ONTARIO'S ENERGY STORY

ENERGYIQ

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INTRODUCTION

Ontario's energy mix landscape has changed dramatically in the past couple of decades. Between 2000 and 2016, Canada's greenhouse gas (GHG) emissions from electricity production dropped by 39 per cent, which is mainly attributed to Ontario's phasing out of coal use. Since then, Ontario has focused on improving the efficiency of its electricity generation through nuclear energy production, expanding on renewable energy and adding new resources, and using natural gas and oil to meet the province's heating and fuel needs.

This factbook offers a snapshot of the energy sector in Ontario. It covers topics such as where natural resources are found for energy production, the process through which energy is turned into electricity, the role of energy exports and imports, how the energy industry impacts the environment, and much more.

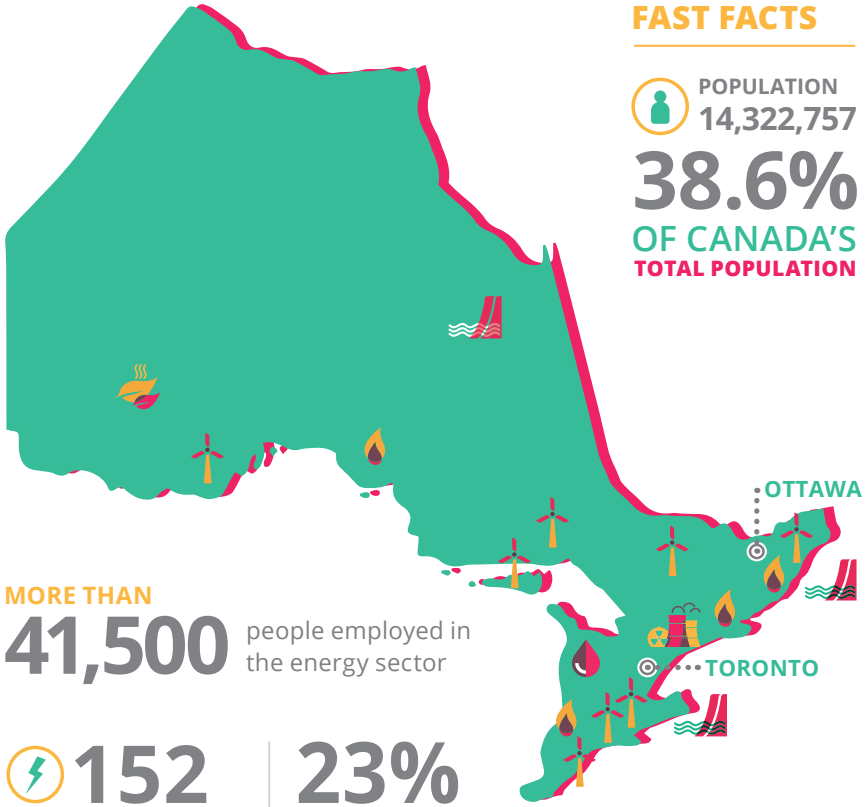
The Ontario Energy Story was produced by Energy IQ, an educational program created and delivered by Canadian Geographic Education. Energy IQ focuses on the demand, production, and transmission of various energy sources in Canada today, with the goal of helping to improve energy literacy across the country among Canadian students and educators.

For more information and resources, visit
energyiq.canadiangeographic.ca

OVERVIEW OF ONTARIO

Ontario produces several types of energy: nuclear, hydroelectricity, wind, natural gas, and small amounts of solar, crude oil, and biomass. There is also a large refining industry in Ontario.

NUCLEAR · HYDRO ELECTRICITY · WIND · NATURAL GAS · SOLAR · CRUDE OIL · REFINING · BIOMASS



FAST FACTS

POPULATION
14,322,757

38.6%
OF CANADA'S
TOTAL POPULATION

MORE THAN
41,500 people employed in the energy sector

152
TERAWATT HOURS
of electricity generated in 2017

23%
of Canada's total electricity generation

NUCLEAR

Nuclear power has been an important part of Canada's energy mix since the 1960s. Canada has four nuclear power plants, three of which are located in Ontario (the fourth being in New Brunswick). When it comes to electricity generation, nuclear power is the second-largest source of electricity in Canada. About 15 per cent of electricity generated in the country is from nuclear power.

IN ONTARIO, NUCLEAR POWER HAS AN INSTALLED CAPACITY OF 13,500 MEGAWATTS (MW) AND SUPPLIES NEARLY 60% OF THE PROVINCE'S ELECTRICITY NEEDS

Nuclear power generation is perhaps one of the most complex energy production processes. It creates a lot of energy from a relatively small amount of uranium. However, uranium has to first be mined and milled (which takes place in Saskatchewan), then processed into a usable fuel source (which happens in Ontario), before it can finally be used for nuclear fission. Canada is the world's second-largest producer and exporter of uranium, as well as the sixth-largest in the world for nuclear power generation.

Canada has developed its own nuclear reactor technology called Canada Deuterium Uranium, CANDU for short. CANDU is used around the world and has been exported to India, Pakistan, Argentina, South Korea, Romania and China.

The Canadian Nuclear Safety Commission regulates and monitors Canada's nuclear industry to protect the health and safety of Canadians and the environment, to uphold international commitments to the peaceful use of nuclear energy, as well as to keep the public informed about what goes on in the industry.

THE BRUCE GENERATING STATION in Tiverton, Ont., is the largest nuclear power plant in the world. With two facility sites (Bruce A and B) and eight reactors between them, this generating station has a capacity of about 6,600 MW. In a year, the Bruce Generating Station can produce enough electricity to power more than five million homes, providing nearly 30 per cent of Ontario's power.

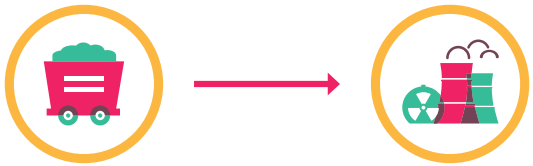
THE DARLINGTON NUCLEAR GENERATING STATION, in Clarington, has a capacity of 3,512 MW, capable of powering two million homes and providing about 20 per cent of Ontario's electricity. The Pickering Nuclear Generating Station (which has two sites, A and B) has a total capacity of 3,100 MW and can provide up to 14 per cent of Ontario's power.

BRUCE
GENERATING STATION

DARLINGTON
GENERATING STATION

PICKERING
GENERATING STATION

In 2001, Ontario made significant changes to its energy landscape by eliminating coal-fired electricity generation. The province had relied on coal for about 25 per cent of its energy supply in 2003, but managed to reduce that to zero by 2014. To help replace coal, nuclear energy in Ontario went from 42 per cent of the province's total generation to 60 per cent over the course of that decade. Nuclear energy in Ontario gained about 1,500 MW when two of the units at the Bruce Generating Station were refurbished in 2012.



RENEWABLE ENERGY

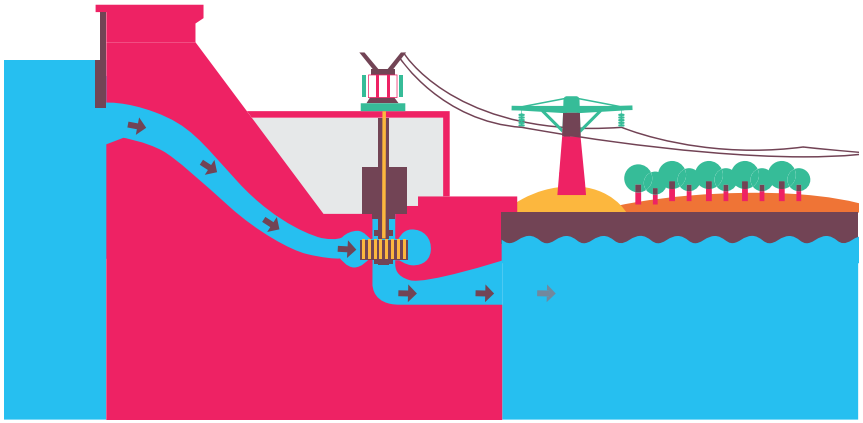
When Ontario began to phase out coal, renewable energy grew its share of the province's total electricity generation. Although hydro power didn't increase significantly, other renewables grew by seven percent.

Renewable energy sources, such as hydro power, wind, solar and biomass, can be found wherever the wind blows, rivers flow, or sun shines. Unlike other energy sources, such as oil, natural gas or nuclear energy, they are not finite and can be replenished.

HYDRO

Hydro power provides about three-fifths of Canada's electricity, making our country the second-largest producer of hydroelectricity in the world. In Ontario, hydro power represents about 26 per cent of the province's total electricity generation, with a generating capacity of 8,872 MW.

The majority of Ontario's hydroelectricity generating facilities are located in eastern Ontario, from the northern Moose River basin to the southern Ottawa River basin and all the way to Niagara Falls. Ontario's largest hydro power generation facility, Sir Adam Beck 2, is a hydroelectric dam on the Niagara River, with a capacity of 1,499 MW.

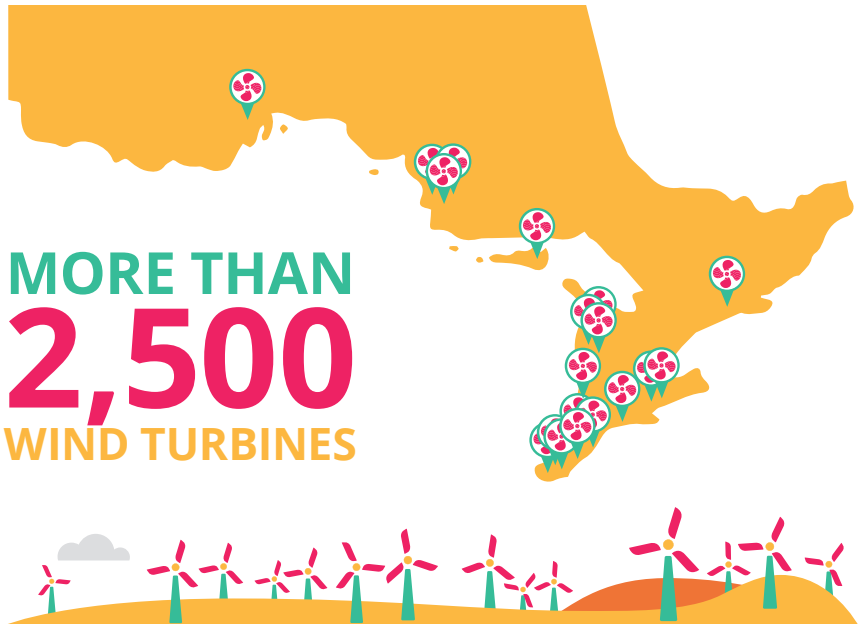


WIND

Wind energy is one of the fastest growing sources of electricity in the world; however, even as the total capacity is still growing in Canada, the addition of new wind farm installations has slowed down in recent years. Wind power is intermittent, meaning that it is not always available, and current technologies are not yet able to properly store the energy produced from wind for a later time.

Ontario leads the way in wind energy production and has an installed electricity generating capacity of about 5,076 MW, which represents 40 per cent of Canada's total wind market. With more than 2,500 wind turbines, Ontario is able to meet nearly eight per cent of its electricity demand. In 2018, Ontario added 175 MW of wind power to the grid.

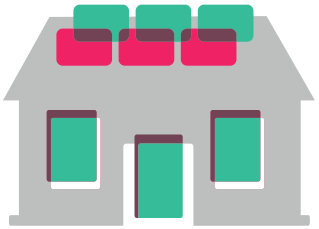
Ontario is home to six out of the 10 largest wind farms in Canada, most of which are located in southern Ontario. The biggest wind farms in Ontario are South Kent, near Chatham-Kent, and K2, near Lucknow, both with a capacity of 270 MW.



RENEWABLE ENERGY

SOLAR

Ontario is Canada's main producer when it comes to solar power, representing about 98 per cent of the country's solar capacity. However, solar power use is still growing and only meets about one per cent of Ontario's electricity needs, with a total installed capacity of 2,291 MW. Solar power generation depends on the availability of sunlight, so it is very seasonal and is affected by climate and latitude. In general, solar panels generate less electricity in the fall and winter, particularly in northern Ontario, where days are shorter in the winter.

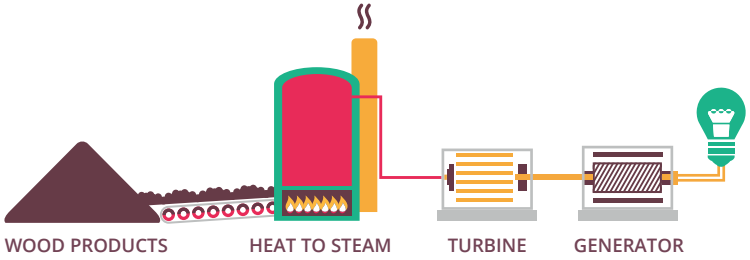


ONTARIO PRODUCES 98% OF CANADA'S SOLAR ENERGY

The largest solar farms in the country are located in Ontario - Sol-Luce Kingston and the Grand Renewable Energy Park both have a 100-MW capacity. Smaller solar panel installations are also used throughout the province to power buildings and businesses, such as community centres, or for residential use to offset electricity costs, with solar panels being mounted on rooftops.

BIOMASS

When Ontario completely eliminated the use of coal for electricity, some of the power plants previously fueled by coal were converted into biomass facilities. Currently, the 205-MW power plant at Atikokan — the largest biomass facility in North America — generates electricity by burning wood products, such as pellets, in a process that produces far fewer GHG emissions than burning coal.



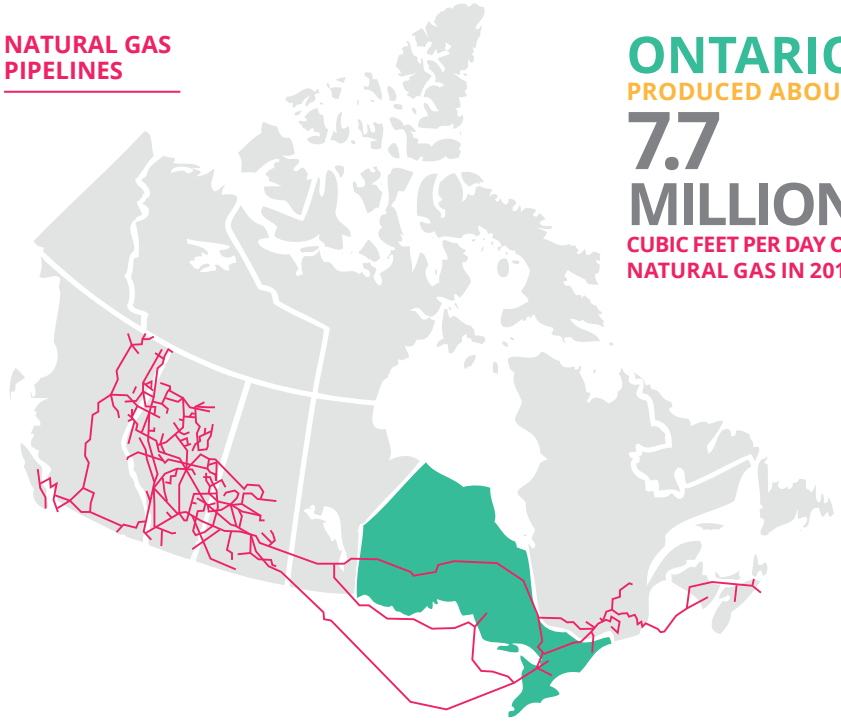
Biomass is a renewable energy source, but it is not carbon neutral. Biomass energy uses by-products from the lumber industry (e.g., sawdust and wood chips, pulp residue), or crops from biomass plantations where corn or trees are grown specifically for energy production. Biomass provides about one per cent of Ontario's electricity generation.

NATURAL GAS

Natural gas is commonly used in homes and businesses for space and water heating, as well as in industrial processes. Ontario's natural gas production accounted for about five per cent of the province's electricity generation. Natural gas production takes place near Sarnia, in southwestern Ontario. This represents less than one per cent of Canada's total natural gas production. There are no natural gas liquids (NGLs) produced in Ontario.

Canada is the fourth-largest natural gas producer in the world and the fifth-largest exporter. The majority of natural gas production is in western Canada. The TransCanada Mainline is a natural gas pipeline that runs from the border between Alberta and Saskatchewan, through Ontario, to the Quebec border. It also connects to the Union Gas Pipeline and the Great Lakes Pipe Canada in southern Ontario, just south of Toronto.

NATURAL GAS PIPELINES



ONTARIO
PRODUCED ABOUT
7.7
MILLION
CUBIC FEET PER DAY OF NATURAL GAS IN 2017

ONTARIO IS THE SECOND-LARGEST CONSUMER OF NATURAL GAS IN CANADA, REPRESENTING ABOUT 24% OF CANADA'S TOTAL NATURAL GAS USE

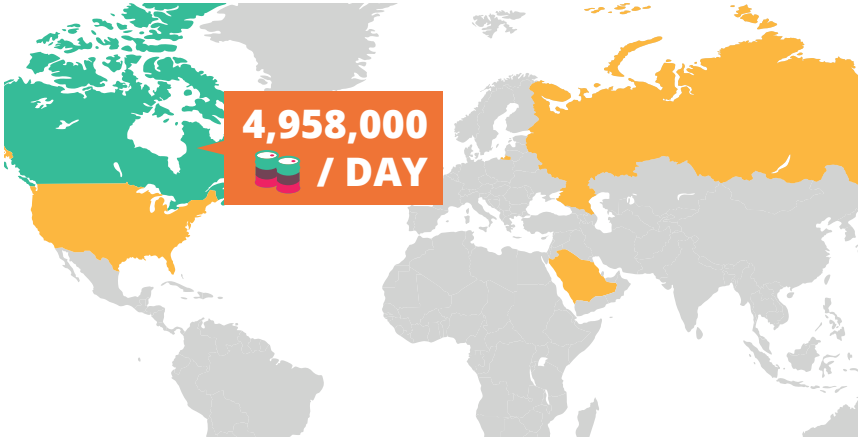
There is an underground storage facility in southwestern Ontario called Dawn Hub, which has a capacity to store about 240 billion cubic feet. Natural gas is injected into porous rock layers more than half a kilometre underground, and then when it is needed (such as for heating in the winter) it is withdrawn.

Natural gas producing areas in the mid and northeastern United States are close to some Ontario markets. In recent years, the province has increasingly imported natural gas from these areas.

Another way to transport and store natural gas is by cooling it -160 degrees Celsius until it becomes a liquefied natural gas (LNG). There is a small-scale LNG facility near Sudbury, Ont., which has been operating since 1968.

CRUDE OIL

CANADA IS THE FOURTH-LARGEST PRODUCER AND EXPORTER OF OIL IN THE WORLD



Although the oil industry is not very big in Ontario, the province holds the unique distinction of being the first in Canada to produce oil commercially in 1858 — that's before Confederation, when Ontario was still a British colony! Oil was first discovered in Ontario in a place that was later given the name Oil Springs, with larger deposits found farther north a few years later in what is now present-day Petrolia.

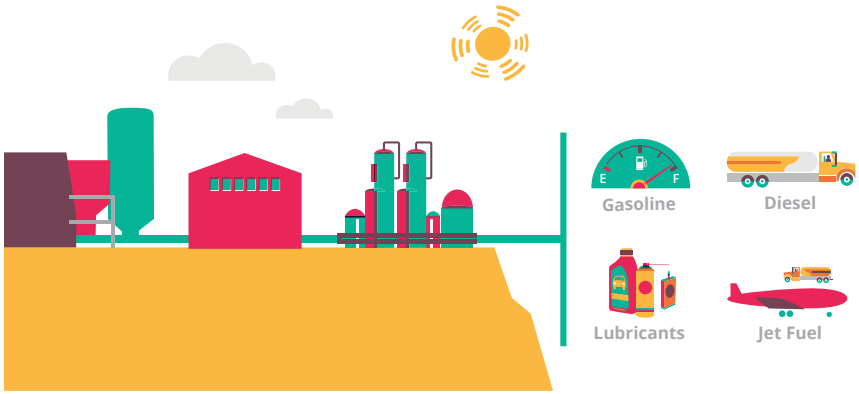
Today, Ontario's oil industry is still located in the southwest part of the province. Ontario produces a small amount of oil, which represents less than 0.1 per cent of total oil production in Canada. In 2017, the province produced about 600 barrels per day of light oil.

About 37 per cent of the oil produced in Canada is shipped to domestic refineries, such as those in Ontario, but the majority of domestic oil is exported mainly to United States.

There are several pipelines that transport crude oil throughout Ontario and they are mainly located in the south of the province. The capacity of these pipelines varies from 74 thousand barrels per day (Mb/d) to 540 Mb/d. The largest of those pipelines, Enbridge Line 5 and 6B, transport oil from western Canada and United States to refineries in Sarnia, Ont. The TRANS-NORTHERN PIPELINE is used to distribute refined petroleum products (RPPs, such as gasoline, diesel fuel, jet fuel and heating oil) and connects distribution centres in Quebec and Ontario.

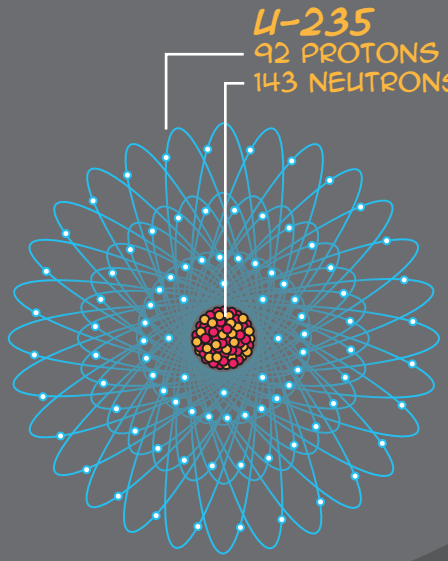
Ontario has the third-largest petroleum refining capacity in Canada at 392 Mb/d. This accounts for one-fifth of Canada's refining capacity. Sarnia, the main hub for Ontario's oil imports and refinement, has three major refineries, and there is a fourth refinery in Nanticoke. Ontario receives crude oil mainly from western Canada, with one-fifth also being imported from the United States.

Ontario's refineries can supply about three quarters of the province's demand for RPPs. Ontario is the largest domestic market for Canadian RPPs; however, the province's per person consumption of RPPs is the lowest in the country.

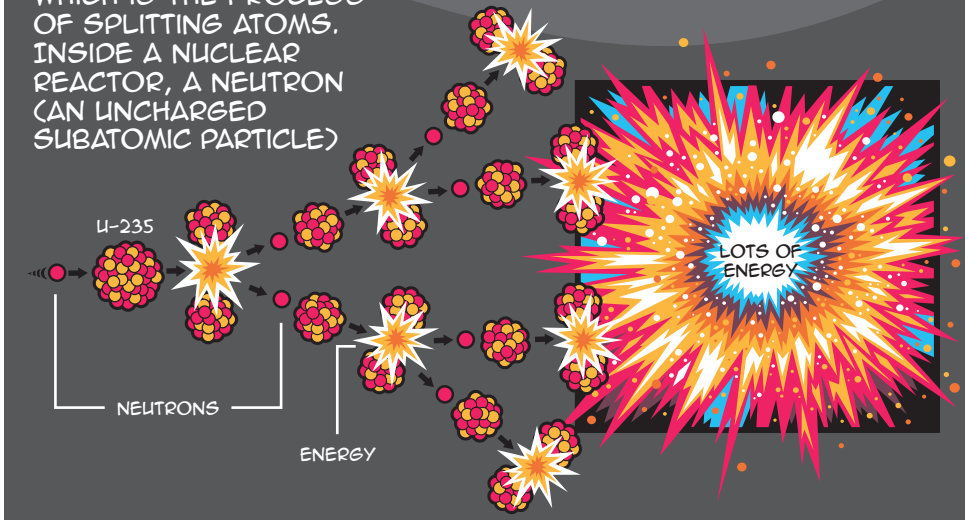


NUCLEAR

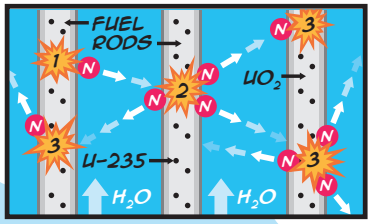
URANIUM IS A HEAVY METAL THAT IS MINED AND PROCESSED TO SERVE AS FUEL FOR NUCLEAR REACTORS. IT IS A RADIOACTIVE ELEMENT AND THE ISOTOPE URANIUM -235 CAN BE USED TO PRODUCE NUCLEAR ENERGY. ISOTOPES ARE VARIATIONS OF THE SAME ELEMENT, WITH AN ATOM HAVING A DIFFERENT ATOMIC WEIGHT DEPENDING ON THE NUMBER OF NEUTRONS IN ITS NUCLEUS.



NUCLEAR ENERGY IS CREATED THROUGH NUCLEAR FISSION, WHICH IS THE PROCESS OF SPLITTING ATOMS. INSIDE A NUCLEAR REACTOR, A NEUTRON (AN UNCHARGED SUBATOMIC PARTICLE)



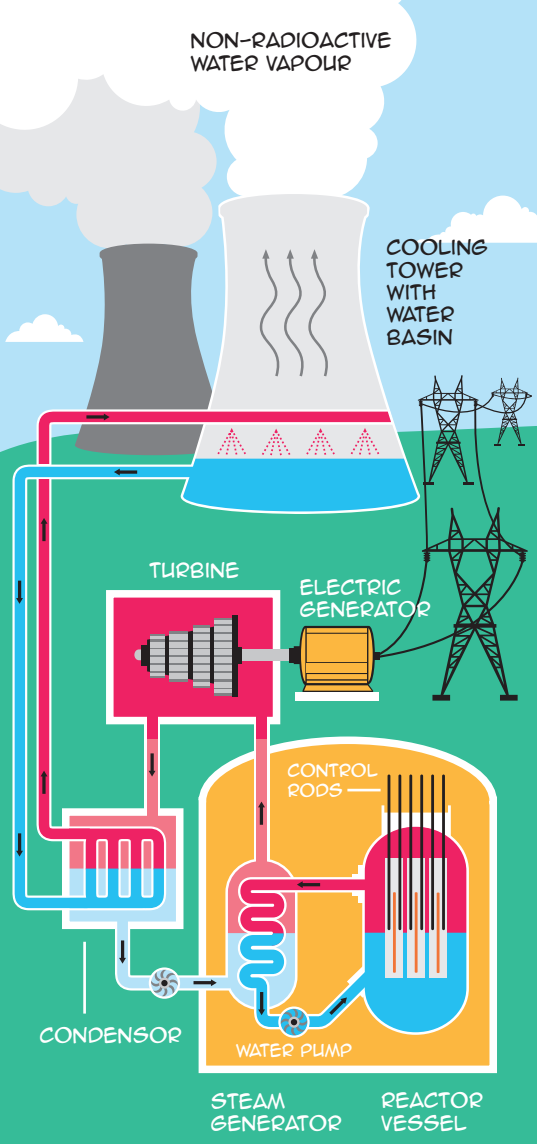
IS FIRED AT THE NUCLEUS OF THE ISOTOPE U-235. THIS EXTRA NEUTRON IN THE NUCLEUS MAKES THE ISOTOPE HEAVIER AND HIGHLY UNSTABLE. TO RELEASE THAT ENERGY, THE ISOTOPE SPLITS INTO TWO SMALLER ELEMENTS. IT ALSO RELEASES A FEW NEUTRONS IN THE PROCESS. THESE NEUTRONS GO ON TO COLLIDE INTO OTHER U-235 ISOTOPES, CAUSING A CHAIN REACTION (I.E., A NUCLEAR REACTION).

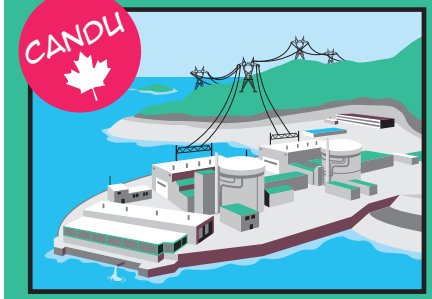


THE NEUTRONS RELEASED IN THE REACTION MOVE AT SPEEDS THAT MAKE IT DIFFICULT FOR THEM TO HIT OTHER ISOTOPES. TO MAKE SURE THE NUCLEAR REACTION CAN CONTINUE, THE NEUTRONS NEED TO BE SLOWED DOWN, OR "MODERATED." WATER IS USED AS A MODERATOR.

NEUTRONS BOUNCE OFF OF WATER'S HYDROGEN NUCLEI AND LOSE ENERGY WITH EACH COLLISION.

NUCLEAR REACTORS ALLOW FOR CONTROLLED NUCLEAR FISSION. CONTROL RODS, MADE FROM A MATERIAL THAT ABSORBS NEUTRONS, ARE RAISED OR LOWERED INTO THE NUCLEAR REACTOR TO CONTROL THE RATE OF FISSION. NUCLEAR FISSION PRODUCES A LARGE AMOUNT OF ENERGY, WHICH IS DISSIPATED AS HEAT.

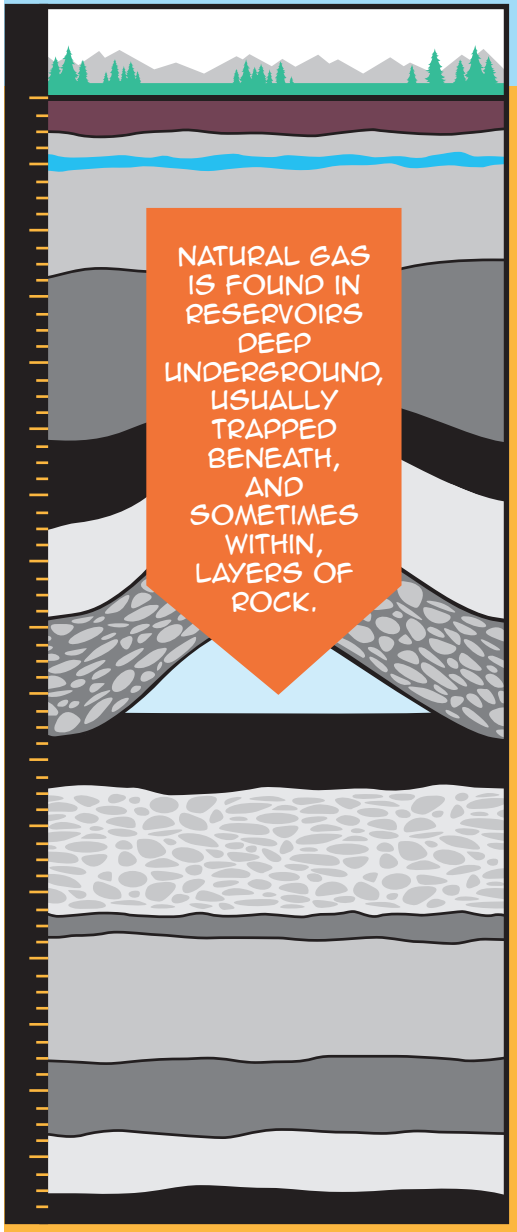




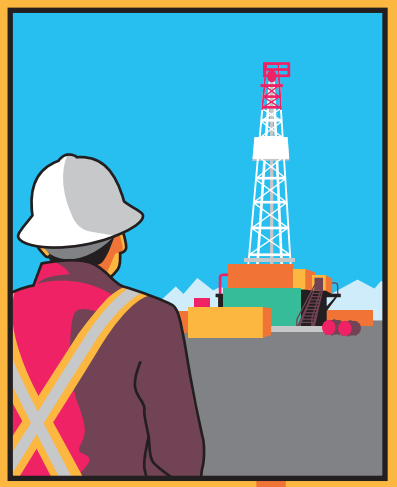
THIS HEAT BOILS WATER AND CREATES STEAM TO POWER THE GENERATORS THAT PRODUCE ELECTRICITY.

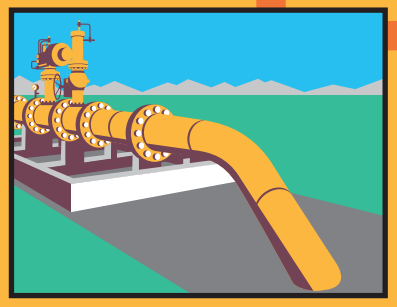
CANADA HAS DEVELOPED ITS OWN UNIQUE NUCLEAR REACTOR TECHNOLOGY, CALLED CANDU, WHICH IT HAS EXPORTED TO THE WORLD.

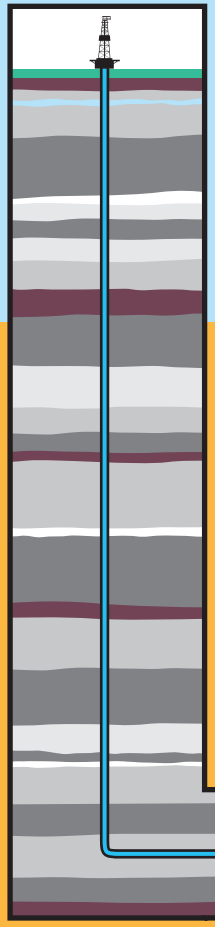
NATURAL GAS



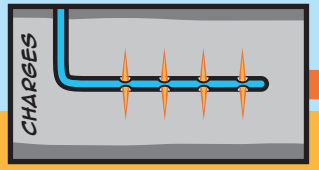
TO EXTRACT ***CONVENTIONAL NATURAL GAS***— GAS TRAPPED IN POROUS SANDSTONE AND LIMESTONE FORMATIONS— WELLS ARE DRILLED INTO THE EARTH, AND THE GAS FLOWS TO THE SURFACE THROUGH THE WELL.

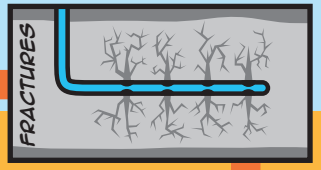






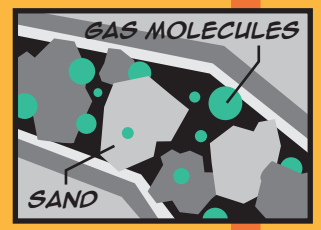
TO EXTRACT ***UNCONVENTIONAL NATURAL GAS***— LOCKED WITHIN SHALE ROCK FORMATIONS— HORIZONTAL WELLS ARE DRILLED DEEP INTO THE EARTH AND A SERIES OF CHARGES ARE SENT DOWN THE WELL TO MAKE SMALL FRACTURES IN THE ROCK IN A PROCESS KNOWN AS HYDRAULIC FRACTURING.



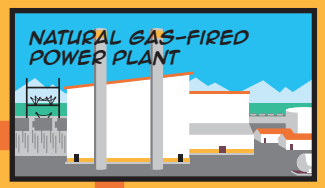


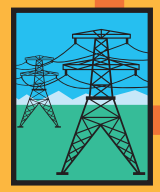
NEXT, A PRESSURIZED MIXTURE OF WATER, SAND AND CHEMICALS IS SENT DOWN THE WELL TO HOLD OPEN THE CRACKS IN THE ROCK.

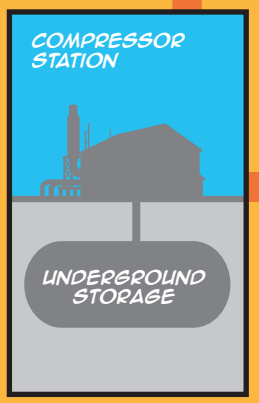
THEN THE GAS, WHICH IS LIGHTER THAN THE FLUID MIXTURE, RISES UP THROUGH THE WELL TO THE SURFACE.

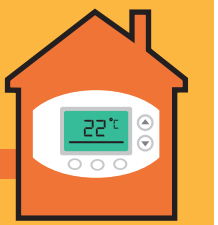


EITHER WAY, NATURAL GAS CAN BE USED TO GENERATE ELECTRICITY, AND HEAT HOMES.



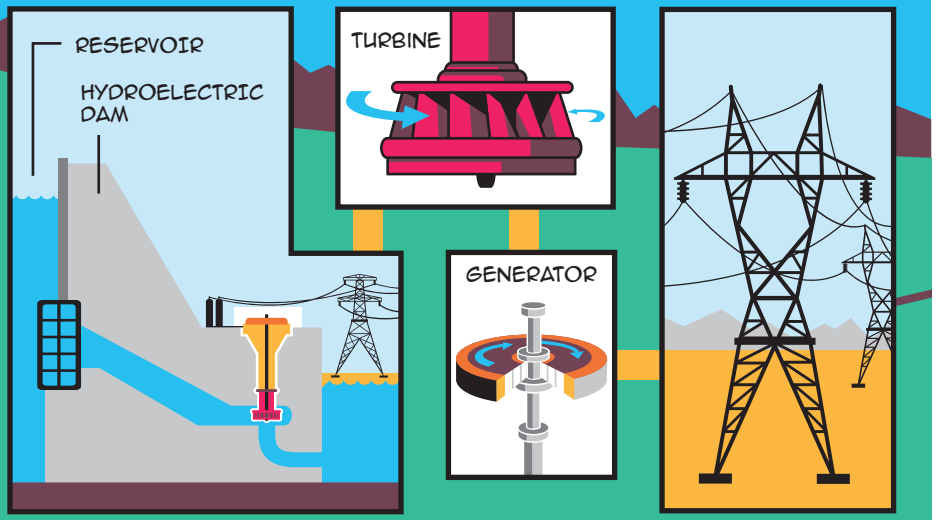






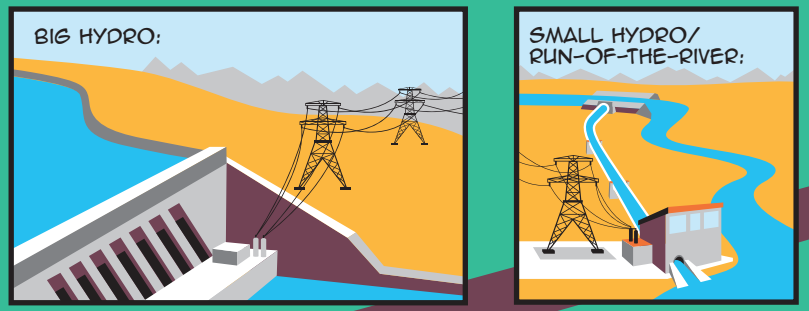
HYDROELECTRICITY

FOR BIG HYDRO PROJECTS, A DAM IS BUILT ON A RIVER TO STORE WATER IN A RESERVOIR. WHEN THE WATER IS RELEASED, ITS KINETIC ENERGY PASSES THROUGH A PENSTOCK (A SET OF CHANNELS OR PIPES). THE WATER TURNS THE BLADES OF A TURBINE, CREATING MECHANICAL ENERGY, WHICH IS THEN CONVERTED INTO ELECTRICITY BY A GENERATOR.

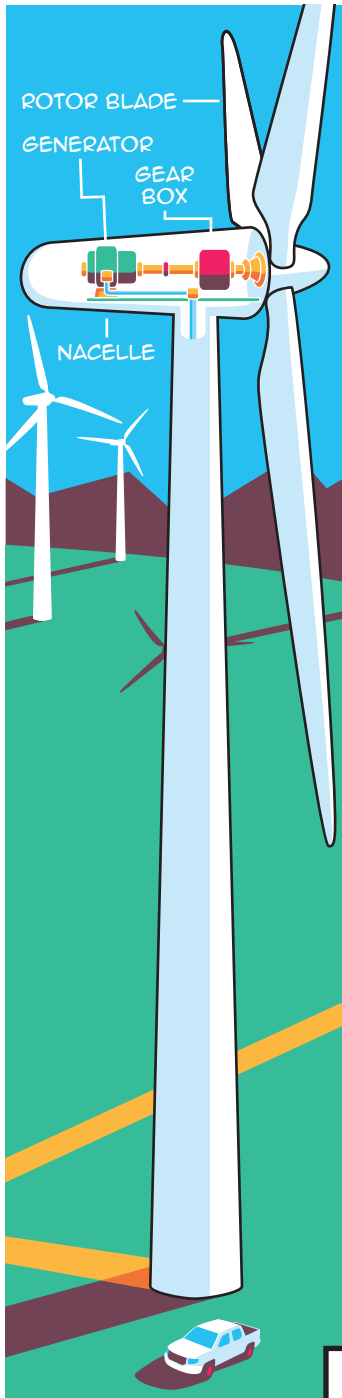


IN A PUMPED STORAGE SYSTEM, WATER IS RELEASED WHEN THERE IS PEAK DEMAND. WHEN DEMAND IS LOW, THE WATER IS PUMPED BACK UP TO THE RESERVOIR USING ELECTRICITY FROM OTHER ENERGY SOURCES. IN RUN-OF-THE-RIVER INSTALLATIONS, THE NATURAL FLOW OF THE RIVER PROVIDES THE NECESSARY KINETIC ENERGY.

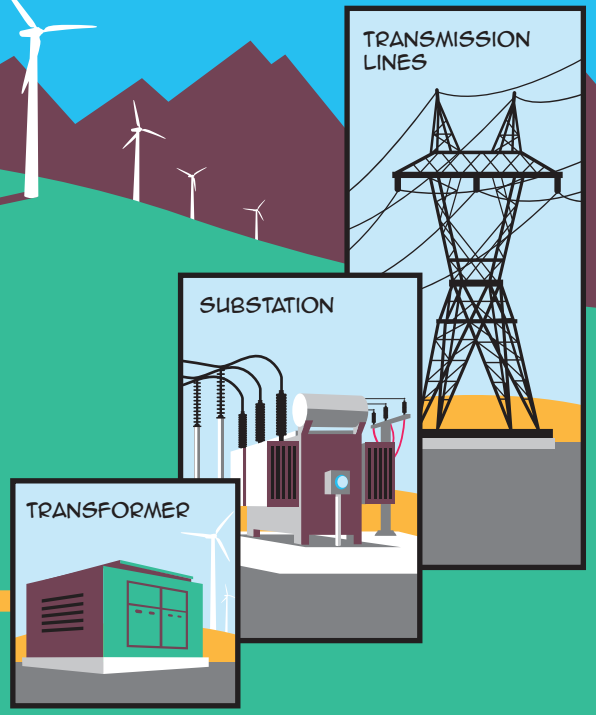
HYDROELECTRICITY IS A RENEWABLE SOURCE OF ENERGY BECAUSE WATER IS NOT USED UP IN THE ENERGY PRODUCTION PROCESS.



WIND



A WIND TURBINE CATCHES THE KINETIC ENERGY FROM A BLOWING BREEZE, CAUSING THE PROPELLER BLADES TO TURN AND CREATE MECHANICAL ENERGY. THE TURBINE IS CONNECTED TO A GENERATOR, WHICH CONVERTS THE MECHANICAL ENERGY INTO ELECTRICITY.



A TRANSFORMER INCREASES THE ELECTRICITY TO A HIGHER VOLTAGE, TRANSMITTING IT TO A SUBSTATION THAT INCREASES THE VOLTAGE AGAIN SO THAT IT CAN TRAVEL OVER LONGER DISTANCES THROUGH THE ELECTRICITY GRID.

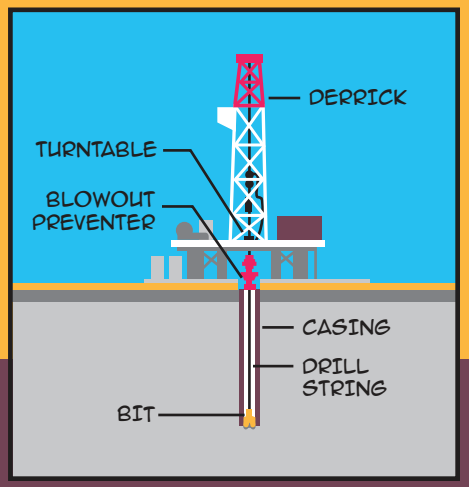
WIND ENERGY IS RENEWABLE, BUT IT IS ALSO INTERMITTENT, MEANING THAT IT IS NOT ALWAYS AVAILABLE.

CRUDE OIL

CRUDE OIL IS A YELLOW-TO-BLACK LIQUID, AND REFERS TO LIGHT, MEDIUM, AND HEAVY HYDROCARBONS. IT IS FOUND IN UNDERGROUND RESERVOIRS, OIL SANDS DEPOSITS, OR OFFSHORE RESOURCES.

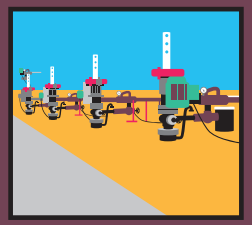
CONVENTIONAL CRUDE OIL

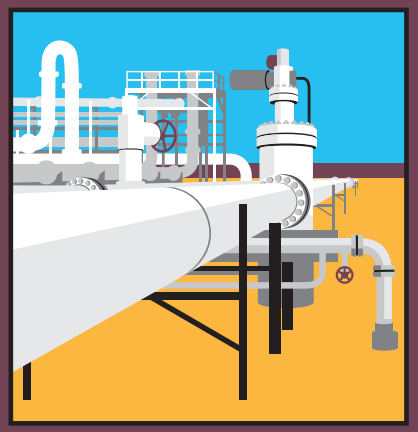
ONCE OIL IS DISCOVERED IN AN UNDERGROUND RESERVOIR, THE SITE IS PREPARED FOR DRILLING. A DRILLING RIG IS USED TO HOUSE THE TOOLS AND PIPES NEEDED TO DRILL HOLES IN THE EARTH AND BRING OIL TO THE SURFACE.



AFTER THE RIG IS REMOVED, THE CREW PUTS A PUMP ON THE WELL HEAD, WHICH PULLS OIL UP THROUGH THE WELL. WHEN COMPLETED, THE WELL BRINGS A STEADY FLOW OF OIL TO THE SURFACE.

DRILLING RIGS ARE FITTED WITH BLOWOUT PREVENTERS (BOP) TO HELP PREVENT ACCIDENTAL RELEASES OF OIL.





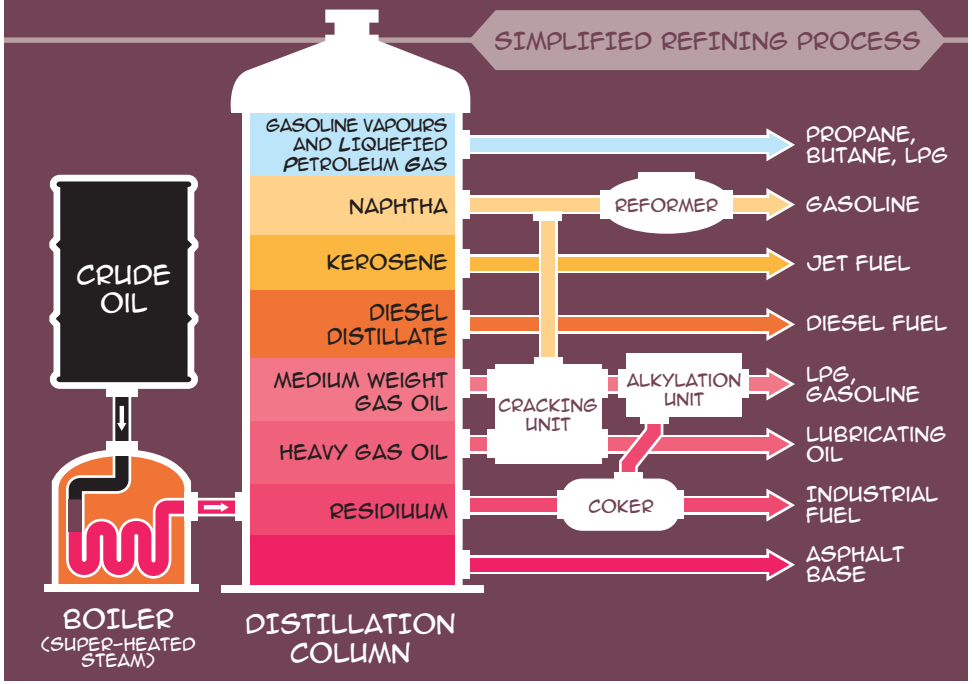
THE CRUDE OIL IS THEN KEPT IN STORAGE TANKS OR TAKEN TO REFINERIES TO BE PROCESSED INTO VARIOUS PETROLEUM PRODUCTS.

OIL IS PRIMARILY TRANSPORTED BY PIPELINES—CANADA HAS A PIPELINE NETWORK OF MORE THAN 840,000 KILOMETRES. IT IS ALSO TRANSPORTED BY RAIL, TRUCKS, OR TANKER SHIPS TO WHERE IT NEEDS TO GO.

REFINING CRUDE OIL

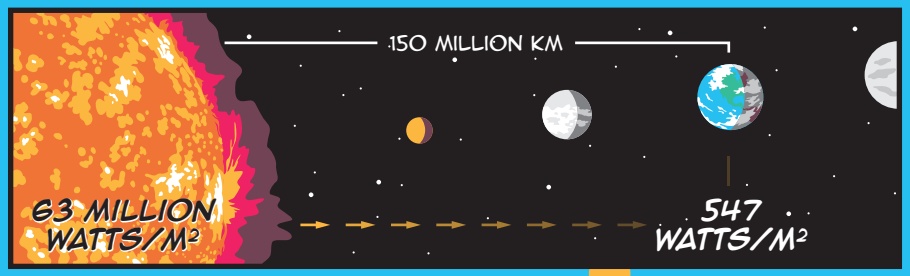
CRUDE OIL IS TRANSFORMED INTO REFINED PETROLEUM PRODUCTS (RPPS), SUCH AS GASOLINE AND JET FUEL, THROUGH A PROCESS CALLED REFINEMENT. REFINERIES ARE LARGE AND COMPLEX INDUSTRIAL STRUCTURES COMPRISING MANY DIFFERENT PARTS AND PROCESSES THAT PRODUCE DIFFERENT RPPS.

THE COMPONENTS MAKING UP CRUDE OIL EVAPORATE AT DIFFERENT TEMPERATURES, ALLOWING THEM TO BE SEPARATED AND REFINED INTO VARIOUS END PRODUCTS.

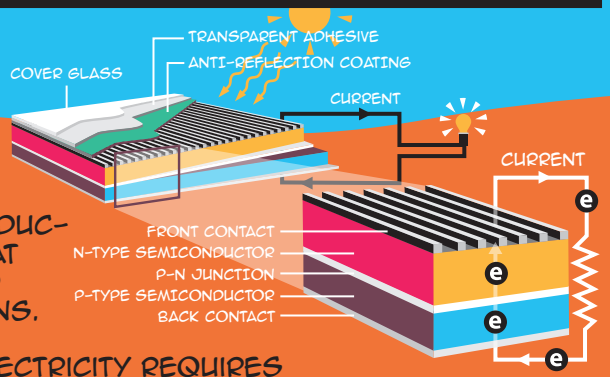


SOLAR

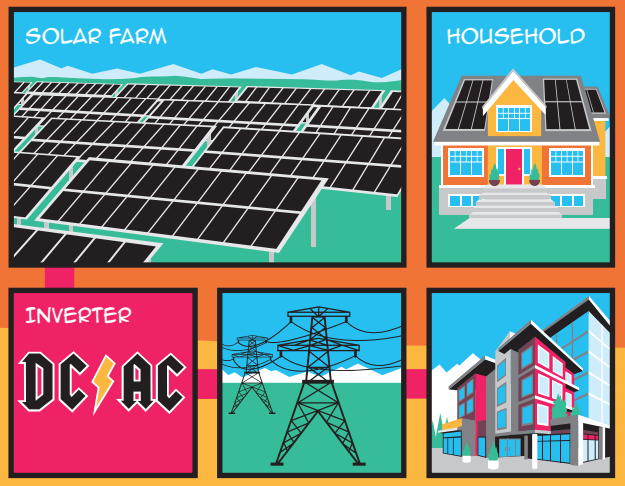
THE SUN CONSTANTLY EMITS AN INCREDIBLE 63,000,000 WATTS PER SQUARE METRE OF ENERGY, BUT MOST IS LOST ON THE 150 MILLION KILOMETRE JOURNEY TO EARTH.



ELECTRICITY IS GENERATED FROM SOLAR ENERGY THROUGH THE USE OF PHOTOVOLTAIC (PV) TECHNOLOGY, MADE OF SEMICONDUCTOR MATERIALS THAT ABSORB LIGHT AND RELEASE ELECTRONS.



GENERATION OF ELECTRICITY REQUIRES CURRENT AND VOLTAGE. IN A SOLAR CELL, THE FLOW OF ELECTRONS CREATES THE CURRENT AND THE ELECTRIC FIELD CAUSES VOLTAGE.

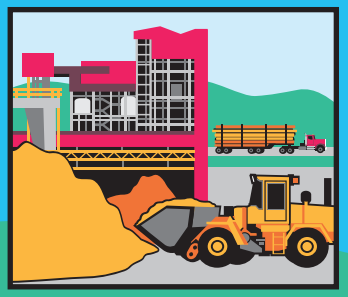


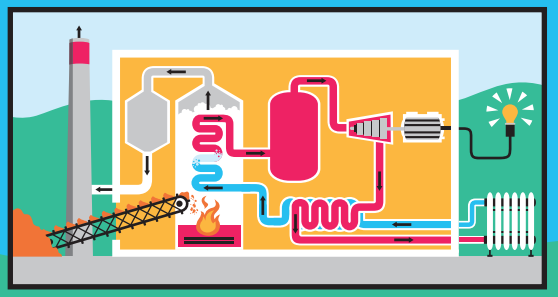
THE ELECTRICITY PRODUCED IN A PV PANEL IS DIRECT CURRENT (DC).

SINCE THE NORTH AMERICAN POWER GRID – AND MOST HOMES AND BUILDINGS – WORKS ON ALTERNATING CURRENT (AC), AN INVERTER IS REQUIRED TO CHANGE THE POWER FROM DC TO AC.

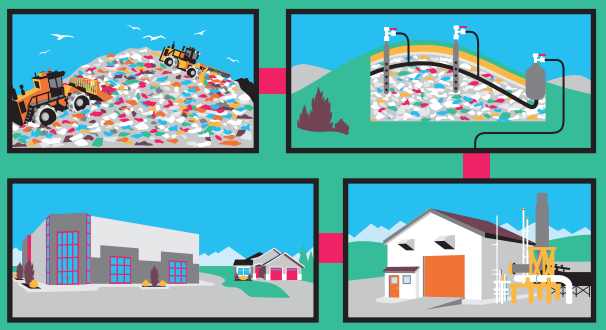
BIOMASS

BIOENERGY BEGINS WITH BIOMASS, WHICH IS ANY ORGANIC MATERIAL THAT HAS STORED ENERGY FROM THE SUN IN A CHEMICAL FORM, SUCH AS TREES, HAY, AND EVEN HOUSEHOLD GARBAGE.



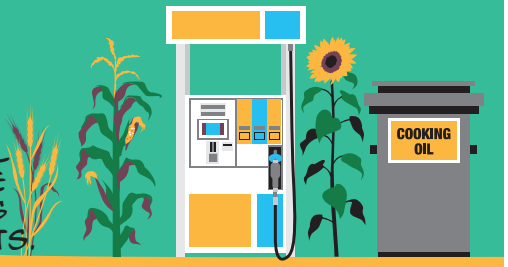


ELECTRICITY: WOODCHIPS, SAWDUST OR OTHER ORGANIC MATERIALS ARE COLLECTED AND COMPRESSED INTO PELLETS. THE PELLETS FUEL A BOILER USED TO PRODUCE STEAM. IT TURNS TURBINES, WHICH SPIN MAGNETS IN A GENERATOR, CONVERTING MECHANICAL ENERGY INTO ELECTRICITY.



LANDFILL GAS CAPTURE: METHANE FROM CAPPED LANDFILLS IS COLLECTED, PROCESSED AND UPGRADED, THEN TRANSMITTED BY PIPELINE TO HOMES AND BUSINESSES.

LIQUID BIOFUELS: BIOETHANOL IS CREATED BY FERMENTING AND DISTILLING BIOMASS SUCH AS STRAW, CORN OR GRAINS. BIODIESEL IS DERIVED FROM VEGETABLE AND ANIMAL FATS, INCLUDING USED OIL FROM RESTAURANTS.



ENVIRONMENTAL IMPACTS

The development, production, and transmission of energy can impact the environment in various ways, but not all impacts are equal. The emission of GHGs contributes to climate change. In 2017, Ontario's GHG emissions were 159 megatonnes of carbon dioxide equivalent — about a fifth of Canada's total GHG emissions.

OIL

In Ontario, about six per cent of GHG emissions were from the oil and gas sector, but the majority of emissions came from the transportation sector, which relies on refined petroleum products. Crude oil and refined petroleum products produce fewer emissions than coal.

Although GHG emissions in Canada have increased between 2005 and 2017, the GHG emissions per barrel of oil produced in the oilsands have dropped 28 per cent. This decrease is due to technological innovation and improvements in efficiency. There are also technologies that are being developed to reduce the amount of carbon emissions from power plants, such as carbon capture storage.

Various extraction methods for oil also rely heavily on fresh water. Tailings ponds allow sand, clay and trace amounts of residual hydrocarbons to settle so that water at the top can be recycled for use in oil sands extraction processes. Tailings ponds are constructed and managed to prevent contaminated water from entering rivers, lakes or underground aquifers. In the case of oilsands operations, land is also cleared of vegetation in order to be mined. It can take several years to return the land back to its original state through land reclamation practices.

NATURAL GAS

Natural gas produces the least amount of GHG emissions out of all the fossil fuels. However, natural gas is composed primarily of methane. Methane traps more heat in the atmosphere than carbon dioxide, but carbon dioxide remains in the atmosphere for longer. Venting and flaring of natural gas, and leaks during production and processing, can contribute to emissions.

Natural gas production also relies on water. Hydraulic fracturing, which is used to extract natural gas from the ground, requires a lot of water. Producers will recycle water or use saline (non-potable) water for fracking operations, reducing the volume of fresh water needed. Careful water management ensures that natural gas wells are properly constructed and maintained so that they don't leak and contaminate nearby groundwater.

NUCLEAR

Although nuclear power doesn't emit GHGs in the process of producing energy, there are other risks to the environment. The biggest challenge with nuclear power is how to ensure safe, long-term storage of hazardous waste. Radioactive materials need to be stored in containers that are leak-proof (which need to be stored in sealed facilities) to ensure they do not get into the groundwater because they can remain radioactive for thousands of years.

There are also GHG emissions and environmental impacts associated with the mining of uranium and the construction of nuclear power plants. In addition, nuclear plants need to be constructed with failsafes in case of possible natural disasters such as earthquakes.

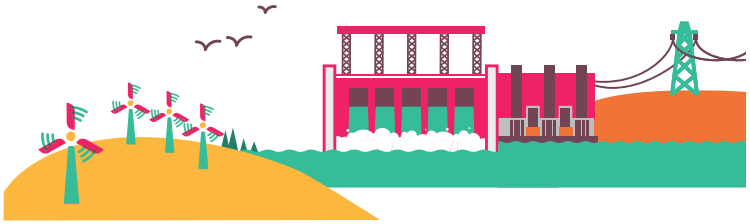
Nuclear power is the most water-intensive method of power generation. Water is boiled to produce steam to turn a turbine, and then this water needs to be cooled down before it can be released back into the environment — warmer water can harm wildlife and kill aquatic plant life.

ENVIRONMENTAL IMPACTS

HYDRO

The infrastructure for hydroelectricity requires large swathes of land and can alter river ecosystems, causing long-term changes to the natural landscape and impacting the migration of fish species. There are some ways to mitigate the negative impact on wildlife, such as with fish ladders that allow fish to migrate around obstacles. Dams can also affect habitats downstream by causing rivers to run dry, which is why most hydro power companies are required to release water periodically to maintain the natural balance.

Another issue with hydro power is the decomposition of vegetation in dam reservoirs (this an issue for very big dams), which releases methane gas and contributes to global warming. Run-of-the-river facilities have a smaller impact on habitats and wildlife because they do not alter the landscape to the same degree as dam reservoirs.



WIND

There are no emissions from wind energy, but the manufacturing, transportation and installation of wind turbines produces some GHG emissions. However, these emissions are minor when compared to most other energy sources.

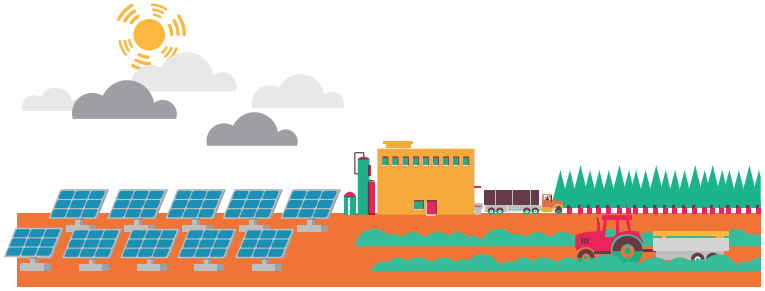
Wind farms can also be harmful to wildlife, specifically when birds and bats collide with wind turbines. This can be mitigated by careful selection of wind farm sites to avoid wildlife migration corridors and by pausing the operation of turbines during periods of low wind so as not to confuse birds or bats by slow-moving blades.

The land used for wind farms can be multipurpose because the wind turbines do not take up too much space, which allows for the surrounding area to be used for animal grazing, trails, or even agriculture.

SOLAR

Solar energy production doesn't directly contribute to climate change, but the manufacturing of solar panels does have an impact on the environment. Some of the materials used for solar panels, such as cadmium and lead, are toxic. These minerals, as well as other compounds, are difficult or expensive to recycle. The hazardous waste can't simply be dumped at a regular landfill because the toxic materials could get into the soil. However, methods for recycling solar panels exist, and as the need for it grows, countries will have to create and enforce standards for proper recycling.

Land being used for solar farms can't be used for anything else, such as farming. In addition, animal habitats can be affected or fragmented. The best way to reduce impact on wildlife is with careful site selection and to make use of existing land that has already been previously developed, such as former landfills or on top of buildings.



BIOMASS

Burning biomass to generate electricity produces GHGs and pollutants, the same as any fossil fuel. There is potential for biomass energy to help reduce GHG emissions if developed responsibly. However, the process of growing plants for biomass energy production requires water and land, and GHGs are emitted in the harvesting and transportation of the biomass. It is necessary to do more research into the long-term viability of using biomass energy, its environmental impacts, and the economic cost of pursuing it as an energy source.

ENERGY ECONOMY

Ontario's energy sector contributed $20.4 billion to Canada's gross domestic product in 2018.

IN ONTARIO, MORE THAN 41,500 PEOPLE DIRECTLY EMPLOYED IN ENERGY PRODUCTION AND TRANSMISSION

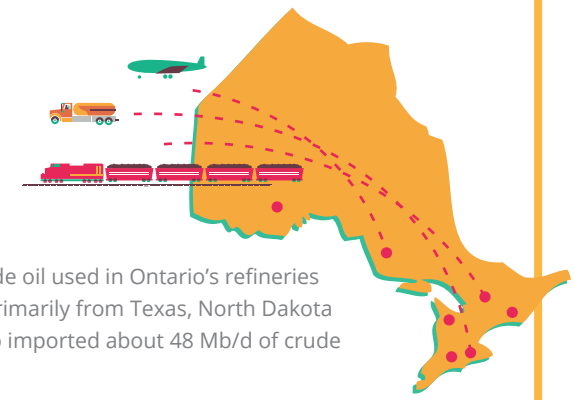
38,000+ EMPLOYED
IN ELECTRICITY GENERATION, TRANSMISSION AND DISTRIBUTION, (DIRECTLY AND INDIRECTLY)

Ontario is a net exporter when it comes to electricity. In 2018, Ontario exported 18.6 terawatt hours, the majority of which went to United States, specifically Michigan and New York.

9,500+ EMPLOYED
IN NUCLEAR POWER PLANTS

Oil and gas production and distribution employed more than 6,700 people, with about another 7,000 employed in supporting roles. Ontario's manufacturers play an important role in Canada's oil and natural gas industry.

In 2016 and 2017, more than 1,100 companies in Ontario supplied goods and services worth about $1.9 billion to the oilsands sector in western Canada.



About 20 per cent of the crude oil used in Ontario's refineries comes from United States, primarily from Texas, North Dakota and Indiana. In 2018, Ontario imported about 48 Mb/d of crude oil from United States.

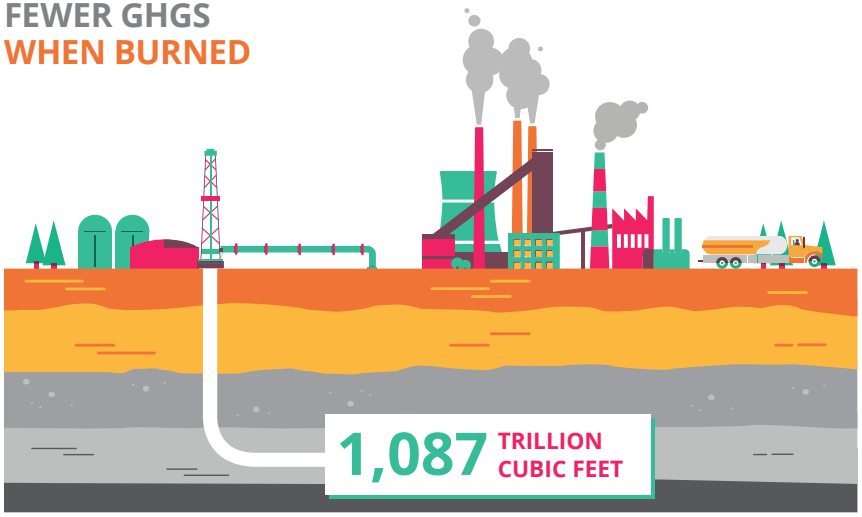
ENERGY POTENTIAL & FUTURE

Nuclear power will continue to play a key role in Ontario's future energy mix. Six of the nuclear reactors at Bruce Generating Station will be refurbished by 2033, which is meant to extend the life of the facility to 2064. The Darlington Generating Station is currently undergoing refurbishment for its reactors, which is expected to be done by 2026. The Pickering site is scheduled to be shut down in 2024 and then decommissioned. Electricity generated through nuclear power is expected to decline slightly by 2040 because of the Pickering shutdown and while Bruce refurbishments are taking place. There are no new nuclear power plants planned for the near future.

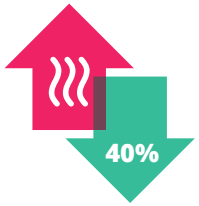
Canada has about 170 billion barrels of remaining established crude oil reserves. There are also about 1,087 trillion cubic feet of remaining marketable gas resources, which could theoretically last Canada for the next few hundred years. Natural gas is an important part of Canada's future energy mix because when it is burned it produces fewer GHG emissions than other hydrocarbons such as coal and oil.

Three small-scale LNG facilities have been proposed for Ontario. One in Thorold has received a permit for construction and two others in northern Ontario are expected to be in service by 2020. The 985-MW Napanee Generating Station is currently under construction and awaiting approval to begin generating electricity using natural gas.

NATURAL GAS EMITS FEWER GHGS WHEN BURNED

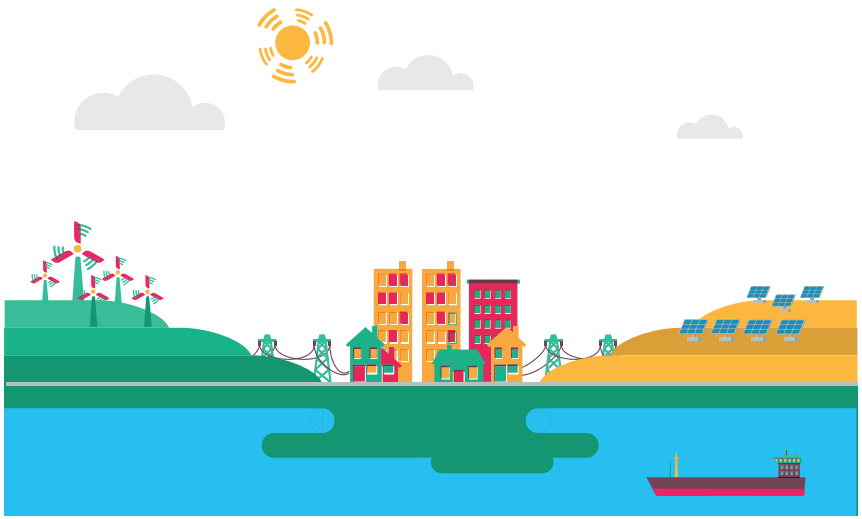


ENERGY POTENTIAL & FUTURE



The federal government has made a commitment to reduce methane emissions from the oil and gas sector by at least 40 per cent by 2025. Strategies for doing this include limiting emissions from leaks and venting.

The share of renewable energy in Ontario's energy mix will continue to grow. Installed solar energy capacity is projected to nearly triple by 2040 in Ontario. Wind turbines are also becoming more affordable and more efficient. In Ontario, there are several large wind farms that have been proposed or are currently under development, such as the 300-MW Henvey Inlet Wind Farm, which will be the largest wind project in Ontario.



ENERGY TERMS

CAPACITY – the maximum amount of power or fuel that can be generated, used, or transported

ESTABLISHED CRUDE OIL RESERVES – oil that is considered to be recoverable and marketable

GHGs – greenhouse gases, such as carbon dioxide, methane, or nitrogen oxide, which contribute to climate change and global warming

GROSS DOMESTIC PRODUCT – the measure of economic activity (goods and services) in a country

LIGHT OIL – oil that is liquid at room temperature, more fluid than crude oil from the oilsands

Mb/d – thousand barrels per day (of oil)

MW – megawatts

REFURBISH – to repair or restore something to a better working order

RPPs – refined petroleum products (made from oil) such as gasoline, diesel, heating oil and jet fuel

TAILING POND – water left over from oilsands production that is set aside to settle in a basin

VENTING/FLARING – controlled release/burning of natural gas during production that can't be sold or used

ENERGY QUIZ

For more fun puzzles and quizzes, visit energyiq.canadiangeographic.ca

Test your knowledge of Ontario's energy resources.

1) How many nuclear power plants are there in Ontario?

A) 1 B) 2
C) 3 D) 4

2) In which year did Ontario eliminate coal as a fuel for electricity generation?

A) 1991 B) 2018
C) 1985 D) 2014

3) What percentage of Ontario's electricity is generated from hydro power?

A) 26% B) 32%
C) 44% D) 56%

4) TRUE or FALSE: The addition of new wind farm installations has slowed down in recent years.

A) True B) False

5) When coal was phased out as a fuel for electricity generation, some of the power plants were converted to run on which energy source?

A) Natural Gas B) Nuclear
C) Biomass D) None of the Above

6) TRUE or FALSE: A solar farm in Attawapiskat, Ont., would produce more energy than a solar farm of the same size in London, Ont.

A) True B) False

7) Where does Ontario rank in Canada for natural gas consumption?

A) First B) Second
C) Third D) Forth

8) What year did Ontario first produce oil commercially?

A) 1867 B) 1858
C) 1922 D) 1936

9) What is the largest nuclear power generating station in the world?

A) Bruce Generating Station B) Darlington Generating Station
C) Pickering Generating Station D) Sir Adam Beck 2 Generating Station

10) TRUE or FALSE: Ontario has the fourth-largest refining capacity in Canada.

A) True B) False

WORD SEARCH PUZZLE

Z	E	K	T	W	R	E	M	C	V	R	V	P	Q	M	T
D	S	F	I	N	T	E	R	M	I	T	T	E	N	T	A
B	L	E	C	O	U	I	S	N	G	K	U	N	O	W	T
P	E	S	G	S	P	B	Z	N	A	P	F	F	G	M	I
P	O	H	H	E	U	Y	F	B	N	K	W	Q	K	S	K
E	O	R	F	H	T	W	O	T	X	U	F	Z	S	A	O
V	S	U	N	M	J	I	N	A	B	P	C	Z	R	X	K
N	C	W	N	S	C	N	B	I	L	O	H	L	C	T	A
C	A	D	Q	A	Y	D	S	T	A	U	M	J	E	E	N
D	N	P	L	R	A	F	O	F	B	G	R	I	O	A	B
A	D	E	T	N	R	F	P	L	P	B	A	R	S	B	R
R	U	M	L	I	G	H	T	O	I	L	P	R	E	X	G
F	G	D	X	A	N	M	I	P	T	U	S	S	A	L	A
E	A	I	Y	B	E	O	R	W	E	D	M	N	O	D	Y
B	S	N	P	O	I	L	S	P	R	I	N	G	S	R	H
K	A	H	S	P	M	R	N	O	P	Z	P	X	I	B	E

Questions

1) What energy source provides nearly 60 per cent of Ontario's electricity? (7 letters)

2) Where is Ontario's main hub for all oil imports and refinement? (6 letters)

3) What is the name of the natural gas underground storage facility in Southwestern Ontario? (2 words, 7 letters)

4) Aside from hydro power, which renewable energy source generates the most electricity in Ontario? (4 letters)

5) What type of oil is produced in Ontario? (2 words, 8 letters)

6) What is the name of the largest biomass facility in North America? (8 letters)

7) What word is used to describe an energy source, such as wind, that is not always available? (12 letters)

8) Sir Adam Beck 2, Ontario's largest hydroelectric facility, is located on which river? (7 letters)

9) What did they name the location where oil was first discovered in Ontario? (2 words, 10 letters)

10) What is the acronym name for Canada's nuclear reactor technology? (5 letters)

ANSWER KEY

Answers To Energy Quiz (Pg 32):

1) C - 3

2) D - 2014

3) A – 26%

4) True

5) C – Biomass

6) False - Solar farms in the north produce less energy than in the south

7) B - Second

8) B - 1858

9) A - Bruce Generating Station

10) False - Ontario has the third-largest petroleum refining capacity in Canada

Answers To Word Search (Pg 33):

Z	E	K	T	W	R	E	M	C	V	R	V	P	Q	M	T
D	S	F	I	N	T	E	R	M	I	T	T	E	N	T	A
B	L	E	C	O	U	I	S	N	G	K	U	N	O	W	T
P	E	S	G	S	P	B	Z	N	A	P	F	F	G	M	I
P	O	H	H	E	U	Y	F	B	N	K	W	Q	K	S	K
E	O	R	F	H	T	W	O	T	X	U	F	Z	S	A	O
V	S	U	N	M	J	I	N	A	B	P	C	Z	R	X	K
N	C	W	N	S	C	N	B	I	L	O	H	L	C	T	A
C	A	D	Q	A	Y	D	S	T	A	U	M	J	E	E	N
D	N	P	L	R	A	F	O	F	B	G	R	I	O	A	B
A	D	E	T	N	R	F	P	L	P	B	A	R	S	B	R
R	U	M	L	I	G	H	T	O	I	L	P	R	E	X	G
F	G	D	X	A	N	M	I	P	T	U	S	S	A	L	A
E	A	I	Y	B	E	O	R	W	E	D	M	N	O	D	Y
B	S	N	P	O	I	L	S	P	R	I	N	G	S	R	H
K	A	H	S	P	M	R	N	O	P	Z	P	X	I	B	E

1) Nuclear

2) Sarnia

3) Dawn Hub

4) Wind

5) Light Oil

6) Atikokan

7) Intermittent

8) Niagara

9) Oil Springs

10) CANDU

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