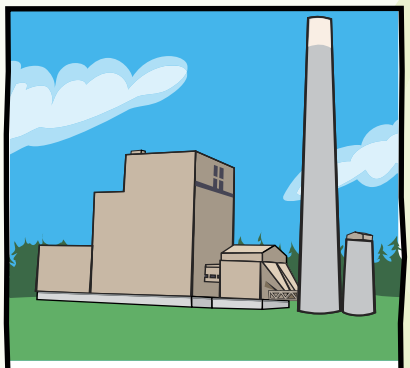
# EXPLORING ELECTRICITY PRODUCTION

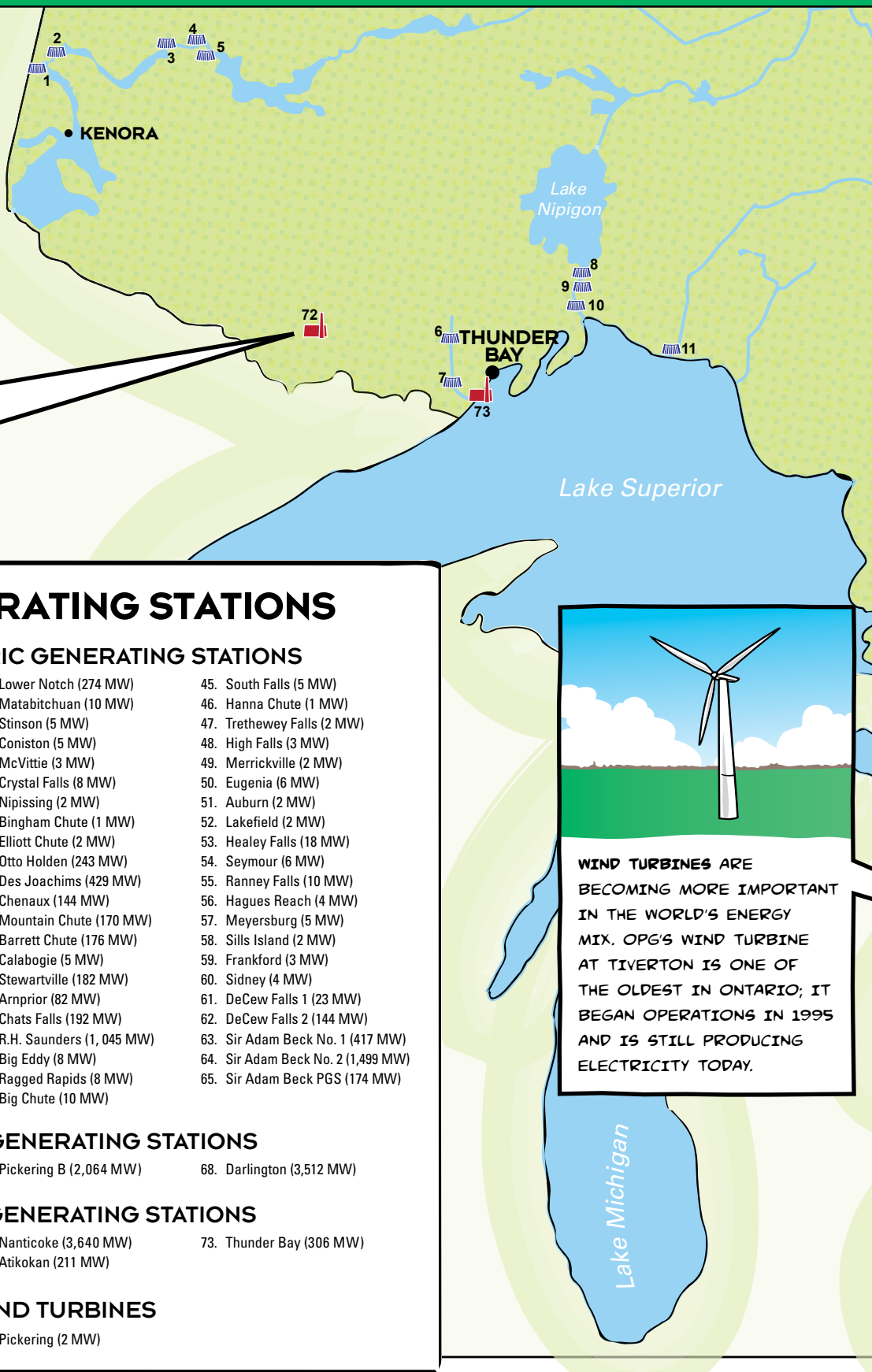

## OPG GRADE 6 STUDENT GUIDE

ONTARIO POWER GENERATION

# ELECTRIFYING ONTARIO:



OPG OPERATES 5 **THERMAL GENERATING STATIONS**, INCLUDING THE ATIKOKAN GENERATING STATION IN NORTHWESTERN ONTARIO. THESE STATIONS BURN **FOSSIL FUELS** (**COAL**, **OIL** AND **NATURAL GAS**) TO PRODUCE ABOUT ONE-TENTH OF OPG'S ELECTRICITY EACH YEAR.




## OPG GENERATING STATIONS

### HYDROELECTRIC GENERATING STATIONS

1. Whitedog Falls (68 MW)
2. Caribou Falls (91 MW)
3. Manitou Falls (73 MW)
4. Ear Falls (17 MW)
5. Lac Seul (12 MW)
6. Silver Falls (48 MW)
7. Kakabeka Falls (25 MW)
8. Pine Portage (142 MW)
9. Cameron Falls (87 MW)
10. Alexander (68 MW)
11. Aguasabon (51 MW)
12. Kipling (157 MW)
13. Harmon (141 MW)
14. Smoky Falls (52 MW)
15. Little Long (133 MW)
16. Otter Rapids (182 MW)
17. Abitibi Canyon (349 MW)
18. Lower Sturgeon (14 MW)
19. Sandy Falls (5 MW)
20. Wawaitin (11 MW)
21. Indian Chute (3 MW)
22. Hound Chute (4 MW)
23. Lower Notch (274 MW)
24. Matabitchuan (10 MW)
25. Stinson (5 MW)
26. Coniston (5 MW)
27. McVittie (3 MW)
28. Crystal Falls (8 MW)
29. Nipissing (2 MW)
30. Bingham Chute (1 MW)
31. Elliott Chute (2 MW)
32. Otto Holden (243 MW)
33. Des Joachims (429 MW)
34. Chenaux (144 MW)
35. Mountain Chute (170 MW)
36. Barrett Chute (176 MW)
37. Calabogie (5 MW)
38. Stewartville (182 MW)
39. Arnprior (82 MW)
40. Chats Falls (192 MW)
41. R.H. Saunders (1, 045 MW)
42. Big Eddy (8 MW)
43. Ragged Rapids (8 MW)
44. Big Chute (10 MW)
45. South Falls (5 MW)
46. Hanna Chute (1 MW)
47. Trethewey Falls (2 MW)
48. High Falls (3 MW)
49. Merrickville (2 MW)
50. Eugenia (6 MW)
51. Auburn (2 MW)
52. Lakefield (2 MW)
53. Healey Falls (18 MW)
54. Seymour (6 MW)
55. Ranney Falls (10 MW)
56. Hagues Reach (4 MW)
57. Meyersburg (5 MW)
58. Sills Island (2 MW)
59. Frankford (3 MW)
60. Sidney (4 MW)
61. DeCew Falls 1 (23 MW)
62. DeCew Falls 2 (144 MW)
63. Sir Adam Beck No. 1 (417 MW)
64. Sir Adam Beck No. 2 (1,499 MW)
65. Sir Adam Beck PGS (174 MW)

### NUCLEAR GENERATING STATIONS

66. Pickering A (1,030 MW)
67. Pickering B (2,064 MW)
68. Darlington (3,512 MW)

### THERMAL GENERATING STATIONS

69. Lennox (2,100 MW)
70. Lambton (1,920 MW)
71. Nanticoke (3,640 MW)
72. Atikokan (211 MW)
73. Thunder Bay (306 MW)

### WIND TURBINES

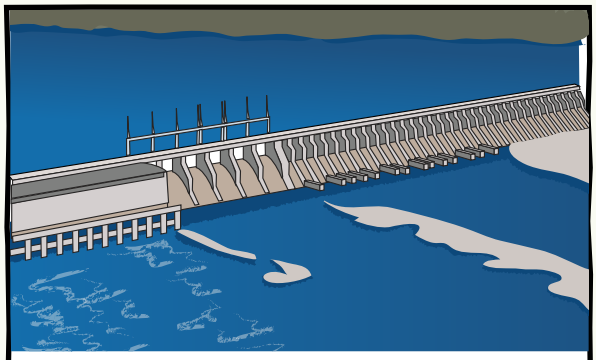
74. Tiverton (0.6 MW)
75. Pickering (2 MW)



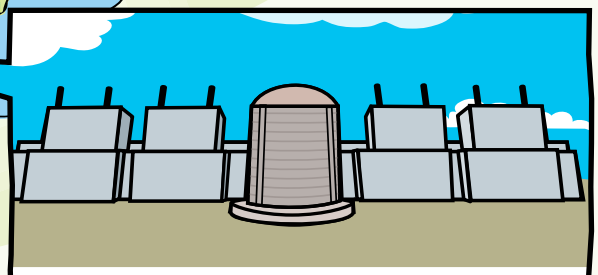
**WIND TURBINES** ARE BECOMING MORE IMPORTANT IN THE WORLD'S ENERGY MIX. OPG'S WIND TURBINE AT TIVERTON IS ONE OF THE OLDEST IN ONTARIO; IT BEGAN OPERATIONS IN 1995 AND IS STILL PRODUCING ELECTRICITY TODAY.

# OPG'S GENERATING STATIONS

OPG SUPPLIES ABOUT TWO-THIRDS OF ONTARIO'S ***ELECTRICITY.*** OPG'S ELECTRICITY GENERATING STATIONS CAN PRODUCE OVER 21,000 ***MEGAWATTS*** OF ELECTRICITY.

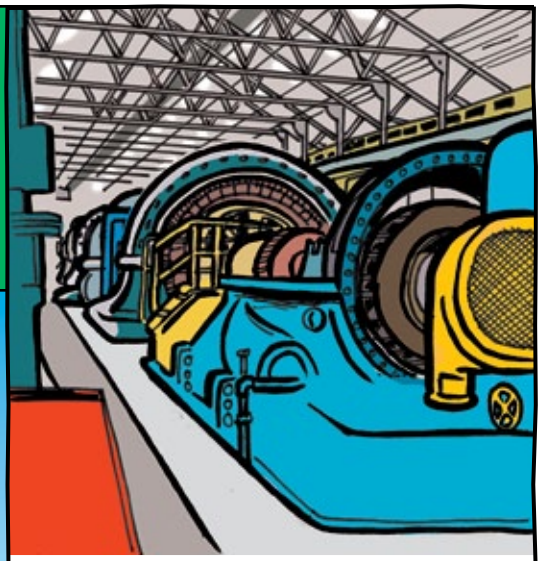


OPG'S **HYDROELECTRIC GENERATING STATIONS** CONTRIBUTE MUCH OF THE ELECTRICITY PRODUCED BY OPG. THE OTTO HOLDEN GENERATING STATION ON THE OTTAWA RIVER HAS A CAPACITY OF 243 MEGAWATTS.



**NUCLEAR GENERATING STATIONS** LIKE THE DARLINGTON NUCLEAR GENERATING STATION PROVIDE MORE THAN HALF OF THE ELECTRICITY THAT OPG PRODUCES ANNUALLY. OPG OPERATES THREE NUCLEAR GENERATING STATIONS.

# HYDROELECTRIC: WATER AT WORK



MOST **HYDROELECTRIC GENERATING STATIONS** USE FALLING WATER TO PRODUCE **ELECTRICITY**. HYDROELECTRIC STATIONS CAN PRODUCE LARGE AMOUNTS OF ELECTRICITY CONTINUOUSLY WITH ALMOST NO **SMOG** OR **GREENHOUSE GAS** EMISSIONS. SINCE THE WATER IS NOT CONSUMED, HYDROELECTRICITY IS A **RENEWABLE** FORM OF **ENERGY**.

THE DECEW FALLS 1 GENERATING STATION IN WELLAND IS THE OLDEST GENERATING STATION IN ONTARIO. IT BEGAN PROVIDING ELECTRICITY IN 1898 AND IS BEING **REFURBISHED** SO THAT IT CAN CONTINUE TO HELP POWER ONTARIO FOR YEARS TO COME.

WATER FLOWS AND LEVELS ARE MANAGED TO ACCOMMODATE ENVIRONMENTAL CONCERNS SUCH AS FISH SPAWNING.

IN SOME PLACES, BOATS USE CANALS AND LOCKS TO GET AROUND THE DAM.

FOREBAY

TRANSFORMER

GENERATOR

PENSTOCK

TURBINE

AT R.H. SAUNDERS GENERATING STATION, AN EEL LADDER HELPS MIGRATORY EELS GET SAFELY PAST THE DAM.

WATER FLOWS DOWN FROM THE **FOREBAY** INTO A NARROW PIPE CALLED THE **PENSTOCK**, WHICH INCREASES THE WATER PRESSURE. THE RUSHING WATER SPINS A **TURBINE** AT THE BOTTOM OF THE PENSTOCK. THE TURBINE IS CONNECTED TO A **GENERATOR**, WHICH GENERATES THE ELECTRICITY.

# NUCLEAR: UNLOCKING THE POWER OF THE ATOM

***NUCLEAR GENERATING STATIONS*** USE HEAT PRODUCED BY THE SPLITTING OF URANIUM ATOMS (***NUCLEAR FISSION***) TO PRODUCE ***ELECTRICITY***. NUCLEAR GENERATING STATIONS CAN PRODUCE VERY LARGE AMOUNTS OF ELECTRICITY RELIABLY WITH ALMOST NO ***SMOG*** OR ***GREENHOUSE GAS*** EMISSIONS, BUT DO PRODUCE RADIOACTIVE USED FUEL. SINCE THE URANIUM CHANGES DURING THE FISSION PROCESS, NUCLEAR POWER IS CONSIDERED A ***NON-RENEWABLE FORM*** OF ***ENERGY***, BUT ITS FUEL IS HIGHLY EFFICIENT - ONE 2.5 CM LONG PELLET OF URANIUM PRODUCES AS MUCH ELECTRICITY AS MORE THAN 500 KG OF COAL.

SOME OF THE **URANIUM** THAT ONTARIO'S CANDU REACTORS USE FOR FUEL COMES FROM SASKATCHEWAN. THE WORLD'S LARGEST URANIUM MINE IS AT MCARTHUR RIVER IN NORTHERN SASKATCHEWAN.

CANDU REACTORS HAVE A VACUUM BUILDING THAT IS DESIGNED TO CONTAIN ANY RADIOACTIVE STEAM AND KEEP IT FROM ESCAPING TO THE ENVIRONMENT IN THE VERY UNLIKELY EVENT OF AN EMERGENCY.

THE REACTOR BUILDING WALLS ARE MADE OF REINFORCED CONCRETE TWO METRES THICK, AND EACH REACTOR HAS TWO SAFETY SHUTDOWN SYSTEMS. THESE ARE SOME OF THE MANY WAYS TO PREVENT THE RELEASE OF RADIOACTIVE MATERIAL WHILE THE REACTOR IS RUNNING OR IN THE VERY UNLIKELY CASE OF AN EMERGENCY.

**USED NUCLEAR FUEL** IS RADIOACTIVE AND VERY HOT WHEN IT COMES OUT OF THE **REACTOR**. AFTER BEING STORED SECURELY AT THE STATION IN WATER-FILLED POOLS CALLED **IRRADIATED FUEL BAYS** FOR ABOUT TEN YEARS, THE USED FUEL IS COOL ENOUGH TO BE MOVED INTO DRY STORAGE CONTAINERS, WHERE IT CAN SAFELY REMAIN FOR DECADES.

STEAM
BOILER
REACTOR
GENERATOR
TURBINE
TRANSFORMER
FUEL BUNDLES
COOLING WATER

***HEAT*** PRODUCED FROM NUCLEAR FISSION HEATS WATER IN A ***BOILER***, WHERE THE WATER IS BOILED INTO ***STEAM***. THE STEAM SPINS A ***TURBINE*** THAT IS CONNECTED TO A ***GENERATOR***, GENERATING ELECTRICITY. THE STEAM IS THEN COOLED BACK TO ITS LIQUID STATE BY WATER TAKEN FROM A NEARBY LAKE OR RIVER AND THEN PUMPED BACK TO THE BOILER TO REPEAT THE PROCESS.

# THERMAL: HARNESSING HEAT

THE NANTICOKE GENERATING STATION IS ONE OF THE LARGEST **THERMAL PLANTS** IN NORTH AMERICA.

***THERMAL GENERATING STATIONS*** USE HEAT FROM ***COMBUSTION*** TO PRODUCE ***ELECTRICITY.*** THERMAL STATIONS CAN PRODUCE LARGE AMOUNTS OF ELECTRICITY AND RAPIDLY INCREASE OR DECREASE OUTPUT TO MEET PEAKS IN ELECTRICITY DEMAND. THEY ALSO CONSUME LARGE AMOUNTS OF ***FOSSIL FUEL*** AND PRODUCE LARGE AMOUNTS OF ***GREENHOUSE GASES.*** FOSSIL FUELS ARE CONSIDERED A ***NON-RENEWABLE*** FORM OF ***ENERGY,*** ALTHOUGH TESTS ARE BEING DONE TO MODIFY THERMAL PLANTS TO BURN ***RENEWABLE BIOMASS.***

OPG'S THERMAL PLANTS WILL STOP USING **COAL** BY THE END OF 2014. **NATURAL GAS** AND BIOMASS MAY REPLACE COAL AS THE FUEL FOR MOST THERMAL PLANTS.

ASH PRODUCED FROM THE BURNING OF COAL AND OIL IS CAPTURED BEFORE THE **FLUE GAS** IS RELEASED INTO THE ENVIRONMENT.

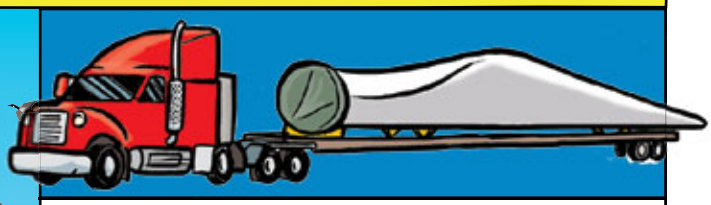
**EMISSION CONTROL** SYSTEMS REMOVE SOME OF THE POLLUTANTS THAT ARE PRODUCED FROM THE BURNING OF FOSSIL FUELS. THESE POLLUTANTS CONTRIBUTE TO **SMOG** AND **ACID RAIN.**

STACK
COAL CONVEYOR
COAL BUNKER
COAL
BOILER
STEAM
TRANSFORMER
FLUE GAS
PULVERIZER
TURBINE
GENERATOR
BURNER
COOLING WATER

***HEAT*** PRODUCED FROM THE BURNING OF FOSSIL FUEL HEATS WATER IN A ***BOILER.*** THE ***STEAM*** PRODUCED THEN SPINS A ***TURBINE*** THAT IS CONNECTED TO A ***GENERATOR,*** GENERATING ELECTRICITY. THE STEAM IS THEN COOLED BACK DOWN TO LIQUID WATER BY WATER TAKEN FROM A NEARBY LAKE.

# WIND: GREEN POWER

**WIND GENERATING STATIONS** USE **MOVING AIR** TO PRODUCE **ELECTRICITY**. WIND TURBINES CAN PRODUCE ELECTRICITY WITH ALMOST NO **SMOG** OR **GREENHOUSE GAS** EMISSIONS, BUT ONLY WHEN THE WIND CONDITIONS ARE GOOD. WIND IS A **RENEWABLE** FORM OF **ENERGY**.



PARTS OF **WIND TURBINES** ARE OFTEN SEEN BEING MOVED ON HIGHWAYS. TURBINES ARE HARD TO MOVE: EACH BLADE IS UP TO 45 METRES LONG AND CAN WEIGH OVER 100 TONNES! A COMPLETE WIND TURBINE NEEDS SEVEN TRUCKS TO CARRY ALL OF ITS PIECES.

BIRDS MAY CHANGE THEIR **MIGRATION** PATTERNS TO AVOID WIND TURBINES.

TO AVOID **TURBULENCE** FROM OTHER WIND TURBINES, THEY CANNOT BE PLACED TOO CLOSE TO EACH OTHER.

TURBINE

GEARS

GENERATOR

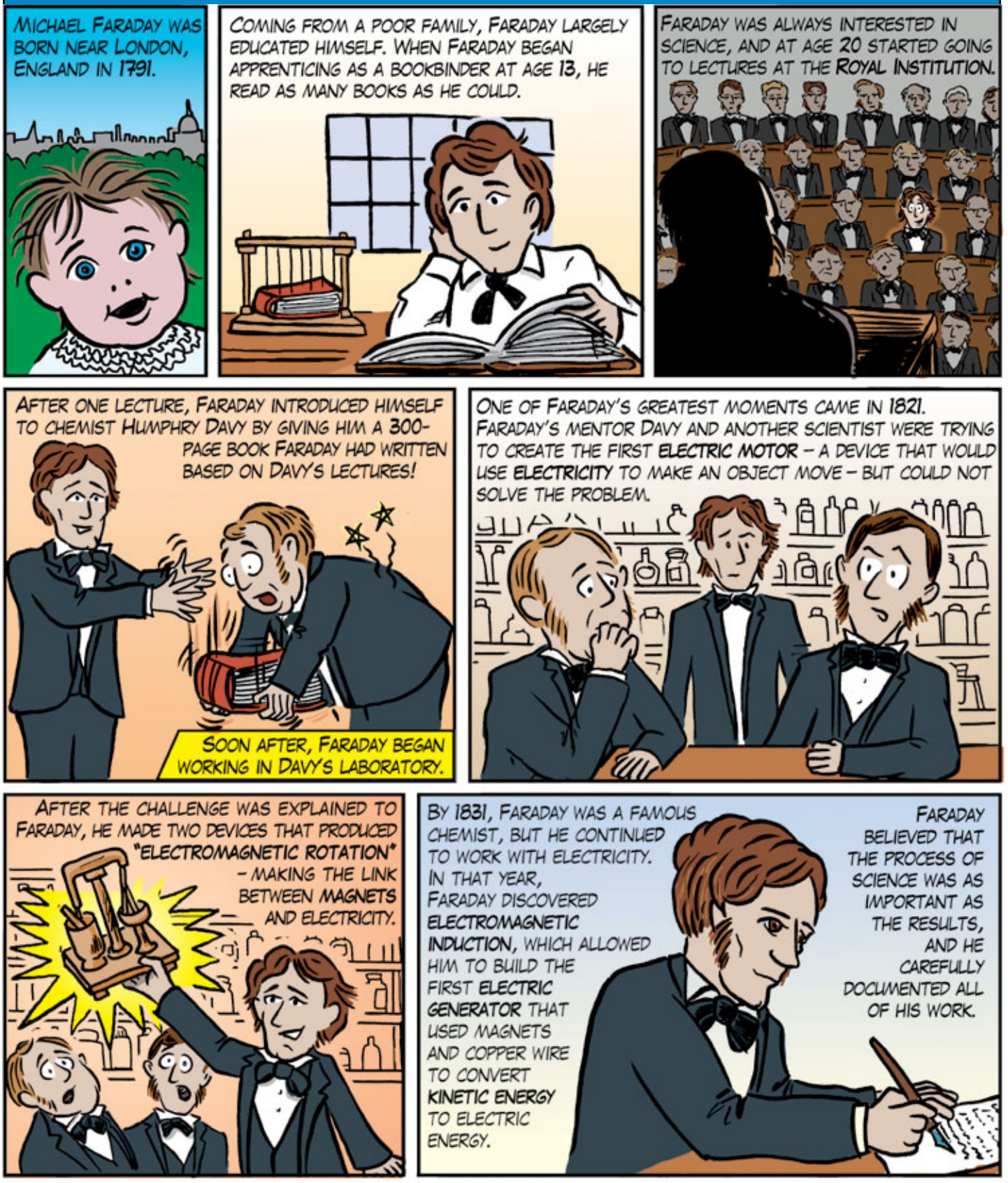
TURBINE BLADE

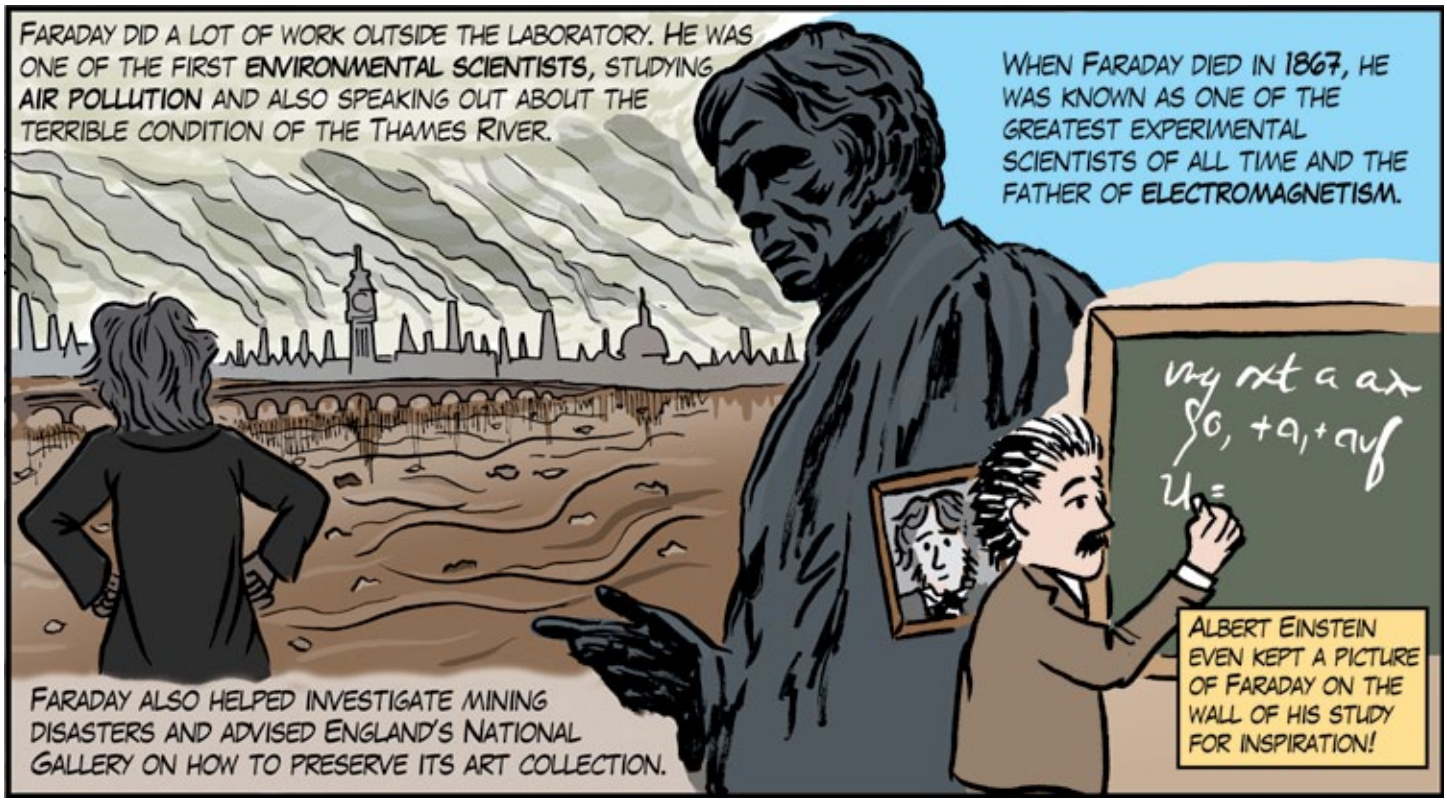
MANY WIND TURBINES ARE LOCATED ON **FARMLAND**. THE LAND CLOSE TO THE TURBINES CANNOT BE USED BY FARMERS.

TRANSFORMER

**MOVING AIR** SPINS THE **BLADES** OF THE WIND TURBINE. THE **TURBINE** THEN, THROUGH A SERIES OF GEARS, TURNS A **GENERATOR**, GENERATING ELECTRICITY.

# MICHAEL FARADAY:
## THE FATHER OF ELECTRICITY GENERATION

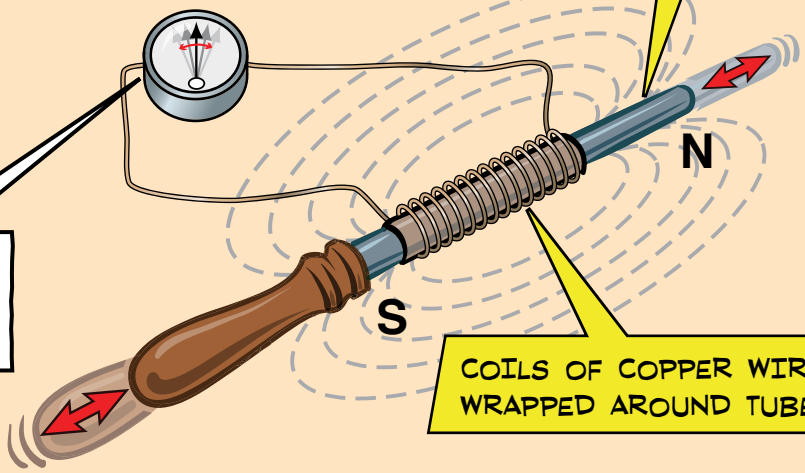





# FARADAY'S ELECTRIC GENERATOR

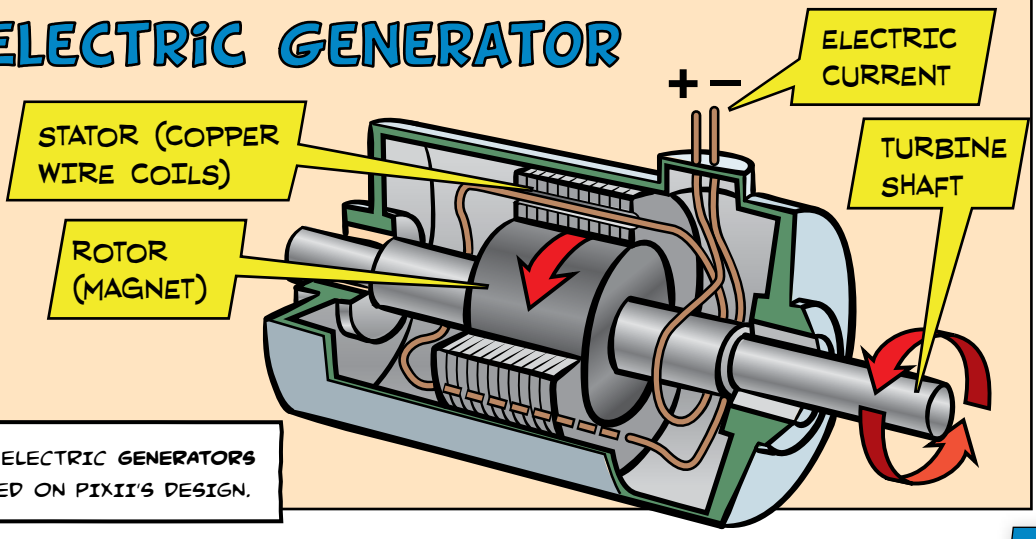
FARADAY'S GENERATOR FROM 1831 HAD A ***MAGNET*** SLIDE BACK AND FORTH THROUGH A COIL OF COPPER WIRE TO PRODUCE ***ELECTRICITY.***

FARADAY USED A **GALVANOMETER** IN HIS EXPERIMENTS TO MEASURE THE PRESENCE OF ELECTRICITY.




# MODERN ELECTRIC GENERATOR

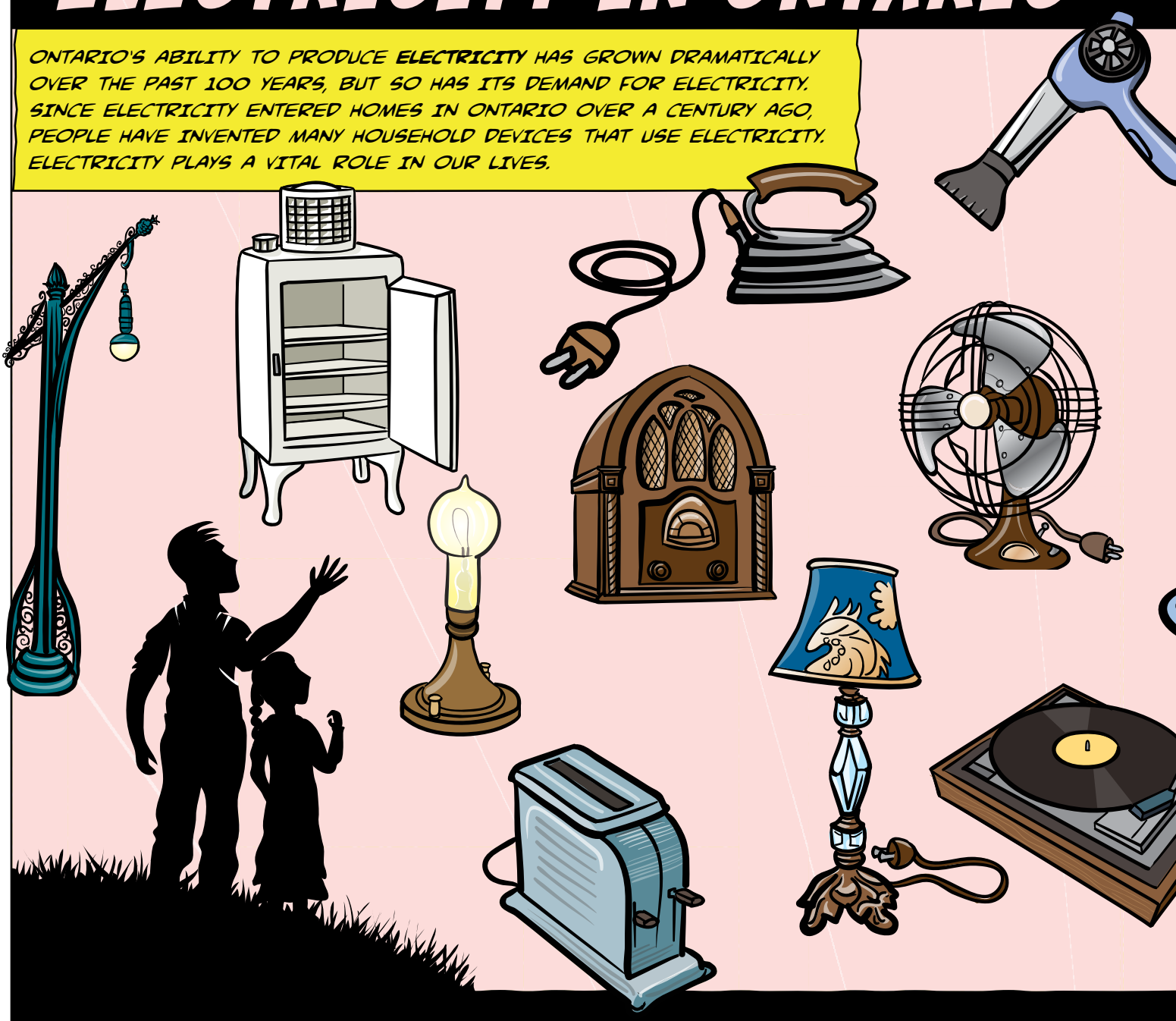
HIPPOLYTE PIXII (1808-1835) IMPROVED ON FARADAY'S DEVICE BY CHANGING THE MOTION OF THE MAGNET. INSTEAD OF MOVING THE MAGNET BACK AND FORTH, PIXII MADE THE MAGNET ***ROTATE*** INSIDE THE COIL OF WIRE.




MODERN ELECTRIC **GENERATORS** ARE BASED ON PIXII'S DESIGN.

# ELECTRICITY IN ONTARIO:

ONTARIO'S ABILITY TO PRODUCE **ELECTRICITY** HAS GROWN DRAMATICALLY OVER THE PAST 100 YEARS, BUT SO HAS ITS DEMAND FOR ELECTRICITY. SINCE ELECTRICITY ENTERED HOMES IN ONTARIO OVER A CENTURY AGO, PEOPLE HAVE INVENTED MANY HOUSEHOLD DEVICES THAT USE ELECTRICITY. ELECTRICITY PLAYS A VITAL ROLE IN OUR LIVES.



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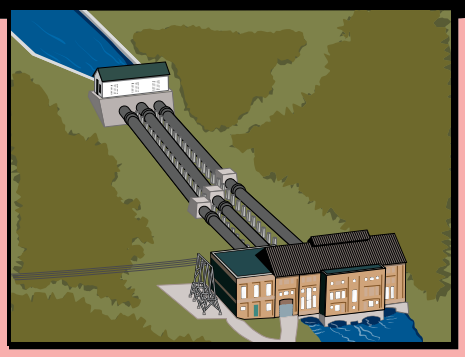

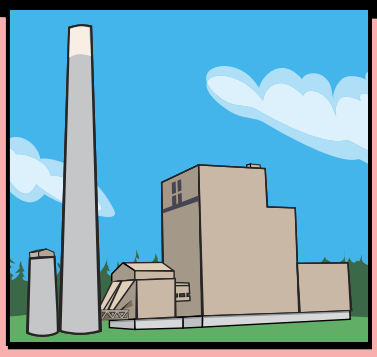

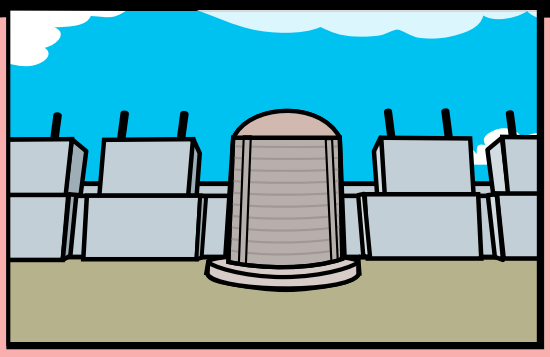

# PAST, PRESENT and FUTURE

HOW WILL YOU USE ELECTRICITY IN THE FUTURE?

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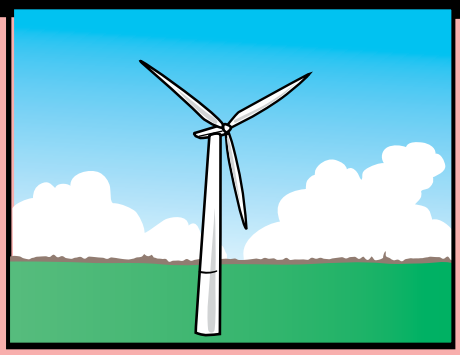

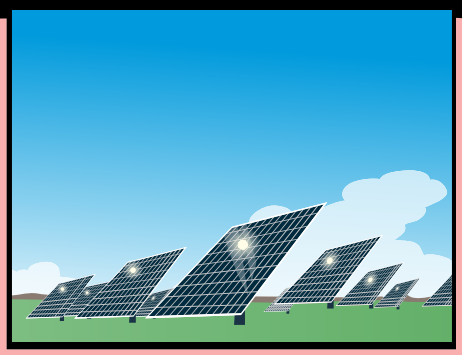

WHERE WILL ONTARIO GET ITS ELECTRICITY 50 YEARS FROM NOW?

# OPG EDUCATION PROGRAM

ONTARIO POWER GENERATION (OPG) IS A COMPANY THAT MAKES ELECTRICITY FOR OUR HOMES, BUSINESSES, AND EVERYWHERE ELSE POWER IS NEEDED. WITHOUT ELECTRICITY, WE WOULDN'T BE ABLE TO USE A COMPUTER, WATCH TV, OR EVEN TURN ON THE LIGHTS.

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 OVER TWO-THIRDS OF ONTARIO'S ELECTRICITY NEEDS.

WITH OUR PLANET'S WELL-BEING IN MIND, OPG IS COMMITTED TO BECOMING A SUSTAINABLE DEVELOPMENT COMPANY. THIS MEANS ALWAYS WORKING TO IMPROVE TECHNOLOGY IN A GREATER EFFORT TO:

- PROTECT THE WORLD WE LIVE IN
- CONSERVE ENERGY BY USING RESOURCES EFFICIENTLY
- CONTRIBUTE TO LOCAL COMMUNITIES
- WORK SAFELY, AND OPERATE OUR FACILITIES IN AN OPEN AND ENVIRONMENTALLY RESPONSIBLE MANNER

FOR MORE INFORMATION, VISIT
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ONTARIO POWER GENERATION

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