



CHARGE UP FOR ELECTRICITY

TEACHER'S RESOURCE GUIDE

Grade 6 – Electricity

Energy and Control Strand

Presented by:

ONTARIOPOWER
GENERATION

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Kathleen McGill – author

Each activity has clear, concise directions. Any cautionary information is stated. While every precaution has been taken to ensure fun and safe experiments, nothing substitutes for supervision and common sense. Ontario Power Generation assumes no responsibility for the misuse or mishandling of materials provided in this program.

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CHARGE UP FOR ELECTRICITY **GRADE 6 CURRICULUM CONNECTIONS**

This interactive presentation is designed to meet the expectations outlined in the new Ontario Curriculum for **Grade 6 Science**. The topic **Electricity** is covered under the strand **Energy and Control**. The following specific expectations are met by participating in this interactive demonstration:

- Investigate ways in which electrical energy can be transformed into other forms of energy;
- Compare the conductivity of a variety of solids and liquids;
- Identify, through experimentation, ways in which chemical energy can be transformed into electrical energy;
- Compare the characteristics of current and static electricity;
- Describe the relationship between electricity and magnetism in an electromagnetic device;
- Identify, through observation, the effects of using different types of core materials in building an electromagnet;
- Identify different types of switches that are used to control electrical devices and explain the key differences among them;
- Formulate questions about and identify needs and problems related to the properties or uses of electrical energy, and explore possible answers and solutions;
- Use appropriate vocabulary, including correct science and technology terminology, in describing their investigations and observations;
- Compile data gathered through investigation in order to record and present results, using tally charts, tables, labelled graphs, and scatter plots produced by hand;
- Design and build electrical circuits and describe the function of their component parts;
- Build and test an electrical circuit that performs a useful function, and draw a diagram of it using appropriate electrical symbols;

Charge Up for Electricity

Grade 6 Curriculum Connections (continued)

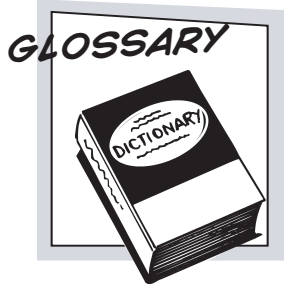
- Construct series circuits and parallel circuits to control a device and compare their characteristics;
- Design and construct an electrical system that operates a device in a controlled way,
- Identify sources of electricity and state whether the sources are renewable or non-renewable;
- Recognize the use of electromagnets in motors and generators;
- Describe the electrical conversions in everyday devices or systems;
- Identify the different ways electricity is produced and evaluate the effect of different production methods on natural resources and living things in the environment;
- Describe how electricity was discovered and harnessed for use and discuss whether we are more or less dependent on electricity than people in the past.

Many expectations are also met in other areas of the new Ontario Curriculum for **Grade 6**. In **Mathematics**, the **Data Management and Probability** strand contains the following specific expectations which are also met by participating in this presentation:

- Construct line graphs, bar graphs, and scatter plots by hand;
- Make inferences and convincing arguments based on the analysis of tables, charts, and graphs.

In **English**, the **Oral and Visual Communication** strand contains the following specific expectations which are also met by participating in this presentation:

- Use constructive strategies in small-group discussions;
- Follow up on others' ideas, and recognize the validity of different points of view in group discussions or problem-solving activities.



GLOSSARY OF TERMS

ampere	unit used to measure electric current
attraction	the force that pulls two opposite electric charges together
chain reaction	a continuous series of nuclear fission reactions
charge	characteristic of an object made of atoms with an unequal number of protons and electrons
circuit	an electrical path in which a current returns to its source
conductor	a material that allows electricity to move easily through it
current	the flow of electric charges through a wire or other conductor
dry cell	a battery that uses solid chemicals as fuel
electromagnetism	the combined effects of electricity and magnetism
electrons	tiny particles in atoms that carry electricity
force	an interaction between two objects
generator	a machine that produces an electric current by rotating a coil of wire in a magnetic field
insulator	a material that will not allow the flow of electrons to move easily through it
kilowatt-hour	unit used to measure electric power
nuclear energy	energy released during a nuclear fission or fusion reaction
nuclear fission	an energy-producing reaction in which a large atom's nucleus is split into smaller parts
nuclear fusion	an energy-producing reaction in which the nuclei of small atoms join together to form a larger nucleus

Glossary of Terms (continued)

parallel circuit	allows more than one path for an electric current to follow
repel	to move apart, as in objects with like electric charge
series circuit	contains a single path for electric current to follow
static electricity	electric charges built up on the surface of an object
switch	a device used to complete or interrupt an electric circuit
telegraph	an electromagnetic device used to transport messages over long distances
volt	unit used to measure electrical force
watt	unit used to measure the rate at which work is done
wet cell	a battery that uses liquid chemicals as fuel

FAMOUS ELECTRICITY SCIENTISTS

DATE	PERSON	LOCATION	DISCOVERY
600 (BCE)	Thales	Greece	First to show that there are electrical forces in nature
1600	William Gilbert	England	Furthered Thales experiments on static electricity and was the scientist who created the word "electricity"
1733	Charles Francois Du Fay	France	First to show that there are two types of electric charge
1752	Ben Franklin	USA	The one who labelled the two charges "positive" and "negative" and discovered that lightning is electricity
1800	Alessandro Volta	Italy	Invented the electric battery; the "volt", a unit of electric measurement is named for him
1805	John Dalton	England	Theorized that all matter is made up of atoms
1819	Hans Christian Oersted	Denmark	Discovered that when an electric current flows through a wire, a magnetic field surrounds the wire
1831	Michael Faraday	England	Discovered that moving a magnet through the centre of a coil of wire generated electric current
1835	Samuel F. B. Morse	USA	Developed the electromagnetic telegraph and the Morse Code
1879	Thomas Edison	USA	Invented the first light bulb as well as the phonograph
1931	Robert J. Van de Graaff	USA	Invented the electrostatic generator, more commonly known as a Van de Graaff machine

INTRODUCTION TO ELECTRICITY



Let's find out about this amazing discovery that has changed our lives so much over the last 100 years!

Everything is made of atoms – this booklet you are reading, the floor under your feet, even your own body. Atoms are very, very, very small. It would take over 1,000,000 atoms to stretch across the width of just 1 human hair! Inside atoms are even smaller particles called **electrons**. Most of the time, electrons stay with their own atom. But sometimes electrons get pulled away. They leave one atom and move to the next. It is this movement of electrons that is electricity!

The electricity we use in our homes and schools is electricity in which the electrons flow continuously through wires in the same way that water flows through a hose. **Static** electricity is created when two objects rub together and the electrons jump from one object to the other.

Electricity can be generated from many sources:

In Nature – Lightning is the most common show of electricity in nature. Also, certain animals and insects show electrical ability such as the electric eel and the glow worm.

Batteries – Batteries use a chemical reaction to make electric current.

Power Station – Power stations create the electricity we use every day. Turn the page to find out the surprising way electricity is generated!

GENERATING INTEREST



Electricity has a special relationship with magnetism. Magnetism can make electricity!

(And electricity can make magnetism – but more about that later).

In 1831, a British scientist named Michael Faraday discovered how to use magnets and copper wire to make electricity. He moved a magnet in and out of a coil of wire and found that this made an electric current flow through the wire. Nowadays, we still use this principle to make the electricity we use today.

At Ontario Power Generation, huge generators are used to provide electrical power for all of us to use in our homes, our schools, our work, everywhere. The generator is the part of the power station that actually makes the electricity. Inside the generator are two sets of coils of wire. One coil is the rotor, which acts as an electromagnet and the other coil is the stator. When the rotor rotates inside the stator, electricity is produced in the stator wires! Unlike a battery, a generator never runs out of electricity as long as the rotor keeps turning. To keep the rotor turning, a huge turbine is attached to the rotor and when the turbine turns, so does the rotor in the generator.

From the power station, the electricity is carried along thick wires called cables or power lines to our homes or other buildings. The wires may be buried under the ground or they may be hung from tall transmission towers.

On the next page, see if you can correctly follow the path of electricity from the power plant to your house!

NOTES ON ELECTROMAGNETISM

Electromagnets are so versatile because with the flick of a switch, you can turn them on and off! In the experiment on electromagnetism, students will build and test their own electromagnet and discover what makes it work.

The following is a list of suggestions to help you help the students understand the scientific process:

- ♦ **Purpose** – You state what the purpose is of the experiment for the students.
- ♦ **Hypothesis** – Have the students make a prediction about the type of core an effective electromagnet will need.
- ♦ **Materials** – You are not limited to the test core materials listed here. These are simply suggestions. Encourage the students to test other materials in the classroom.
- ♦ **Method** – The electromagnet can get quite hot. Please ensure the students understand this. To maintain the integrity of their test results, they must wrap each core item the same number times with the wire.
- ♦ **Diagram** – Do not use circuit symbols for this experiment. Have the students draw it out so they illustrate the paper clips sticking to the electromagnet when the wires are hooked up to the battery. Make sure it is properly labelled.
- ♦ **Observations** – As the current flows through the wire, it starts to permanently magnetize any metal in the core of the electromagnet. You will find that if your students give the core material a little tap on the table after the current has been turned off, it will help to de-magnetize the metal.
- ♦ **Conclusion** – Your students will discover that an effective electromagnet needs a core of magnetic material, usually iron or steel.

Not only can electromagnets be turned off and on, they can also have their power varied! The students have already discovered that the more turns in the coil of wire (50 turns of coil vs. 10 turns of coil), the stronger the magnetic force. The same is true if you add another battery. Have the students develop an experiment to test the effects of increased battery power in their electromagnet. When you experiment with more battery power, never exceed 6 volts total for safety reasons – the coils just get too hot. So, start small by using one 1.5V D cell battery and adding additional D cells, one at a time, until you reach a maximum of 6 volts (4 cells in total).



ELECTROMAGNETISM EXPERIMENT

Purpose: What makes an electromagnet?

Hypothesis: I predict that....

Materials:

- ♦ Steel or iron nail
 - ♦ Insulated wire with bared ends (50-60 cm)
 - ♦ Wooden pencil
 - ♦ Plastic pen
 - ♦ 6V battery
 - ♦ Box of paper clips
 - ♦ Piece of chalk
 - ♦ Brass or aluminum screw
1. Build an electromagnet: wrap the wire around the nail (20 times) to form a tightly wound coil making sure the wire does not overlap itself. Leave at least 15 cm of wire free on each end to hook up to the 6V battery.
 2. Place the paper clips in a pile on a desktop. Without hooking up the wires, take the nail and dip it into the clips. What happened when the nail was lifted out? Record your observations.
 3. Touch the ends of the wires to the two terminals on the 6V battery (you may see a spark – it's harmless). Take the nail and dip it into the clips. [SAFETY NOTE: DO NOT TOUCH THE WIRES TO THE BATTERY FOR MORE THAN 10 SECONDS BECAUSE YOU COULD BURN YOUR FINGERS] What happened when the nail was lifted out? Record your observations.
 4. Repeat steps 1-3 substituting a wooden pencil, piece of chalk, plastic pen and brass screw for the nail. Record all observations.

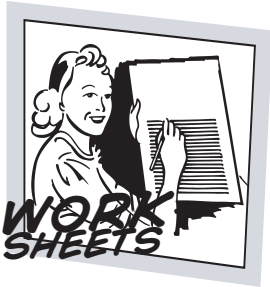
Diagram: On the back of this sheet draw, colour and label a diagram of your experiment.

Electromagnetism Experiment (continued)**Observations:**

Electromagnet Core	Hooked Up To Battery (Yes/No)	Number of Paper Clips Picked Up
nail	no	
nail	yes	
pencil	no	
pencil	yes	
chalk	no	
chalk	yes	
pen	no	
pen	yes	
screw	no	
screw	yes	

Conclusion: I discovered that....

Name: _____



STUCK ON YOU WORKSHEET

Did You Know?

Electromagnets can be found in a variety of everyday devices like televisions, stereo speakers, computer disk drives and just about anything that has a motor in it. Scientists predict that electromagnets will one day replace door locks and train wheels. Electromagnets are so much more versatile than natural or permanent magnets because their strength can be varied and they can be turned off or on with just the flick of a switch!

Complete the following:

Record the number of paper clips picked by the electromagnet:

10 turns of the wire _____ 15 turns of the wire _____

20 turns of the wire _____ 25 turns of the wire _____

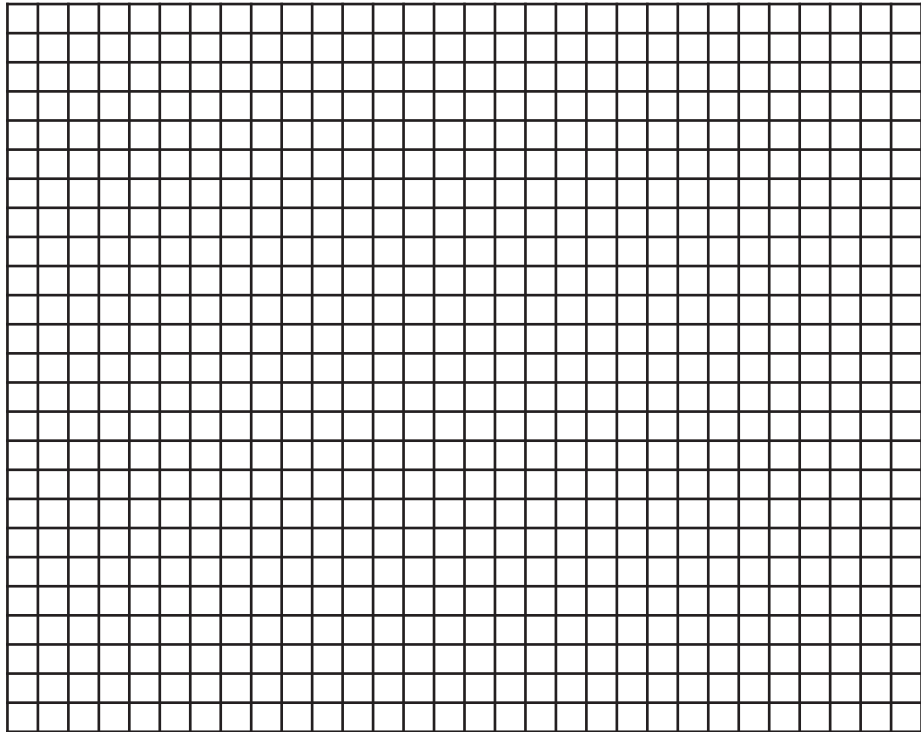
30 turns of the wire _____ 35 turns of the wire _____

40 turns of the wire _____ 45 turns of the wire _____

50 turns of the wire _____

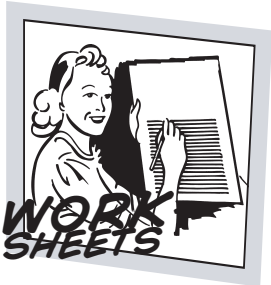
Using the above data, plot a line graph to show the information. Label the y-axis "Number of Paper Clips Picked Up" and the x-axis "Number of Turns of Wire". Choose appropriate number scales to accurately illustrate your findings.

Stuck On You Worksheet (continued)



What effect did increasing the number of coils have on the strength of the electromagnet? Can you predict what would happen to the strength of the electromagnet if you continued to increase the number of turns in the coil.

Name: _____



TAP TALK WORKSHEET

Did You Know?

Samuel F.B. Morse developed the electromagnetic telegraph in 1835 and the Morse Code in 1838. This invention allowed people to communicate directly with one another over long distances.

Complete the following:

1. Write a word on the line below. Don't let anyone see it!

2. Use a Morse Code Conversion Sheet to translate your word into Morse Code.

3. Send your word on the Telegraph Tapper. Pause at least one second between letters. Other members of your group will record the Morse Code and translate it.
4. Now record the Morse Code words your friends sent below.

Name of Sender: _____

Morse Code Word: _____

English Translation: _____

Name of Sender: _____

Morse Code Word: _____

English Translation: _____

Tap Talk Worksheet (continued)

Name of Sender: _____

Morse Code Word: _____

English Translation: _____

Name of Sender: _____

Morse Code Word: _____

English Translation: _____

Name of Sender: _____

Morse Code Word: _____

English Translation: _____

5. Compare the Morse Code word that you sent to the words that your group recorded. How similar are they? Can you think of any reason why there might have been differences?

MORSE CODE CONVERSION CHART

A	·-	O	---	1	·----
B	-···	P	·---·	2	··---
C	-···	Q	---·-	3	···-
D	-··	R	·-·	4	····-
E	·	S	··	5	····
F	··-·	T	-	6	-····
G	-·-·	U	··-	7	-····
H	····	V	··-·	8	-----·
I	··	W	·-·-	9	-----·
J	·-·-	X	-··-	0	-----
K	-·-	Y	-·-·-		
L	····	Z	---·		
M	--				
N	-·				

NOTES ON ELECTRICITY USAGE

The next few pages are resources for you to use to help you create a project on “Electrical Energy Usage”. Ideally, you would like the students to come away with the knowledge of how to read an electricity meter, calculate the cost of the electricity used, recognize the appliances that consume the most amount of energy, understand factors that influence electricity consumption and finally, be able to create strategies to reduce the amount of electricity they use. Not all students live in homes where they can read a meter that indicates their own dwelling’s electrical consumption. When this is the case, have these students read the school’s meter and develop a plan to help the school save money on electricity or have the students read the meter of a friend or relative.

The electricity meter can only record the total amount of electrical energy used in a home; it cannot distinguish if the energy was used to power a stove or a stereo. In order for students to learn how to conserve energy, they must learn how to calculate how much energy was used by each appliance. The following formula will help:

$$\text{Electrical energy} = \text{Electrical power} \times \text{Time Interval}$$

$$E = P \times rT$$

Where E = electrical energy measured in kilowatt hours (kWh)
 P = electrical power measured in kilowatts (kW)
 ΔT = time interval measured in hours (h)

Example: How many kilowatt hours of electrical energy are used in one month by a kettle that has a power rating of 1.5 kW (1500 Watts) and is operated for 1h each week?

Data:

Electrical energy used = ? kWh

Time interval = 1h x 4 = 4h

Power = 1.5 kW

Equation:

$E = P \times \Delta T$

$E = 1.5 \text{ kW} \times 4$

$E = 6 \text{ kWh}$

The electrical energy used by the kettle in one month is 6 kWh

Notes on Electricity Usage (continued)

Once the students have discovered how to read their meters and how to calculate the amount of energy used by each appliance, calculating the cost of the electrical energy will seem easy! Have the students (or yourself) call the local utility company to find out the current cost of one kilowatt hour of electricity. The example below uses a rate of \$0.075/kWh. Let's calculate how much it costs to use the kettle for a month:

Cost = Electrical energy (kWh) x Rate (cost per kWh)
Cost = E x Rate

Example: Calculate the cost of the electricity needed to operate the kettle for one month if it uses 6 kWh of energy and the rate charged for electricity is \$0.075/kWh.

Data:

Energy used = 6 kWh
 Rate = \$0.075/kWh
 Cost = ?

Equation:

Cost = E x Rate
 Cost = 6 kWh x \$0.075/kWh
 Cost = \$0.45 [or 45 cents]

The cost to operate the kettle for one month is \$0.45.

ELECTRICAL USAGE PROJECT

In this project, the students will collect and analyze information about the use of electrical energy in their homes (or school), calculate how much it costs and devise strategies to reduce their electricity consumption in the future. The following are some suggestions on how to organize this project:

- ♦ Choose a time period for the students to monitor their electricity consumption (i.e., a month, a week).
- ♦ Show the students how to read an electricity meter.
- ♦ Ask the students to predict which appliances they think their families use the most and which will use the most during the monitoring period. Have the students record their predictions.
- ♦ Have the students create a table to record their daily meter readings. Remind them they must check the meter at the same time everyday to ensure the integrity of their data.
- ♦ Have the students record the daily activities and events which could affect the amount of electricity used. For example: weather (hot temperatures could mean air conditioning), light (dull days could mean more lamps on), laundry day, family outing (no one home to use appliances).
- ♦ Have the students list the appliances they have chosen to monitor for this project (any more than 5 is too much recording!). Have them record daily when the appliances were used and for how long.
- ♦ When the monitoring period is over, have the students summarize their findings on a chart with the following headings:

Electrical Appliance	Power Rating (kw)	Time Used (h)	Energy Use (kwh)	Cost (\$)
---------------------------------	----------------------------------	------------------------------	---------------------------------	----------------------

- ♦ Using the information from their completed chart, have the students list the appliances, starting with the one that costs the most to the one that cost the least. How does this list compare to the students' initial predictions? Have them comment on any unexpected differences.

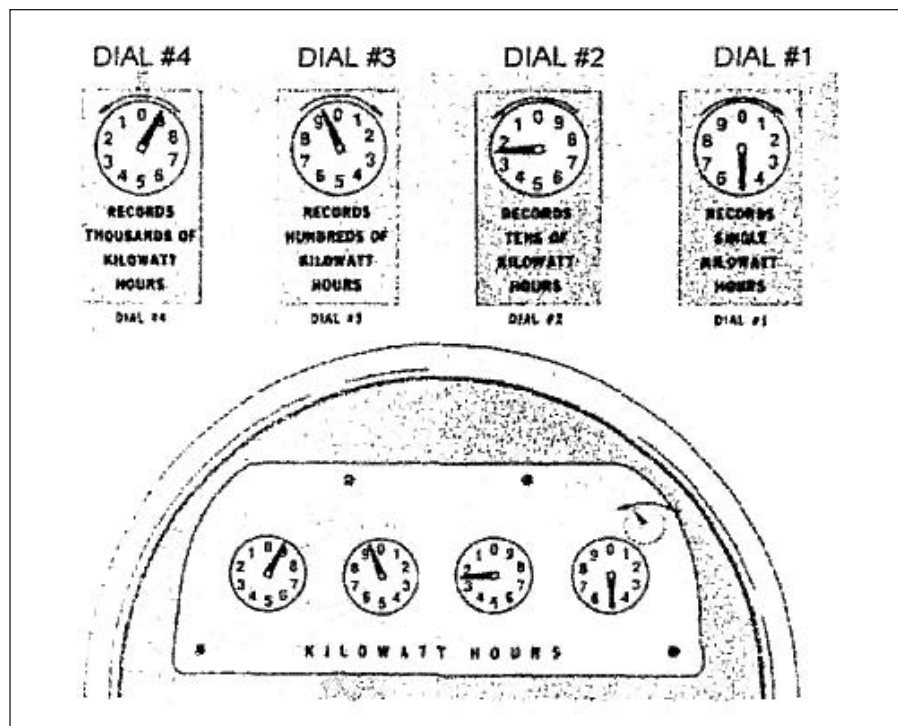
Electrical Usage Project (continued)

- ♦ Have the students calculate what percentage of the total electricity consumed during the monitoring period was from the appliances. Record this on a circle graph.
- ♦ Have the students identify ways to conserve energy and write a proposal to their family making suggestions about how to reduce their electricity consumption.
- ♦ Have the students implement their plan at home and monitor their electricity meters again for the same time period as before. Have them compare how much they were able to save in electricity and money.

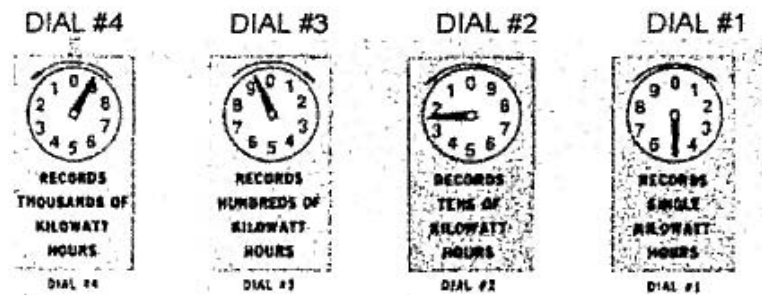
HOW TO READ YOUR ELECTRICITY METER

An electricity meter is a precision instrument which records the amount of electricity used in your home. A kilowatt hour (kWh) is 1,000 watts of electricity used for one hour. To give you some comparison, this is equivalent to the power required to burn a 100 watt light bulb for 10 hours, or to operate a standard 5,000 watt electric clothes dryer for approximately 12 minutes.

Electricity meters usually have 4 or 5 main dials and are fairly simple to read by following the steps shown here. Read the dials from right to left and write the figures in your log in the same order. Not all meters have 5 main dials, but if yours does, it records tens of thousands of kilowatt hours. The very small dial on your meter is a test dial to verify the correct reading of dial #1. In this example, the pointer has started a new revolution and the correct reading of dial #1 is 5. Please keep in mind the following important points so that your reading will be correct when you make a record in your log:



How to Read Your Electricity Meter (continued)



- ♦ Some meters record a proportional fraction of the energy used. To calculate the total kilowatt hours used, the readings must be multiplied by the multiplier factor printed on the faceplate; a typical multiplier is 10 and this is shown on your meter by a "MULT x 10" imprint on the faceplate. It means your readings must be multiplied by 10 when you calculate the kilowatt hours.
- ♦ Some of the pointers rotate clockwise, others counter-clockwise.
- ♦ When a dial pointer is between two numbers, read the smaller of the two.
- ♦ When the dial pointer rests almost squarely on a number, as it does on dial #4, the dial to the immediate right will determine which number you record.
- ♦ On Dial #3, the pointer is between 9 and 0, indicating that the pointer has not yet completed a full revolution. This means that the correct reading for Dial #4 is 8 (if the pointer on Dial #3 had gone past 0, indicating the completion of a full revolution, the reading for Dial #4 would have been 9).
- ♦ As in the drawing, read the dials from right to left: the first number to record is 5; the second is 2; the third is 9; and the fourth 8; for a total reading of 8,925 kWh.

APPLIANCE USAGE CHART (page 2)

<p style="text-align: center;">How to Determine the Cost of Running Appliances Using These Rates</p> <p style="text-align: center;">$\text{Wattage} \times \text{hours used} \div 1000 = \text{kWh}$</p> <p style="text-align: center;">$\text{kWh} \times \text{cost per kWh} = \text{cost}$</p>				
APPLIANCE	APPROXIMATE AVERAGE WATTAGE	MONTHLY HOURS OF USE	MONTHLY KWH	APPROXIMATE COST\$**
HUMIDIFIER (PORTABLE)	100	80-540	8-54	.60-4.05
IRON (HAND)	1000	1-10	1-10	.08-.75
KETTLE	1500	1-10	1-15	.08-1.13
LAWN MOWER	1500	2-4	3-6	.23-.45
LIGHTING SINGLE LAMP (60W)	60	17-200	1-12	.08-.90
COMPACT FLUORESCENT (60W EQUIVALENT)	18	17-200	.3-3.6	.02-.27
CEILING FIXTURE (3 BULBS)	180	6-195	2-35	.15-2.63
TRI-LIGHT (TABLE LAMP)	100	10-200	1-20	.08-1.5
CHANDELIER (5 LAMP)	300	10-183	3-55	.23-4.13
FLUORESCENT (2 TUBE 4 FT.)	100	10-200	1-20	.08-1.50
MICROWAVE OVEN	1000	5-30	5-30	.38-2.25
OIL FURNACE (BURNER)	260	96-288	25-75	1.88-5.63
POWER SAW	275	2-4	.6-1	.05-.08
RANGE	12500	10-50***	125-625	9.38-46.88
(SELF CLEANING CYCLE ONLY)	3200	1/2-1 1/2	2-5	.15-.38
REFRIGERATOR-FREEZER FROST FREE (17 CU. FT.)	500	150-300	75-150	5.63-11.25
NON-FROST FREE (13 CU.FT.)	300	190-300	56-90	4.20-6.75
SEWING MACHINE	75	4-14	.3-1	.02-.08
SHAVER	15	3-5	.05-.08	.00-.01
STEREO	30	1-170	0.03-5.1	0.00-0.38
SUN LAMP	280	1-4	.28-1	.02-.08
SWIMMING POOL FILTER MOTOR 1/2 HP	900	720	648	48.60
3/4 HP	1200	720	864	64.80
1.0 HP	1500	720	1080	81.00
1.5 HP	2100	720	1512	113.40
TELEVISION	80	60-440	5-35	.38-2.63
TOASTER	1150	1-3.5	1-4	.08-.30
TOASTER OVEN	1250	2-24	2.5-30	0.19-2.25
TOOTHBRUSH	10	1-2	.01-.02	.00
VACUUM CLEANER (PORTABLE)	800	2-6	2-5	.15-.38
(CENTRAL)	1600	2-6	4-10	.30-.75
VIDEO CASSETTE RECORDER	40	50-200	1-8	.08-.60
WAFFLE IRON	1100	1-2	1-2	.08-.15
WATER BED HEATER	400	150-300	60-120	4.50-9.00
WATER HEATER TYPICAL FAMILY OF 4	3800	98-138	375-525	28.13-39.38
TYPICAL FAMILY OF 2	3800	66-92	250-350	18.75-26.25









*Per season**Call your local Hydro for your cost per kWh, on average about \$.075 per kWh.

†Add the cost of hot water from non-electric water heater.

***Hourly energy consumption varies drastically depending on cooking patterns/habits.

CIRCUIT SYMBOLS

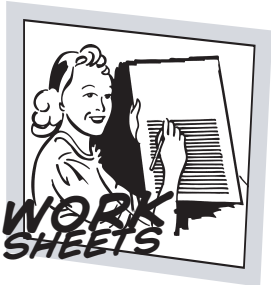
Table of Symbols

Symbol	Name	Description
	Cell	Source of current. Long bar represents the positive terminal.
	Battery	Two or more cells joined together. This battery is made up of 2 cells.
	Lamp	Small lightbulb
	Switch	Can be opened to stop current flow or closed to allow current to flow.
	Fuse	Prevents too much current from flowing through the circuit.
	Galvanometer	Measures very small currents (milliamperes).
	Ammeter	Measures a wide range of currents (amperes).
	Voltmeter	Measures the amount of energy given to (or lost by) electrons in a circuit (volts).

Imagine the time it would take for scientists and electricians to draw all the parts of a circuit as real-life illustrations every time they planned a circuit! It is far easier and much faster to draw circuits using symbols. Each symbol represents a part of a circuit. The following table lists some of the standard symbols used to draw circuits.

There are certain rules to follow when drawing circuit diagrams. First, cells should be shown connected correctly, that is, positive terminal to negative terminal. Second, connecting wires should be shown as single straight lines at right angles to each other. It does not matter what kind of bulb holder, switch or cell you use – the symbols are always the same. It also does not matter how you connect the components, whether by twisting the wires together or by using alligator clips, these are not shown on the diagram either.

Name: _____



"SERIES-US" WORKSHEET

Did You Know?

In a series circuit, there is only one pathway for electricity to go. That means, as you add more lights, the battery must distribute the voltage equally through more lights. It also means, a break in the circuit disrupts the flow of electricity. Have you ever used old holiday lights that all went out when only one bulb blew? Remember, the frustration of checking every single bulb to find which one blew so you could fix the whole string of lights! This type of lighting is wired in a series circuit. Each light directly follows the one before. If there is a break at any point in the circuit, the electricity stops and the entire circuit goes dead.

Complete the following:

1. (a) What happened to the first bulb's light when you added a second bulb to the circuit?

- (b) What happened to the first and second bulb's lights when you added a third bulb to the circuit?

- (c) What happened to the first, second and third bulb's lights when you added a fourth bulb to the circuit?

- (d) What happened to the first, second, third and fourth bulb's light when you added a fifth bulb to the circuit?

- (e) Why do you think this happened to the light bulbs? Explain.

“Series-us” worksheet (continued)

2. (a) What happened to the first bulb when you unscrewed the second bulb?

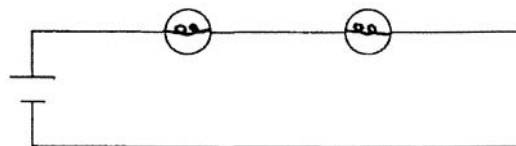
- (b) What happened to the two other bulbs when one was unscrewed?

- (c) What happened to the three other bulbs when one was unscrewed?

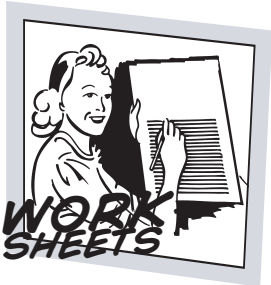
- (d) What happened to the four other bulbs when one was unscrewed?

3. If all the lights in your home were connected in a series circuit, what would happen if you turned off a light switch? Why?

4. This circuit diagram shows two lights and a cell connected in a series circuit (Note: a battery is two or more cells connected together). Using your Circuit Symbols sheet, draw a series circuit with five lights and one cell on the back of this sheet.



Name: _____



PARALLEL UNIVERSE WORKSHEET

Did You Know?

In a parallel circuit, two sets of wires run side by side off a common power supply (i.e., battery). This way, lights installed on one circuit will not interfere with lights connected on another. It also means that all the lights receive the same amount of voltage from the battery because they are all equally connected to it – every bulb has one wire going to the positive terminal and another wire going to the negative terminal. That's why most holiday lights today are wired in parallel circuits.

Complete the following:

- (a) What happened to the first bulb's light when you added a second bulb to the circuit?

- (b) What happened to the first and second bulb's lights when you added a third bulb to the circuit?

- (c) What happened to the first, second and third bulb's lights when you added a fourth bulb to the circuit?

- (d) What happened to the first, second, third and fourth bulb's lights when you added a fifth bulb to the circuit?

Parallel Universe Worksheet (continued)

2. (a) What happened to the first bulb when you unscrewed the second bulb?

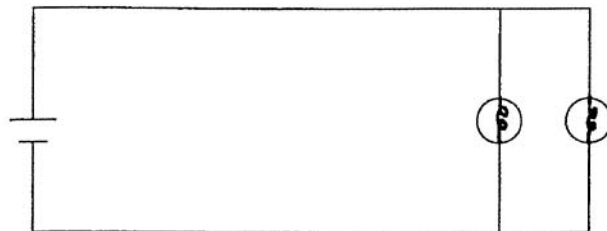
- (b) What happened to the two other bulbs when one was unscrewed?

- (c) What happened to the three other bulbs when one was unscrewed?

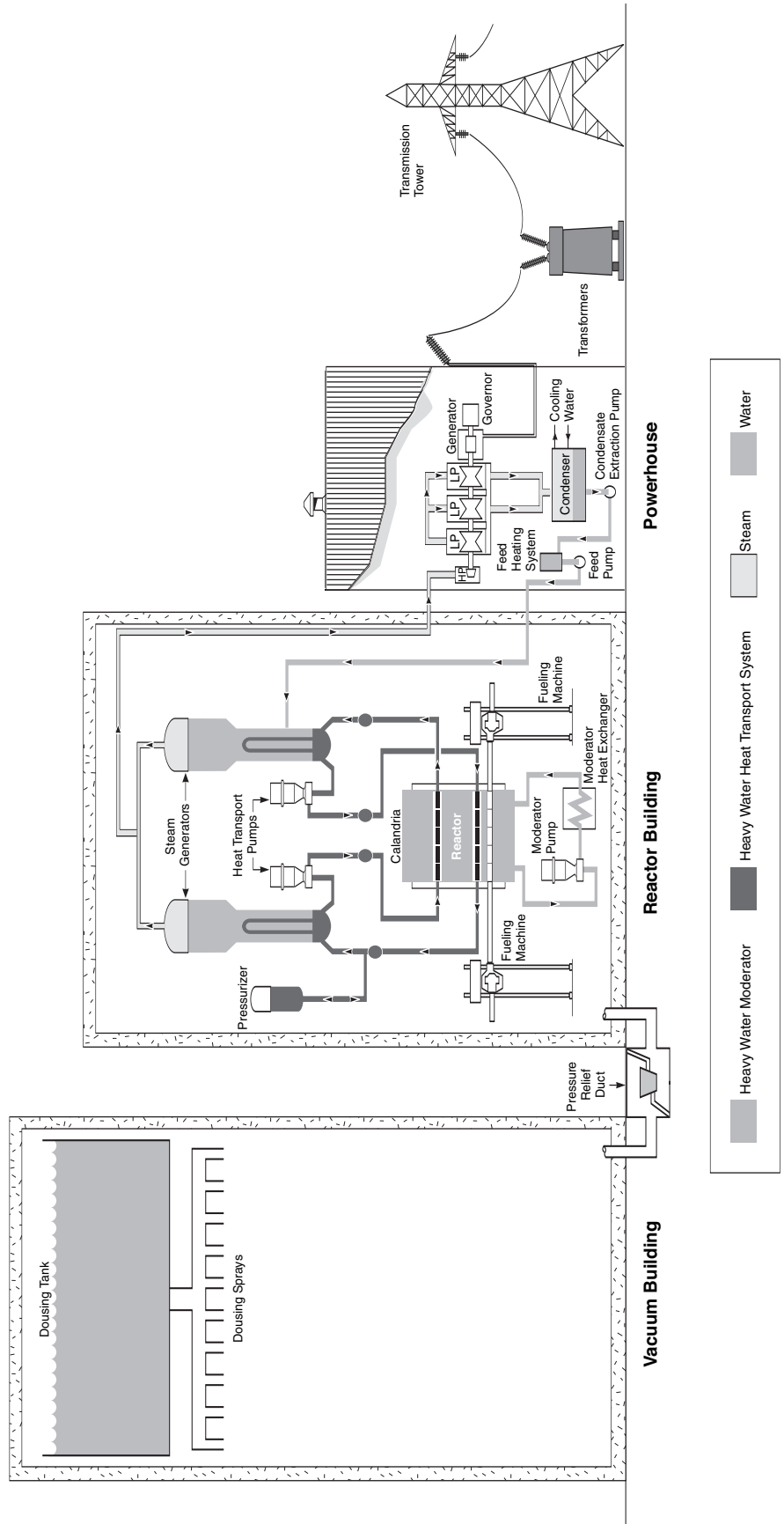
- (d) What happened to the four other bulbs when one was unscrewed?

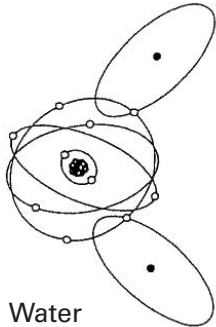
- (e) Why do you think this happened to the light bulbs? Explain.

3. This circuit diagram shows two lights and a cell connected in a parallel circuit (Note: battery is two or more cells connected together). Using your Circuit Symbols sheet, draw a parallel circuit with five lights and one cell on the back of this sheet.

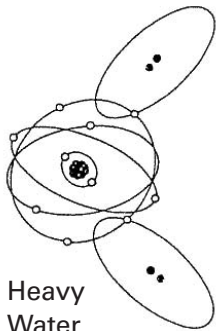


NUCLEAR GENERATING UNIT SCHEMATIC CANDU PRESSURIZED HEAVY WATER REACTOR





Water
molecule
(H₂O)



Heavy
Water
molecule
(D₂O)

PICKERING NUCLEAR: *HEAVY WATER*

Unlike most of the world's nuclear reactors, the Canadian-developed CANada Deuterium Uranium (CANDU) Nuclear reactor uses heavy water to transfer heat and to help control the nuclear reaction.

What is heavy water?

Heavy water is a clear, colorless liquid that looks and tastes like ordinary tap water. It occurs naturally in water in minute quantities, about one part heavy water to 7,000 parts of ordinary water. The importance of heavy water to the Canadian reactor is suggested in the name itself-CANDU. Unlike normal water, which is composed of hydrogen and oxygen (the well known H₂O formula), heavy water is made up of deuterium and oxygen (D₂O). The name heavy water stems from the presence of deuterium, which is a form of hydrogen that has an extra neutron in its atomic nucleus and weighs slightly more than ordinary hydrogen. As a result, heavy water is about 10 percent heavier than normal water. It also has different freezing and boiling points.

Helping the chain reaction.

An explanation of the way nuclear power is generated will help in understanding heavy water's role in the process. Ontario Hydro's CANDU reactors are fuelled with natural uranium, which consists mainly of uranium 238 with a very small percentage of uranium-235 (0.7%). It is this tiny percentage of uranium 235 that is important in the production of nuclear energy because the unstable properties of the uranium-235 atom make it easy to split when struck by a neutron.

Once this happens, enormous heat is produced, and this heat can be used to generate power. The initial splitting or "fissioning" of the uranium atom will produce two or three more neutrons. If these neutrons are able to split other uranium-235 atoms, which in turn give off more neutrons to split yet more uranium-235 atoms, then a chain reaction is created. It is this self-sustaining chain reaction

or "fissioning" that enables nuclear reactors to produce the constant heat energy needed to generate electricity.

There is one important consideration in this process. The neutrons from the split atom travel at a speed of about 19,000 kilometers per second. At this velocity, the probability of the neutrons colliding with uranium-235 atoms is very small. For this reason, a material called a moderator must be used to slow down, or "moderate," the neutrons to about three kilometers per second so they are more likely to collide with the uranium-235 atoms and have a better chance of causing fission. Heavy water is a particularly good moderator because the deuterium atom already contains a neutron. This means that neutrons released when the atom is split have little chance of being absorbed by the heavy water and, once slowed, will continue to split other uranium atoms and sustain the chain reaction. Heavy water is about 30 times better than ordinary water in slowing down neutrons without absorbing them. In fact, because heavy water is such a good moderator, CANDU reactors can use natural uranium unlike most other commercial reactors, which use ordinary water as their moderator and therefore must use fuel that has been "enriched" with extra atoms of uranium-235. The process of enriching uranium is expensive, and reactors that use enriched uranium can require up to double the fuel to produce the same amount of electricity as a CANDU reactor.

A heat transport medium.

Ontario Hydro also uses pressurized heavy water to carry heat from the reactor to the huge boilers that produce steam to run the electric generators.

When the chain reaction starts, heavy water is heated by being circulated through the tubes, it moves on to a boiler where it, in turn, heats ordinary water to steam. Heavy water is a good heat transport medium for the same

Pickering Nuclear: Heavy Water (continued)

reason that it is a good moderator: the extra neutron. Because of this extra neutron, heavy water is less likely to absorb neutrons crucial to the fissioning process while it collects the heat from the reactor.

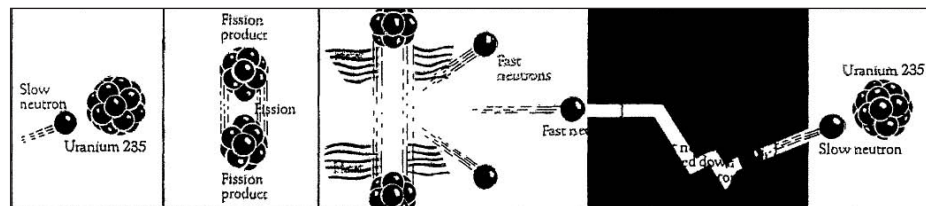
How it's produced.

The reactors at the Pickering Nuclear Generating Station initially required 60 tones of heavy water which are "topped up" each year with about five tones-less than one percent of their total requirements. Roughly 340,000 tones of lake water are needed to produce one tone of heavy water. After passing through the system, water is returned to the lake, depleted of 19 percent of its heavy water molecules. This discharge has no affect on the quality of the water in the lake.

Heavy water is produced using two processes. First, a series of chemical enrichment processes using hydrogen sulfide gas (H₂S) increases the concentration of heavy water in the water to about 35 percent.

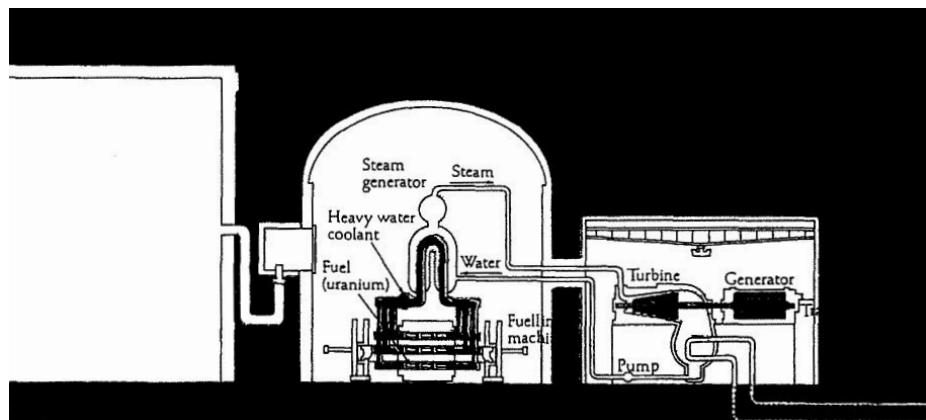
The second step is a distillation process, which brings the water to 99.75 percent or more heavy water.

Once the heavy water is in use, small amounts may leak from the reactors. Most of the heavy water that escapes from the reactors is collected in sumps or vapor dryers. Because each generating station has a small heavy water upgrading facility it is possible to purify this heavy water and introduce it back into the system.



How heavy water is used:

A slow neutron strikes nucleus of uranium-235 atom and splits – fissions – it into smaller atoms. Neutrons given off at the same time are slowed by the heavy water moderator so they can strike and split other nuclei and sustain a chain reaction.



Ontario's Electricity System

