posting

ASSESSMENT TOOLS:
- Career Posting Checklist and Self-Reflection

MATERIALS AND RESOURCES

MATERIALS
- **BLM 1-1**: Internet Resources – 1/student
- **BLM 5-1**: Career Posting Checklist and Self-Reflection – 1/student
- LCD projector or SMART Board™

HOW IT WORKS
ELECTRICITY GENERATION

INTERNET RESOURCES:

- OPG's mypowercareer.com web site has information on employment opportunities at OPG and profiles of people who work there.
- Human Resources and Social Development Canada's National Occupational Classification (NOC) (www5.hrsdc.gc.ca/NOC/) is a national reference on occupations in Canada that has information on duties and employment requirements for thousands of different jobs.
- Ontario Skills Passport (skills.edu.gov.on.ca) is cross-referenced to the NOC and has in-depth information on the skills and skill levels required for many careers.
- TradeUP for Success (tradeup.ca) has information on skilled trades careers in the electricity industry.

PREPARATION:

1. Internet access will be needed in the classroom.
2. Students will need individual access to the internet either during class time or outside of class hours.

PRIOR LEARNING

Prior to this lesson, students will have:

- Experience with internet research
- Experience with persuasive writing

FYI

In 2008, OPG had over 12 000 regular employees working across Ontario.

MINDS-ON

DAY 1 - WHOLE CLASS

Brainstorm with students possible careers related to electricity generation. Choose one career (e.g., Power Station Operator) and, using the internet with the class, search the National Occupational Classification (NOC) web site for a description of that job (NOC code 7352). Using the NOC identifier, go to the Ontario Skills Passport web site for a list of skills required for that job. Discuss with the students the skills that they have acquired in this course which would be relevant to this job, and also which high school courses they would have to take in the future to qualify for this job.

ACTION

INDIVIDUAL

Each student will choose a career in electricity generation found on the mypowercareer.com web site. Additionally, students could consult the list of careers on the Career Profiles page in the About Careers section of the CNA's Nuclear Technology: Exploring Possibilities web site for choices. Students will be required to write a sample job posting for that position. Have the students copy the requirements for the assignment in their notebooks. The following must be included in the job posting, which will total no more than 250 words:

- Job title
- Job overview
- At least 3 job duties
- Education level required
- At least 5 job requirements
- Location of the job
- Types of shifts that will be worked
- Any travel requirements

Differentiated Instruction - INTELLIGENCES

Invite students to design a graphic advertisement for their job posting instead of a text-only job posting.

After students have chosen the job they wish to write a posting for, they should consult the mypowercareer.com web site, the NOC web site and the Ontario Skills Passport web site for more information to support their job posting.

Students will type out their job posting, making the job seem as desirable as possible to potential applicants. The job posting will be submitted with a cover page that has the student's name and the job title which they chose – the student's name should not be on the actual job posting page.

HOW IT WORKS
ELECTRICITY GENERATION

Review the assignment requirements with the students.

CONSOLIDATION AND CONNECTION

DAY 2 - INDIVIDUAL ACTIVITY

After the job postings are handed in, the teacher will record the students' names and assign a unique identifier to each student and his/her job posting. Write that identifier on each job posting, then distribute the job postings to the class, making sure that no student gets his/her own job posting. Each student will also receive a copy of **BLM 5-1**: Career Posting Checklist and Self-Reflection BLM. The students will then assess the job postings they were given for completeness using the Career Posting Checklist and use the Self-Reflection section of the BLM to think about and record which skills they have developed in this course which would be relevant to the job posting, along with which courses they would have to choose in the future to qualify for this job.

BACKGROUND INFORMATION:

OPG's 65 hydroelectric stations, 3 nuclear stations, 5 thermal stations, 2 co-owned gas-fired stations and 2 wind power turbines employ 12 000 people. There are a wide variety of careers available at OPG, including chemical engineers, civil engineers, electrical engineers and mechanical engineers, mechanical technicians, electrical and control technicians, station operators, market traders, accountants, human resource specialists, planners, biologists, project managers and more.

TEACHER'S NOTES:

BLM 1-1: INTERNET RESOURCES

We offer you these suggested links to use as resources or as web-accessed components for your students. These are suggestions only and OPG is not responsible for the content of these web sites or maintaining the links.

LESSON 1: ELECTRICITY GENERATION IN ONTARIO

- **Ontario Power Generation:** www.opg.com and www.opg.com/learningzone
- **Canadian Association of Petroleum Producers:** http://membernet.capp.ca/
- **Canadian Gas Association** (natural gas): http://www.cga.ca/
- **Canadian Hydropower Association – Hydropower in Canada: Past, Present and Future**: http://www.canhydropower.org/hydro_e/pdf/hydropower_past_present_future_en.pdf
- **Canadian Nuclear Association – Education Resources**: http://cna.ca/curriculum/default.asp
- **Canadian Nuclear Association – 2009 Nuclear Handbook:** http://www.cna.ca/english/pdf/NuclearFacts/2009/CNA_Nuclear_Energy_Booklet09.pdf
- **Canadian Solar Industries Association**: http://www.cansia.ca/
- **Canadian Wind Energy Association:** http://www.canwea.ca/index_e.php
- **Environment Canada – Greenhouse Gases:** http://www4.hrsdc.gc.ca/.3ndic.1t.4r@-eng.jsp?iid=64
- **Independent Electricity System Operator:** http://www.ieso.ca
- **Natural Resources Canada - The Canadian Renewable Energy Network: Clean Fossil Fuels:** http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/clean_fossils_fuels.html
- **Natural Resources Canada - The Canadian Renewable Energy Network: Wind, Solar, Biofuels:** http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/canren.html
- **Ontario Green Energy Act:** http://www.greenenergyact.ca/
- **Ontario Power Authority:** http://www.powerauthority.on.ca
- **Ontario Sustainable Energy Association:** http://www.ontario-sea.org/

LESSON 3: BASELOAD VS. PEAK DEMAND

- **The Weather Network - Ontario Power Consumption:** http://www.theweathernetwork.com/power/index

LESSON 5: CAREERS IN ELECTRICITY GENERATION

- **Ontario Power Generation:** mypowercareer.com
- **Human Resources and Social Development Canada National Occupational Classification (NOC):** http://www5.hrsdc.gc.ca/NDC
- **Ontario Skills Passport:** skills.edu.gov.on.ca

ONTARIO POWER GENERATION

BLM 1-2: ENERGY SOURCE COST-BENEFIT ANALYSIS TEMPLATE

Names: ________________________ Date: _______________

Energy Source: __________________ Perspective: _______________________________

Number of plants/units required to produce 500 MW =				
CRITERIA	BENEFIT(+)	COST(-)	UNSURE	JUSTIFICATION
	_______ Benefit	_______ Cost	_______ Overall Total	

Overall Assessment:

Sources Used:

BLM 1-3: ENERGY SOURCE COST-BENEFIT ANALYSIS SELF-ASSESSMENT

Name: ______________________________ Date: ____________________

KNOWLEDGE AND UNDERSTANDING:

I can identify and explain costs associated with electricity production	yes	no	not sure
I can identify and explain benefits associated with electricity production	yes	no	not sure

Evidence to support my rating: ____

____

Teacher notes: ____

____

THINKING AND INVESTIGATION:

I located electronic sources relevant to the research	yes	no	not sure
I can justify the costs and the values we assigned to each cost	yes	no	not sure
I can justify the benefits and the values we assigned to each benefit	yes	no	not sure
My overall assessment was reasonable and based on cost/benefit data	yes	no	not sure

Evidence to support my rating: ____

____

Teacher notes: ____

COMMUNICATION:

Our chart is well organized	yes	no	not sure
Our calculations are all done accurately	yes	no	not sure

Evidence to support my rating: ____

____

Teacher notes: ____

BLM 2-1: INQUIRY CHECK LIST

Name: ____________________________ Investigation:_______________________________

Date: ______________________

Knowledge and Understanding	Comment	✔
I explained the relationship between current, potential difference and power in parallel and series circuits in which the load is kept constant		
Thinking and Investigation	Comment	✔
I wrote a prediction which was clear and testable		
I controlled variables		
I used standard equipment and materials safely		
I used meters correctly		
I accurately constructed series and parallel circuits		
I measured current and potential difference at various points in the circuits using appropriate meters		
I analyzed data (computations for V, I and P)		
I made calculations accurately and precisely		
I made and justified conclusions based on observations		
Communication	Comment	✔
I communicated prediction, materials, procedure, observations, analysis and conclusions in writing		
I recorded measurements in a data chart		
I accurately drew circuit diagrams of series and parallel circuits		
I used appropriate SI units of measurement		
I used appropriate electricity terminology		

Additional Comments:

BLM 3-1: HOME ELECTRICITY CONSUMPTION

Name: ______________________________ Date:______________________

Times Measured: From __________ To _________

Item in Use	Start Time	End Time	Length of Time In Use (hours)	Consumption Rate (watts/hour)	Total Consumption (watt-hours)

HOUR BEGINNING	CONSUMPTION (WATT-HOURS)	HOUR BEGINNING	CONSUMPTION (WATT-HOURS)	HOUR BEGINNING	CONSUMPTION (WATT-HOURS)
12:00 a.m.		8:00 a.m.		4:00 p.m.	
1:00 a.m.		9:00 a.m.		5:00 p.m.	
2:00 a.m.		10:00 a.m.		6:00 p.m.	
3:00 a.m.		11:00 a.m.		7:00 p.m.	
4:00 a.m.		12:00 p.m.		8:00 p.m.	
5:00 a.m.		1:00 p.m.		9:00 p.m.	
6:00 a.m.		2:00 p.m.		10:00 p.m.	
7:00 a.m.		3:00 p.m.		11:00 p.m.	

Average consumption per hour (watt-hours): ____________________

Peak consumption hour: __________________________________

Lowest consumption hour: ________________________________

BLM 3.2: BASELOAD VS. PEAK DEMAND ASSIGNMENT RUBRIC

Name: ____________________ Date Due: ____________________

	LEVEL 1 - THE STUDENT:	LEVEL 2 - THE STUDENT:	LEVEL 3 - THE STUDENT:	LEVEL 4 - THE STUDENT:
KNOWLEDGE AND UNDERSTANDING				
Understanding of basic concepts related to electricity generation and consumption in Ontario	Demonstrates limited knowledge of baseload and peak demand	Demonstrates some knowledge of baseload and peak demand	Demonstrates considerable knowledge of baseload and peak demand	Demonstrates thorough knowledge of baseload and peak demand
THINKING AND INVESTIGATION				
Use of processing skills and strategies (gathering and recording data)	Data gathered is incomplete and is presented in a disorganized manner	Data gathered is somewhat complete and presented in a somewhat organized manner	Data gathered is complete and presented in an organized manner	Data gathered is very complete and presented in a very organized manner
Use of critical/creative thinking processes, skills, and strategies (e.g., analyzing, interpreting, evaluating, forming and justifying conclusions on the basis of evidence)	Data analysis is incomplete and demonstrates limited critical/creative thinking	Data analysis is somewhat complete and demonstrates somewhat effective critical/creative thinking	Data analysis is mostly complete and demonstrates considerable critical/creative thinking	Data analysis is very complete and demonstrates highly effective critical/creative thinking
COMMUNICATION				
Expression and organization of ideas and information (clear expression and logical organization)	Expresses and organizes ideas and information with limited effectiveness	Expresses and organizes ideas and information with some effectiveness	Expresses and organizes ideas and information with considerable effectiveness	Expresses and organizes ideas and information with a high degree of effectiveness
APPLICATION				
Proposing courses of practical action to deal with problems relating to science, technology, society, and the environment (creation of an action plan to alter electricity consumption patterns at home)	Proposes courses of practical action of limited effectiveness	Proposes courses of practical action of some effectiveness	Proposes courses of practical action of considerable effectiveness	Proposes highly effective courses of practical action

BLM 5-1: CAREER POSTING CHECKLIST AND SELF-REFLECTION

Name: ______________________________ Date: ______________________

Identifier of Posting Assessed: ____________________

ITEM	YES	NO
Accurate **Job Title** included		
Accurate **Job Overview** included		
3 **Job Duties** listed:		
1.		
2.		
3.		
Required Education level listed		
5 valid **Job Requirements** listed:		
1.		
2.		
3.		
4.		
5.		
Location of work listed		
Types of Shifts listed		
Travel Requirements (if any) listed		

Teacher notes: ____

____

SELF-REFLECTION ON SKILLS:

Which skills have I developed in this course which would be useful for this job?

____

____

____

____

____

Which high school courses would I have to take in the future to prepare me for this job?

____

____

____

Teacher notes: ____

____

____

OPG wishes to thank the Ontario science education consultants whose valuable input greatly helped with the development of this Teacher's Guide.

For more information please visit:

www.opg.com/learningzone

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

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