Renewable Energy Sources

Re-Energy Program
Backgrounder

Comparing Energy Sources

Energy can be grouped into two main categories based on its source—non-renewable energy and renewable energy.

Renewable Energy

Renewable energy is the form of energy that quickly replaces itself after being used and is usually available in a never-ending supply. Renewable energy comes from natural flow of sunlight, wind, or water around the world. With the help of special collectors, we can capture some of this energy and put it to use in our homes and businesses. As long as sunlight, water, and wind continue to flow, and trees and other plants continue to grow, we will have access to a ready supply of renewable energy.

Over the last 200 years, the energy that industrialized countries have relied on has mostly come from non-renewable sources such as coal and oil, sources that cannot renew or replenish in a short amount of time. Buried deep underground, they take millions of years to form, and once they are used up, they are gone. In the case of oil, one of the fossil fuels, some experts predict that people will use up the Earth's supply in as little as 40–45 years. Oil, like coal and natural gas, comes from the fossils of plants and animals that were alive millions of years ago.

Renewable energy sources promise a way to power the future without using up the Earth's natural resources. They also produce energy in ways that are much less harmful to the environment. Fossil fuels release a lot of greenhouse gas pollution into the atmosphere, especially carbon dioxide (CO_2), which are harmful for the environment. In fact, the burning of fossil fuels is the main cause of climate change. Because oil, natural gas and coal (as well as uranium in the case of nuclear energy) must be mined, then processed in a plant and transported great distances, they also disrupt many natural habitats. Renewable energy is becoming more popular not only because it uses sources that are renewable, but also because it is much cleaner.

Kinds of Renewable Energy

This backgrounder looks at six kinds of renewable energy and their sources:

- solar energy — from the sun
- wind power — from the wind
- hydro power — from falling water
- bioenergy — from burning plant material
- geothermal energy — from the Earth's natural heat
- tidal power — from the ocean's tide

Solar Energy

Humans have marveled at the power of the sun since the beginning of time. The sun is the source of all energy on Earth. It drives the water cycle and wind, and it provides us with our food supply. Some societies have worshipped the sun, and many have found ways to harness the sun's heat and light for human use.

For billions of years, the sun has poured out huge amounts of energy in several forms—including light, heat, radio waves and even x-rays. The Earth, in orbit around the sun, intercepts a very small part of the sun's immense output. On Earth, direct sunlight is available from sunrise until sunset, except during solar eclipses. The sun sends about 2,000 times more energy than humans use to the Earth every day. In one hour, the amount of solar energy falling on the Earth could power the whole planet for an entire year!

Canada is one of the sunniest countries in the world, even during the winter. Yet compared to countries such as Germany, Spain and China, Canada uses very little solar energy for heat and power. In 2020, for example, China, the world leader in solar electricity, installed more than 49,655 megawatts (MW), while Canada installed only 15 MW. The global Solar Energy Market is expected to grow at a compound annual growth rate of 20% from 2020 to 2026.

Solar collectors and modules are designed to capture some of the sun's energy and change it from radiation into more usable forms such as heat or electricity. Solar energy can be collected in two ways:

- **as heat** using glass-covered flat metal plates,
- **as electricity** using solar cells made from silicon or other semi-conductor materials.

Heat energy is also called *thermal energy*. Solar heating uses the sun's heat energy to provide heat for buildings, greenhouses, solar cookers and hot water heaters. That can simply mean using the sun's heat to warm a home through windows that face south. Solar heating can also involve the use of solar collectors that capture and store heat energy. A solar collector is a shallow box painted black on the inside, with a clear glass or plastic top. The sun's heat energy enters the box through the clear top and is absorbed by the black paint. The result is a lot of heat, which is contained by the box. The heat is carried away by water that flows through metal tubes that line the box. The sun-heated water is then carried through insulated pipes to a tank.

Light energy involves the use of photovoltaic (PV) cells which absorb light and produce electricity. The word *photovoltaic* comes from *photo* meaning light and *voltaic* meaning electric. Fine wires are sandwiched between two wafers with different electrical properties. Sunlight causes electrons to travel between the layers and produce electricity. The most common material used for PV cells is a special kind of silicon crystal. Silicon, in the form of sand or quartz, is one of the most common elements found on Earth. Photovoltaics are commonly used in calculators, rechargeable flashlights and radios, and they are mounted on rooftops to generate electricity for buildings.

It is also possible to produce more electricity by mounting and connecting many PV cells on a panel. Grouped together, PV cells are called a *solar array*. Solar arrays can be different sizes, providing small or large amounts of power. Sometimes reflective mirrors are used to produce even more electricity. Solar PV can now be used to supply the electrical grid. Large-scale standalone PV power plants are being built in several countries including the United States, Spain and Portugal. PV can also be used on its own with a battery to provide power in remote locations. PV collectors have been used to meet home lighting and other power needs in developing countries. There, batteries are used to store power so that electricity can be available when sunlight is not. Two billion people in the world have no access to electricity, and some believe that solar energy would be the best way to provide them with a clean, affordable solution.

Manufacturing solar collectors for heat energy does involve the controlled use of very small amounts of toxic materials. When solar panels are in use, they are completely safe and do not release any toxic materials into the environment. They can be placed on roofs, over parking lots or on unused land. The production of PV cells also involves the use of a number of chemicals and materials, especially silicon. PV cells are now being designed to use fewer chemicals. Once built and in use, PV cells have no toxic effects.

Solar power is efficient and clean, and its source of power is free. Installing solar power can be costly, but as technology has advanced, it has become more affordable. Solar water heaters cost only a little more than water heaters that use non-renewable energy. In 2017 wind turbine prices had an average cost of $0.06 per kWh, and at times dropped to $0.04 per kWh. At the same time, the cost of solar photovoltaic (PV) had fallen to $0.10 per kWh. In comparison, electricity produced by fossil fuels typically ran from $0.05 to $0.17 per kWh.

Hydro Energy

The Greek word for water is *hydro*, and generating electricity from water is all about tapping into the energy of falling water. Hydro power involves storing vast amounts of water and then releasing them to turn giant turbines and make energy available as it is needed. Humans have used water power to supply energy for a long time. Archaeologists have discovered descriptions of water wheels used for grinding grain that date back to more than 3,000 years ago. Today, the energy of falling water is used mainly to drive electrical generators at hydroelectric dams. As long as snow and rainfall can fill the streams and rivers, moving water can be a renewable source of energy.

Canada generates about 60% of its electricity supply from hydroelectricity, mostly from facilities with large dams. Large-scale hydro developments are common in Canada, provinces of British Columbia, Manitoba and Quebec generate more than 88% of their power through hydroelectricity.

There are two types of hydro power:

- **Large Hydroelectric Dams** that are usually built on larger rivers. A dam captures the water so it can be released as needed. The water falls from the top of the dam to the bottom where the turbines are located. The spinning turbines are connected to generators that convert the energy into electricity. The more water there is and the steeper the slope, the more energy the water will produce. The water is then released and continues flowing downstream.
- **Micro Hydro** works like a small dam. It diverts water from small rivers or streams to generate electricity and then returns the water downstream. Micro hydro, which generates up to 10 MW of electricity, produces about 6% of the world's hydro power.

While large hydro projects are considered a source of renewable energy, they may not be sustainable in the long run because of their impact on the environment.

Hydroelectric generation does not produce significant greenhouse gas emissions, but does have other major environmental impacts. The reservoirs often destroy vast areas of highly productive forest and wildlife habitat. The dams also damage freshwater ecosystems by blocking the movement of fish and other organisms. Pollution from mercury and other contaminants is a problem in many reservoirs in northern Canada. Because large-scale hydro power requires the damming of river valleys to create a large lake of water, it can have a big impact on a number of species, including humans. The world's largest hydro dam, the Three Gorges dam in China, has created a lot of anxiety to local residents around its potential for flooding or if it completely collapsed which would be a disaster as it would release over 10 billion cubic metres of reservoir water.

Because the water in a dam is released at different rates depending on the amount of electricity that needs to be generated, shoreline levels keep changing. Very little plant life can survive on the shorelines due to this constant change. The plants that once existed in the flooded area eventually rot and release carbon dioxide into the atmosphere. In some places, when flooded plants decay, they also produce very small amounts of the greenhouse gas methane. Yet overall hydro is a very clean source of power: it creates about 18 grams of greenhouse gas pollution per kWh compared to 900 grams for coal and 400 grams for natural gas.

Land species in low-lying areas that need the habitat are forced to move, and they often struggle or cannot survive in higher altitude habitats. Fish struggle too. Fish often lay eggs on shorelines, but with the changing water levels, some eggs might not hatch. Fish swimming upstream or downstream are also affected because the dam stops their upstream or downstream movement. Fish ladders can help, but they do not always work.

Hydro power supplies about 16% of the world's electricity consumption. Most of that power is produced by 45,000 large hydro dams.

If designed in ways to keep the impact on the environments and on humans as low as possible, hydro power can be an excellent source of renewable energy. Canada could more than double its current hydro power use, from 78,000 MW at present to 156,000 MW, but that would impact many more rivers, valleys and habitats.

Bioenergy Energy

Humans have been using bioenergy since we learned to use fire thousands of years ago. Bioenergy is produced from biological materials, including ***biomass***, the biological materials used to make biofuel. The term "biomass" refers to any form of plant or animal tissue. In the energy industry, biomass refers to wood, straw, biological waste products such as manure, and other natural materials that contain stored energy. The energy stored in biomass can be released by burning the material directly, or by feeding it to micro-organisms that use it to make biogas, a form of natural gas. Energy from biomass is still used around the world, for everything from cooking and heating to generating electricity.

To produce heat or electricity, wood chips from sawmills are most commonly used as a biomass energy source. This material, which is called *hog fue*l, is burned in large boilers, not unlike coal, and the heat is used to produce steam. The steam is fed into a turbine that powers a generator. The electricity that is generated is then used to power the sawmill, and any extra electricity becomes part of the electrical grid.

Until the mid-1800s, biomass was the major energy source worldwide. It is still an important energy source in developing countries where it supplies 19–90% of the energy.

Bioenergy sources are used today in a number of ways:

- to produce **heat** by burning or making gas
- to produce **electricity** by making steam
- to produce **transport fuels** by making ethanol and biodiesel

When biomass is used to produce natural gas, animal and human waste can be used to make clean- burning natural gas. It is a simple process that takes place naturally in sewage systems. Biomass from grains, corn and sugar cane can also be converted into ethanol and biodiesel that are used as transportation fuels. These biofuels are becoming more popular as people look for alternatives to fossil fuels to reduce greenhouse gas emissions. In Brazil, 73% of the cars run on ethanol. Because the biomass source for ethanol and biodiesel is also a source of food (corn, for example), there is some concern about giving up food for fuel.

When plants are burned as a biomass energy source, they release some carbon dioxide into the atmosphere just as they would if they were to decompose naturally. Because they would release the same amount of carbon dioxide either way, they are considered to be a *climate neutral* source of energy. Burning wood does releases carbon monoxide and some particulates into the air, such as ash, which are hard on humans.

Ethanol in Canada is made from corn or wheat, and greenhouse gas pollution is released when fossil fuels are used to farm these crops, to process them and then to transport the fuel. When this greenhouse gases pollution is taken into account, a litre of ethanol produces about one-third less greenhouse gas pollution than burning oil.

The biggest concern around burning biomass is around sustainability. In fact, biomass can be considered a renewable resource only when two conditions are met:

1. Biomass is used for energy at a rate slow enough to allow for regrowth.
2. Bioenergy use does not conflict with other uses such as food, habitat and lumber.

To be sustainable, plant materials cannot be harvested faster than they can regrow. To allow for regrowth, experts suggest that people cut no more than 2% each year. Removing too much biomass from forests can endanger the species that depend on them. In developing countries where biomass is still a major source of fuel, animal habitats do become threatened.

To be a real alternative to oil, biofuels must be made from non-food materials. A lot of the plant waste that is left to rot in Canada could be used to make biofuels. If collected and processed properly, the annual plant waste that Canada produces now could replace half (or more) of our gasoline use.

Tidal and Wave Power

The ocean's tides result from the gravitational forces of the moon and sun and the rotation of the Earth. Rising and falling tides can be used to produce power much like the falling water at a hydroelectric facility. Because the tide is completely predictable, the power that is produced by tidal power plants is very reliable. England, France and Canada all use tidal power, but not much when compared to other renewable energy sources. The total energy contained in tides worldwide is 3,000 gigawatts (GW), though estimates of how much of that energy is available for power generation by tidal barrages are between 120 and 400 GW, depending on the location and the potential for conversion.

There are different ways to produce tidal power. **Tidal barrage** power uses turbines placed in a dam-like structure across a basin (called an *estuary*). As the tide rises, it is stored in the estuary, and then as the tide recedes, the water is released and runs through the turbines to produce electricity. Because tidal barrage power affects how long mudflats are exposed, it has a negative impact on wildlife, birds and fish. *Mudflats* is the term used for the areas covered and then exposed as the tide comes in and goes out again. It is critical habitat for some species.

Tidal fences can also be used to harness tidal power. Tidal fences use slow-turning underwater turbines to generate electricity. They can gather energy effectively even where tides move as slow as three knots. Tidal turbines on the ocean floor do affect marine life, but much less than tidal barrage because they do not trap water in an estuary or make use of the critical mudflat habitats that some marine life relies on.

If tidal and wave turbines are connected together in large farms and then connected to the grid, they could be an excellent energy source. With some changes to the electrical grid, tidal power could be used to reduce greenhouse gas pollution.

Geothermal Energy

Geo is the Greek word for Earth, and *thermal* means heat, so *geothermal* refers to *earth heat*. Geothermal energy uses the heat stored in the earth's crust from the movement of continental plates and the earth's molten core. Rock that is about 3,000 metres (~10,000 feet) below ground is hot enough to boil water. On average, the temperature of the earth rises about three degrees for every 100 meters deeper you go, but hotter temperatures are found in volcanic areas. As temperatures increase, the underground rocks actually turn into a liquid (called *magma*). Magma rises toward the Earth's surface, and if it reaches the surface, it is called lava. Most magma remains underground and heats surrounding rocks and water. When that hot water or its steam travels up through faults and cracks in the rocks and gets to the Earth's surface, we see it in the form of hot springs or geysers, which are naturally occurring pools of hot water and steam.

Geothermal energy is widely used in the United States, Indonesia, Philippines, Italy, Turkey, New Zealand, Mexico, Italy, and Iceland. Meager Mountain, a volcanic complex in British Columbia, is the only site in Canada where geothermal energy is being actively pursued. Experts predict that it could produce as much as 100–250 MW of electricity. The government of British Columbia has mapped other possible geothermal sites in the province as well.

Geothermal energy can be used for both heat and electric power.

- **Heat.** When used for heat, the hot water is run through pipes that provide heat for homes, businesses, greenhouses or indoor swimming pools.
- **Electricity.** When geothermal energy is harnessed to generate electricity, the steam that reaches the Earth's surface is used to turn turbines that are connected to generators that make electricity. This use of steam is much like that in other power plants, such as coal-powered plants or nuclear power plants, but because the steam occurs naturally and does not have to be created by heating hot water, it saves a major step.

When geothermal is used to heat buildings, there is very impact on the environment. The hot water from the Earth is circulated through pipes in the building and sent back underground to be reheated by the Earth. The hot water pumped to the surface sometimes contains pollutants such as sulphur, which must be removed before the water is used in a power plant. The total greenhouse gas pollution from geothermal energy plants is only 5% of that of fossil fuel power plants.

Some of the best sources for geothermal energy are in remote wilderness areas. The roads and pipes that are needed to access them can be hard on those areas. When geothermal energy is used to generate electricity, some minerals as well as gases such as carbon dioxide can be released from the ground. The amount released is very little compared to what is released by non-renewable energy sources.

If geothermal energy is extracted from underground, it can have an impact on underground water reservoirs. Removing water too quickly can cause a shortage in underground water reservoirs which can lead the ground above them to collapse.

What Is the Future of Renewable Energy?

Renewable energy is the way of the future. Today, our energy needs are met mostly by non-renewable energy sources. Most people burn oil and gas for their cars, and a lot of electricity comes from burning coal. In years to come, we can expect to see more renewable technologies meet more of our energy needs.

Alternative sources of power are already being used by many towns and cities for heating and electricity. More individual Canadians are using solar panels, solar water heaters, wind power and geothermal heat sources for their homes and businesses. The cost of these renewable technologies is becoming more affordable all the time.

Non-Renewable Energy

We harness energy from many different sources to meet our energy needs. Some of those sources are renewable, covered above, and some are non-renewable. Historically, much of our energy comes from coal, oil, natural gas, or radioactive elements. These sources of energy are considered non-renewable because once they are removed from the ground and used, they are not immediately replaced. In fact, the world's natural gas, crude oil and coal deposits took millions of years to form.

Today, the energy that we rely on most comes from non-renewable sources. As their name suggests, non-renewable energy sources do not renew or replenish in a short period of time. Buried deep underground, they take millions of years to form, and once they are used up, they are gone.

Non-renewable energy sources are often referred to as fossil fuels because they come from the fossils of plants and animals that were alive millions of years ago. Fossil fuels include coal, oil, and natural gas. They have been the main sources of energy in industrialized countries for about 200 years. Uranium, a mineral that is found in certain types of rock, is not a fossil fuel, but it is another non-renewable source of energy. It has been used to create nuclear power for more than 50 years.

Because non-renewable energy sources come from materials that are buried underground, it is hard to know exactly how much remains. Experts can predict the number of years of each source we have left, but the exact number will depend on how many new discoveries are made and the rate at which the energy is consumed. Some experts predict that humans could use up the Earth's oil in 40–45 years. Natural gas supplies are expected to run out in 67–72 years.

This backgrounder looks at oil and gas, coal and nuclear power. It explains how they are used for energy and describes some of the ways their use impacts the Earth and its ecosystems.

Crude Oil and Natural Gas

Oil is a non-renewable resource that was formed millions of years ago from fossilized animals. In its natural state, it is called crude oil, a smelly, black-brown fluid made up of different sized hydrocarbons as well as sulphur, oxygen and nitrogen. Crude oil can be found in layers of porous sedimentary rock deep below the Earth's surface. Some deposits may be more than two kilometres below the surface! Natural gas (which is actually a mixture of different gases) can often be found with crude oil, trapped in layers of spongy or porous rocks. When crude oil is found in semi-solid form mixed with sand, as it is in the Athabasca oil sands in Alberta, it is called crude bitumen or oil sands.

Oil and gas are widely used to produce heat and electric power as well as for transport fuel and other products. At a refinery, crude oil is made into products that we use every day.

Crude Oil Products	Uses
Octane	Gasoline
Light Oils	Diesel, kerosene, jet fuel, light lubricants
Heavy Oils	Lubricants, heavy fuel oil
Pentane, hexane, heptane	Explosives, petrochemicals, fuels, plastics

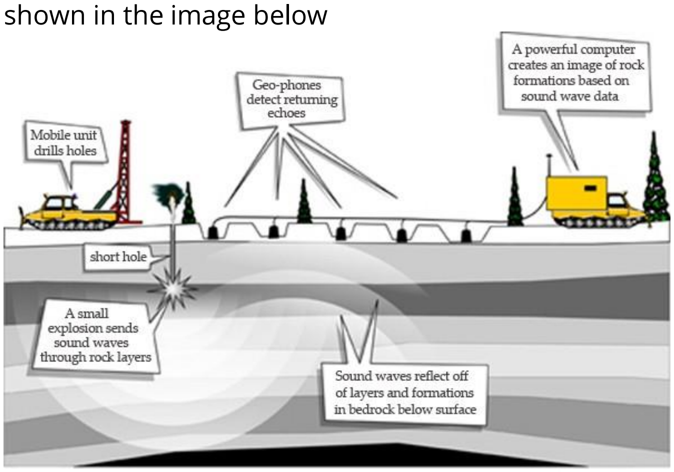
The gases that make up natural gas are separated from each other and made into many useful products.

Natural Gas Products	Uses
Methane (referred to and sold as natural gas)	Furnaces, hot water heaters, clothes dryers, stoves, barbeques, fireplaces, some vehicles
Ethane	Polyethylene plastic
Propane	Barbeques, some vehicles
Butane	Camp stoves, lighters

Did You Know?

- More than half of the energy used by Canadians comes from oil and gas. 33% of our use is oil and 25% is gas
- On average, Canadians use about three tonnes of oil each year, making Canadians some of the biggest consumers of oil in the world
- Using all that oil and gas per person also makes Canadians some of the biggest emitters of greenhouse gas pollution

Looking for oil and natural gas deposits involves a process called *seismic surveying*. Seismic surveying uses vibrations and the recording of echoes to detect possible oil or gas deposits underground. Holes are drilled into the ground in a grid pattern over a large area to hold explosives. When the explosives explode, they create vibrations. Microphones, called *geophones*, are placed in a grid pattern to record the echoes from the vibrations. Surveyors use computers to make sense of the sound waves and figure out where the oil and gas are located. This process is shown in the image below



Source: The Pembina Institute.

Once the surveying process has determined where oil and gas deposits seem to be, a drilling rig is brought in by truck. The drilling rig bores a hole down through the upper layers of the Earth's crust to get to the deposit. Conventional crude oil is pumped to the surface with the help of a pump jack, which works like the lift pump of an old-fashioned water well. Raw natural gas is extracted through drilled gas wells.

In Canada, after oil or gas is extracted from the ground, it is shipped in pipelines to a refinery. A pipeline requires a *right of way*, which is a cleared path through forest or farmland where the pipe will be laid underground. There are thousands of kilometres of pipeline *right of ways* across many parts of Canada.

Like the mines themselves, these pipelines disrupt and destroy natural habitats, as do the new roads that must be created to bring in equipment during the surveying and drilling stages.
Caribou is just one of many species that have been affected by oil and gas developments. In Alaska, for example, the Arctic National Wildlife Refuge (ANWR) which borders onto the Northern Yukon in Canada, is an important calving ground for caribou that sits above oil reserves. Oil and gas companies have wanted to drill for oil there for many years, but conservationists have managed to protect the caribou and their calving ground.

Oil and gas development is hard on the environment in other ways as well. The explosives set off during surveying and drilling have an impact underground. Also, when a well is drilled, the rock chips, mud, water and other materials that are produced must be disposed of. These materials can be a problem for the environment if they contain traces of oil, salt or other harmful substances.

Oil sands developments use up a huge amount of freshwater to wash the oily materials out of the soil and sand in which they are trapped. The waste material ends up in what is called *tailings ponds*. These big ponds of waste are toxic.

At the Alberta Oil Sands, 500 ducks died when they landed in toxic tailings ponds near Syncrude's Aurora North Site mine. Most of the ducks that landed were too heavily coated in oil and toxic waste to survive. When drilling at sea, drilling rigs disturb the ocean bed. The noise affects the movement of whales and other wildlife nearby. When the extracted oil is transported in large tanker ships, there is always the risk of a spill. A tanker spill can destroy salmon stocks and whale populations as well as shoreline habitat for many species. The Exxon Valdez spill in 1989, for example, resulted in 42 million litres (that's about 17 Olympic-sized swimming pools) of oil in Prince William Sound in Alaska. The spill killed thousands of birds, animals and whales. There are fewer spills now than there were in the 1970s, but they do still occur. The last major oil spill that happened was the Deep Water Horizon oil spill of 2010.

The refining process also creates problems for the environment. The refining process releases chemicals and large amounts of the greenhouse gas carbon dioxide (CO_2) into the atmosphere. Oil creates more CO_2 than natural gas, but less than coal. In some parts of Canada, the CO_2 produced during oil production could be disposed of underground in deep water bodies. However, this method is not yet widely used.

Of course, burning oil and gas releases even more CO_2. Vehicles that run on gasoline are the leading cause of air pollution. They release CO_2 and other greenhouse gases into the atmosphere as does burning natural gas to heat buildings and water. Oil and gas bring us many products and conveniences, but they do so at a very high cost to the environment.

Coal

Coal is a non-renewable energy source formed millions of years ago from decayed and fossilized plants. It is a brownish-black rock made mostly of carbon and sulphur. Coal burns easily and releases heat energy. It is used to create heat for industry (to make steel, for example) and to create electric power.

Coal played an important role in human history when countries used it to become industrialized and move away from subsistence agriculture. In the late 1800s, coal began to be mined in large quantities to fire the boilers of steam locomotives. Today, coal is the number one source of electricity worldwide. It is the most available of the fossil fuels, and supplies of coal are expected to last another 169 years. Canadians consumed 43 million tonnes of coal equivalent in 2016, about 3.8% of the world's use of coal that year.

In Canada, coal-fired power plants are mainly found in Alberta, Saskatchewan, Ontario and Atlantic Canada. Most of the coal we use in Canada is to generate electricity.

Coal is often found in seams which means it is found compressed between two rock layers that cover a large area. It can be found fairly close to the surface or deep underground. The coal that is found closest to the surface is easier, less costly, and safer to extract. Mines close to the surface are called *strip mines*.

Coal-fired power plants are often located close to coal mines to reduce the cost of transporting coal to the power plant. Coal arrives in large trucks at the power plant where it is crushed and pulverized into a black powder that is blown into large furnaces (or *boilers*) that heat water to create steam. The steam is then used to turn turbines that are connected to generators.

The generators produce electricity that is transmitted through transmission and power lines to businesses and homes. The power lines are all connected through a system called the *electrical grid* or *power grid*. Most places in Canada receive their electricity through the electrical grid, except for very remote locations. Similar to oil and gas pipelines, transmission towers require right of ways which are often referred to as *transmission corridors*. These transmission corridors cut across entire provinces. Whenever you see a large transmission tower, you are looking at a part of the electrical grid.

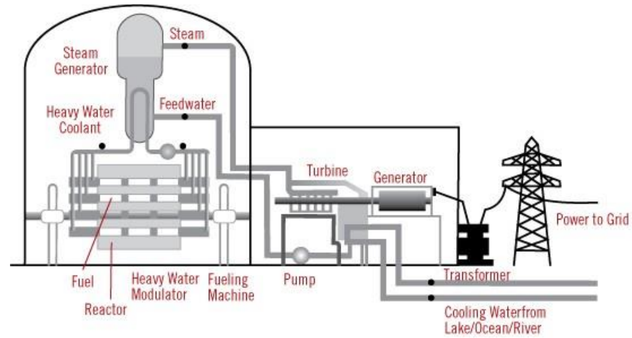
Coal mining, especially strip mining, involves removing huge amounts of soil. That disrupts and destroys local habitats of plants and animals through soil erosion, dust and noise, and water pollution. In some places, mining has taken the tops off entire mountains, dropping waste materials into the river valleys below. Even more of a problem for the environment than the mining of coal is the burning of coal. Coal is the dirtiest of fossil fuels because when it burns it produces such large amounts of greenhouse gas. Burning coal releases more carbon dioxide into environment than oil, and double that of natural gas. It also releases mercury and sulphur into the atmosphere as well as creates solid waste (called *slag*). As a way to make coal power "clean," some people are now suggesting that we capture the carbon dioxide produced by coal power plants and store it underground. **Carbon capture and storage** is still a new idea, and it will be difficult to find enough of the right locations to make it work for all the coal burned around the planet.

Nuclear Power

Nuclear energy comes from a non-renewable resource, the element uranium, which is found in Canada, Australia, West Africa and Kazakhstan. Canada currently has six commercial nuclear power plants, five in Ontario, and one in New Brunswick. The last time a nuclear power plant was built in Canada was in the 1980s.

Nuclear power was first used to make electricity in 1951. There are now 443 nuclear power reactors in operation in the world, and together they produce about 10% of the world's energy. Of the 30 countries using nuclear energy, France uses it most, creating nearly 70% of its electricity using nuclear power. About 15% of Canada's electricity is generated by nuclear power plants.

Uranium is mined from the earth and then refined and made into *fuel bundles* before it can be used in a power plant. The key component in the nuclear power plant is the nuclear reactor. Water is heated in the reactor core through the *fission* of uranium atoms to make steam. The generator part of the reactor splits the *nuclei* (which is at the centre) of uranium atoms, creating heat as well as flying particles of atoms that collide and start a chain reaction. This process can be seen in the image on the right.



Source: The Pembina Institute

The chain reaction must be carefully controlled to produce a steady output of energy. An uncontrolled chain reaction results in huge releases of energy that can cause a reactor meltdown. In the past, nuclear accidents have shown how dangerous it can be to rely on nuclear power. The Chernobyl disaster in 1986 released toxic wastes across Europe and caused many human deaths.

Did You Know?

- Several components in spent fuel bundles remain radioactive for one million years
- Other components in spent fuel bundles could be used to make nuclear weapons

Uranium mines are small in size compared to coal mines, but they produce radioactive waste at the site as well as heavy metals. One of the biggest challenges of nuclear power is what to do with the used up (or *spent*) fuel bundles. They can be reprocessed or they can be transported to long-term storage sites, but **neither of these options provides a safe, permanent solution.**

Nuclear power does not create nearly as much greenhouse gas pollution as fossil fuels do. Nuclear power produces 25 grams of greenhouse gases per kWh of electricity. Compare that to 900 grams for coal and 450 grams for gas-powered plants.

How to dispose of radioactive waste is a big concern around the world and here in North America. Canadian heavy water CANDU nuclear reactors release the highest rates of radioactive material Tritium in the world. The United States currently has about 50,000 tonnes of waste fuel from reactors which it stores above ground at nuclear power plants. The Canadian government is looking into several options for Canada's spent fuel bundles.

What Is the Future of Non-Renewable Energy?

There are many good reasons for using non-renewable energy sources wisely. One reason is to ensure that these natural resources will be available for future generations. Another reason is to limit the harm they do to the environment.

The industrialized countries of the world, such as Canada and the United States, now depend heavily on non-renewable energy sources, and especially fossil fuels, to meet their energy needs. However, people are making more and more use of renewable sources. They do not release harmful emissions into the atmosphere like coal, oil and gas do. Also, because renewable energy sources are not extracted from the Earth, they do not need much processing. Overall, they are much easier on the environment.

In the future, we can expect to see more use of low-impact renewable energy sources. The transition away from fossil fuels will take time, but Canada is in a strong position to help lead the way.

Questions

1. Give some examples of non-renewable energy sources. Describe why they are considered non-renewable.
2. Give examples of renewable energy. Explain why they are considered renewable.
3. What are some of the advantages of renewable energy over non-renewable energy?
4. Can you describe any examples of how renewable energy is being used in your region?