ONTARIO SOCIETY OF PROFESSIONAL ENGINEERS

Introduction

Canada is the second largest consumer of energy, per capita, in the world. Canadians, as .05% of the world's population, consume 2% of available global energy. The use of energy in Canada is a direct result of choices Canadians make in their daily lives.

The world has gone through transitions in its energy use over the centuries. Energy sources transitioned from wood to coal, and then from coal to oil and gas. The transition to nuclear fission energy, which began in the 1950's, was interrupted by public concern in the 1970's and 1980's after the Three Mile Island and Chernobyl accidents. The choice and use of energy has generally been determined by local availability, cost and recently, also by environmental factors. Worldwide concern about global warming is now driving another transition away from high carbon emitting fuels, especially coal and oil.

Electrical energy is not available naturally in a practical form. It needs to be manufactured in an electrical generating station using fuel (fossil, nuclear, biomass) or transformed from other forms of energy (hydro, solar, wind). Electricity is the most flexible and useful of all energy types, and the availability of affordable quantities of electricity ensures that individuals have a high quality of life.

Forms of energy vary by their composition and renewal time. For example, forms such as wind and solar are renewed by nature in a short time interval (days/weeks) and their consumption is considered sustainable. Forms such as biomass are renewed by nature in an intermediate time interval (days/years/decades). The consumption of biomass is also considered sustainable, but it requires land and water, thereby competing with other land and water uses such as food production.

Other forms of stored energy such as coal, oil and gas is renewed by nature on a very long time interval, tens of millions of years. Due to this, their consumption is considered unsustainable. Also, combustion of fossil fuels produces carbon dioxide, raising concerns around the world with respect to both global warming and acidification of the oceans. Recent trends in power generation aim to lessen dependency on nonrenewable sources of energy, and focus more attention on renewable forms.

Stored energy in the form of nuclear fuel is a special case of unsustainable energy consumption, because its supply is not naturally renewed. Radioactive isotopes such as uranium, thorium, deuterium, etc., were formed inside stars, and are now found in our rocks and oceans. Currently, only nuclear fission (the splitting of large atoms) is available as a practical energy source. With the present state of technology and for safety reasons, nuclear fuels are only used at a large central location to produce steam which in turn is used to produce electricity.

Nuclear fusion energy is produced by combining light atoms (deuturium or tritium - heavy isotopes of hydrogen) in a fusion reactor. Unfortunately, this form of energy is still in the research and development stage and is at least 50 years away from becoming a practical energy source. Its advantage lies in the vast amounts of hydrogen that lie in the Earth's oceans, which can supply anticipated global energy needs for centuries to come.

After many years of wind and solar energy development, it has become clear that more research, development and time will be needed to get the cost of renewable energy (especially solar and biomass) low enough to both satisfy global energy demand, and displace coal and oil. Also, due to the intermittent nature of wind and solar energy, other forms of energy are required to meet grid demands when they are not available. Typically, gas-fired generation is used as the backup to wind and solar energy. Some utilities also use hydraulic plants to smooth out the variable output of wind and solar plants.

Technologies with low carbon output and input, such as nuclear energy, are now becoming increasingly popular to meet the growing need for a low carbon, affordable and continuous energy source. Unfortunately, nuclear reactors create nuclear waste that must be isolated from the environment and managed for long periods of time. Also, there are public concerns about the impact of nuclear plant accidents and diversion of the fuel for use in weapons programs.

As demand both grows in Canada and increases rapidly in the developing world, new energy sources are needed. Increasingly efficient and sustainable options are being examined, to preserve the availability of energy for future generations. Energy used closest to its source is least damaging to the environment, because it does not require additional energy to transport it to the location of the demand.

Levelised costs of electricity provided in this guide are from the 2010 IEA/NEA international study on energy costs with the exception of CANDU plant costs. The data is quoted in USD, which includes a carbon tax of $30 per tonne of carbon dioxide. A similar tax has not been instituted in Canada. Electricity generation costs described do not include the transmission and distribution of energy, which is impacted by local conditions. The costs in the IEA/NEA study do not take into account the inclusion of carbon capture and storage, a possible method of diverting excess carbon away from the atmosphere. However, decommissioning costs were included as 15% of the total construction costs, spread out over a time period of ten years.

No one source of electricity is cheapest and most sustainable, and local conditions and risks will determine the energy mix contained within the grid of Canadian communities. This guide is an outline of several types of energy sources, summarizing their advantages and disadvantages. It is intended to provide the reader with an informative overview of the sources of energy available. This in turn should help individual's make more informed energy choices and to participate more effectively in a public discussion of Ontario's energy plans.

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Wood/Biomass

Summary:

- Plants and wood contain cellulose, which is constructed from chemical energy generated by the sun. This chemical energy is released as heat when biomass is burned. Biomass also produces carbon dioxide, a greenhouse gas, when it is burned. However, the burning of biomass to provide energy is not considered a contributor to global warming. This is because biomass naturally decays to produce greenhouse gases such as methane, which are more detrimental than CO_2. Methane is 23 times more potent than carbon dioxide over a 100 year period. Consequently, burning biomass for energy is more environmentally friendly than letting it decay naturally.
- Biomass, (wood chips and waste materials, forest residues such as bark, pulp, animal and crop waste, and organic waste) is shipped to a holding site and then burned. Heat from this burning is used to produce steam, which may turn a turbine and electrical generator, or may be used to produce hot water.
- Wood may also be heated in an environment without oxygen until it releases carbon monoxide and hydrogen, which is captured for energy production purposes. Wood is often used for cogeneration, which is the production of both heat (steam or hot water) and electricity simultaneously.
- Bioenergy plants may also have tanks which extract methane from the biomass, which is used for both electricity production and soil enrichers like fertilizer.
- Bioenergy may be extracted from landfills, where gas may be captured from decaying solid waste.
- Ethanol may be extracted from biomass which contains starches and sugars (such as sugarcane, corn, and wheat) to produce fuel for automobiles and small machinery.
- Bioenergy from land is less sustainable than bioenergy from waste, because land is limited and has high value uses such as food production, shelter and recreation. Therefore, bioenergy must be developed on principles of non-interference and sustainability.
- Biomass is considered a renewable form of energy as long as measures to renew it are taken, eg. trees are planted to replace those that died or were cut down.

Advantages	Disadvantages
• Biomass uses waste products and is readily available at a local level. • 90% less emissions than fossil fuel. • Ethanol can supplement 5-10% of automobile gasoline, thereby reducing dependency on this nonrenewable fuel. • Bioenergy in northern and rural communities encourages self-sufficiency, sustainability and reduced energy costs. • Reduces methane emissions into the atmosphere from decaying biomass.	• Bioenergy may impact crops, food availability, soil quality and erosion of land. This impact is seen with heavy use in the developing world, which is largely dependent on this energy source to sustain increasingly larger populations. • Costs of gathering and harvesting biomass remain relatively high, as biomass must be sorted before it is processed. Energy from biomass is roughly double the price of natural gas. • Processing raw materials into energy takes high amounts of energy, thereby lowering the

	efficiency of biomass as an energy source.

In Ontario/Canada:

- Wood and biomass account for 0.1% of Canada's electricity generation and 6 % of energy production. This is a stark contrast to the rest of the world, as biomass provides 14% of energy across the globe.
- Biofuel is a common source of energy in northern Canada, where communities have less access to national grids and less electrical generating capacity.
- There are currently 12 biomass plants in Canada, and 9 ethanol manufacturing facilities.
- Half of Canadian provinces have exempted biofuels from provincial fuel taxes, with the federal government providing additional credits to some businesses for the federal fuel tax.
- The levelised cost of electricity for biomass ranges between 7 and 25 cents per kWh, depending on the resources available at the source.

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Wind

Summary:

- The harnessing of the wind dates back to the ancient Egyptians, who built sailboats to travel along the Nile.
- Wind turbines, or wind towers with blades, are built in open spaces such as fields. Wind turns the blades, which in turn rotates a generator to produce electricity. Cables carry this current into the electrical grid, where it is distributed to homes and businesses.
- Wind comes from solar energy. The sun heats the Earth, creating different temperatures in different places. This unequal distribution of heat causes warm air to rise and cool air to drop, and wind is the movement of this air.
- Wind turbines are best set up where the wind blows fastest and for the longest period. The doubling of wind speed can provide up to 8 times more energy. However, wind blows fastest when it is uninterrupted by objects so optimal spacing of wind turbines is important.
- Wind turbines begin turning at wind speeds of 13 km/hr, and automatically stop turning in extremely strong winds above 90 km/hr to prevent damage to the equipment.
- Wind is the world's fastest-growing energy source, and global wind capacity grows by an average of 30% each year.

Advantages	Disadvantages
• Wind energy has no cost for fuel so its long term energy price is stable; however, there are royalty costs to the owner of the land. • Wind energy generates no greenhouse gas emissions or waste. A single large wind turbine reduces greenhouse gas emissions by approximately 6000 tons, annually. • Wind has a very low carbon footprint, as most of its environmental costs are associated with construction of the grid and wind farms. • Wind farms require no water to operate, other than the occasional washing of blades in areas with extremely low rainfall. • Out of all of the sources of energy, wind turbines are the most easily assembled, easily removed, and most portable. • This portability means wind farms are easily established in rural communities, who may build self-reliant energy systems using sustainable forms of power. • When established, wind power has the least impact on habitats of wildlife.	• In order to be used properly, a wind farm needs to be set up and accessible, which requires significant investment in infrastructure and development. • The wind does not always blow, resulting in wind farms that have maximum annual capacity factors of about 40% and are not considered economic at less than 30%. Because of this, alternate forms of energy must be available as a back-up, and this should be included in any investment or cost calculations. • In order for wind turbines to be installed and maintained, prime agricultural land may have to be set aside for energy generation. • Wind turbines produce noise. • Wind turbines kill birds on occasion, especially if they are installed in a migratory route. • There is a negative visual impact on natural scenery, especially with large wind farms. This is more problematic in tourist and recreational areas.

	• Wind requires a large land area compared to fossil and nuclear energy.

In Ontario/Canada:

- Use of wind power to pump water in Canada dates back to farms on the Canadian prairies, and has developed from that time to become the world's fastest-growing source of electrical power.
- Canada is ranked sixth in the world in the production of wind energy.
- There are 99 wind farms across Canada, which produce 1% of Canada's overall energy, by source. The Canadian Wind Energy Association has developed a wind energy strategy that would meet 20% of the country's energy needs by 2025, generating enough energy to power 17 million homes annually.
- In 2006, wind powered over 300 000 Canadian homes, and 2009 was the first year that every province had wind power contributions to the grid.
- Offshore wind energy near the Great Lakes offers significant potential to nearly double the energy capacity that Ontario has. Environmental assessments are now in place to study the impact on developed wind energy on aquatic species and the migration of birds in the area.
- Canada's highest wind capacities are in Alberta and Quebec, which provide ideal environmental profiles for the development and production of wind energy. Calgary Transit is the only emissions-free light-rail transit (LRT) system in North America, powered by commercial wind energy. It is called Ride the Wind! Under the Ride the Wind! program, the train's emissions have been reduced by over 20 000 tones to almost zero- similar to taking 4000 cars off the road.
- In January 2010, the Ontario provincial government signed a $7 billion dollar deal with Samsung to implement investments in green energy (wind and solar) technology.
- An Ipsos Reid poll conducted in June 2010 found that 90% of Ontarians would support a wind farm in their region of the province, with levels of support remaining high even if the wind farm were to be in their own community.
- Onshore wind costs approximately 3000 USD/kWe for a wind farm built in Canada, and the costs of wind generation usually decrease as the capacity of the wind plant increases. Note: These costs do not incorporate the transmission costs required to incorporate new farms into electricity grids.
- Wind energy in Canada costs approximately 9 US cents/kWh. Offshore wind energy is slightly more expensive, at approximately 13 US cents/kWh.

Internationally:

- Denmark gets 20% of its energy from wind.
- Global wind energy production rests around 59,000 megawatts worldwide, or enough to power 18 million households. The global wind industry employs over 235 000 people worldwide.

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Solar

Summary:

- Solar energy can be harnessed either as light, for direct photoelectric energy or as heat for thermal energy either used directly or to convert to electricity in a turbine/generator.
- Solar energy is captured when photovoltaic cells are placed with direct and unobstructed access to light from the sun. These cells contain layers of silicone, which, when struck by sunlight photons, create negative and positive charges between them. The electrical energy is then directed into wires to be carried to the grid.
- Electricity collected per cell is low-voltage direct current, but by combining the cells and passing the current through an inverter, the electricity can be increased to 110 volts (alternating current that is used inside the home) or via transformers to higher voltages for distribution through the electrical grid.
- Thermal solar collectors use energy from the sun to heat air or water.
- As a form of self-generating and sustainable power, solar power is rather accessible to individuals who wish to use it on their homes or small businesses.
- The expected lifetime of solar plants is approximately 25 years.
- Solar energy has been used since the beginning of time, primarily for heat. More recently it has been used to generate electricity. As new technology is developed to make it more efficient and less costly, additional solar capacity will be installed.
- Levelized costs of electricity from solar plants are approximately 40.9 USD/kWh, and about 47.0 USD/kWH for residential systems. Despite solar power originating from residential systems being more expensive, residents often have the option to sell generated power back to the grid when production exceeds consumption.

Advantages	Disadvantages
• Solar energy has no fuel costs • Solar can be set up almost anywhere. • Solar has no noise or green house gas emissions during operation. • Despite the intermittent nature of solar power, the technology exists to predict when it will and won't be available. Short term fluctuations in sunlight can be filtered out using battery storage for photovoltaic systems, or using thermal storage for large thermal installations.	• Total costs including grid connections remain high, typical capital costs being approximately 6,000 USD/kW and energy costs of 38 to 76 US cents/KWh. • The best and most expensive silicone solar cells reach a maximum of 25% - 40% efficiency due to losses in visible light, and the low conducting capabilities of silicone. The lowest cost thin film cells are only about 6 to 10% efficient. • Solar power is an intermittent energy source and is not always readily available, so backup generation is required. This adds to the capital costs by 700 to 1,000 USD/kW for gas fired generation.

In Ontario/Canada:

- Solar cell investors benefit from a generous rate of return on solar energy in Ontario.
- Ontario offers a micro-FIT (feed in tariff) program for systems under 10 kW capacity and an FIT program for larger systems.

Hydro

Summary:

- Hydro power harnesses the flow of water to create electricity. The final amount of electricity produced depends on the quantity/volume of water, and the height from which it flows. The more of both, the more electricity is produced.
- Dams are used to store the water, which, when released, turns a turbine and then a generator to create electricity. 'Run-of-the-river' hydropower diverts water through a channel that runs alongside the river, and is more environmentally-friendly and less damaging to habitats than other forms of water energy capture.
- Hydropower is one of the most efficient sources of energy, converting at a rate of approximately 95%.
- Hydro dams and their turbine-generators can be designed with or without storage. Those with storage can hold back production during low load periods and generate more during peak periods.
- The production of energy from water may vary with the seasons and changes in climate, for example, if a river dries up in summer or freezes in winter.
- A special case of hydro power is a pumped storage facility. Here, the water in a lower reservoir is pumped up to the dam during low load periods, and it is later used to generate electricity during peak periods. Hydraulic pumped storage facilities are capable of allowing the output of base load plants (eg. nuclear and run-of-the-river hydraulic) to be shifted to meet peak load demands, by storing their output until it is needed. This increases the efficiency of hydroelectric plants by not having to spill unused energy at run-of-the river plants during low demand periods. Hydraulic pumped storage facilities can also be used to smooth out fluctuations in solar and wind generation.
- Once built, hydropower plants operate for about 80 years with only minor repairs. With major upgrades, hydropower plants can last much longer.

Advantages	Disadvantages
• The hydro industry is relatively mature. However, it requires large amounts of capital to build a dam, typically 6,000 USD/kW or more. • Hydropower is flexible in that it can be used to quickly respond to demands in energy, holding or diverting more water as needed. The flow of water can easily be regulated and stored, which makes it an ideal energy source for rural communities. • Despite construction interruptions, and changes in land use, ecosystems are built to naturally adapt to changes, and hydro dams and reservoirs often become habitats for	• Hydro infrastructure leaves a significant footprint on natural spaces such as waterfalls, lakes, and rivers. Because of this, communities are hesitant to introduce new energy-generating plants near their waterways. • The construction and development of hydropower dams impacts wildlife by modifying animal habitats. Modern hydropower is developed in a sustainable manner, however, most hydro-generating plants in Canada were created when sustainability was not a pressing issue. • Geographical features limit the options that

many species. Technical solutions are available for fish migration around dams (eg: fish ladders). • Hydropower facilities are easily upgraded as new technologies are developed.	can be used at a hydro plant. For example, the Great Lakes cannot tolerate a large level change, so they cannot be used as a storage facility.

In Ontario/Canada:

- Hydro accounts for about 25% of Ontario's electrical energy production, 60% of Canada's electrical energy production, and 20% of the world's electrical energy production.
- In 2004, Canada was the top hydropower producer in the world.
- Canada is second in the world in use of domestic freshwater hydro resources.
- Decew Falls, one of Canada's pioneering hydropower projects developed in 1898, is still in operation today.
- There are over 450 hydropower plants in Canada. Every province in Canada except PEI has the capabilities to harness hydropower.
- Ontario's electrical energy supply is very clean in comparison to other jurisdictions, in large part because of a combination of 25% hydro power and 50% nuclear power.
- Industrial uses of water in Canada were mostly for oil production, up until the 1980s. This has dropped in recent decades due to advances in energy technology.
- Nova Scotia has one of three tidal power plants in the world, which channel the tidal power of waves in the Bay of Fundy, which has the highest tides in the world.

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Coal

Summary:

- Coal is a rock formed from fossils of plant and organic life which contain a variety of minerals. It is created when this material is compressed by geological pressure.
- Different types of coal vary not only by their composition but also by how hard it is pressed.
- When a coal deposit is found, the environment of the surrounding area determines how that reservoir will be mined. Large excavations are done by using open-pit mines, but strip mining may be found to be more convenient when the coal found is closer to the surface. The geology of the site determines the mining process.
- To generate electricity, coal is crushed and burned in a furnace with a boiler. The heat of the boiler converts water into steam, which spin turbines, which turn generators, which create electricity.
- Most coal plants are built in approximately four years, and last for approximately 40 years.
- Most modern coal plants operate at 40% efficiency, combined cycle plants operate at over 50% efficiency, and co-generation plants (both heat and electricity) operate at about 70% efficiency.
- Coal is most efficiently used when used with fuel cells. The fuel cells oxidize chemicals from coal to produce energy, and operate at 65%-80% efficiency.
- Like many fossil fuels, coal is cheapest when used as closely as possible to the source from which it was mined.
- Coal is the #2 source of energy in the world (#1 being oil).
- Coal provides 40% of the world's electricity but only 17% in Canada.
- Coal energy costs between 6.8 and 7.2 US cents/kWh (including a 30 USD/ton carbon tax).
- Coal capital costs average about 2,000 to 3,000 USD/kW (not including carbon capture).

Advantages	Disadvantages
• Coal is the world's most abundant fossil fuel, and the amount of coal available is extremely high, unlike oil. • Many power generating companies in Canada not only use coal for electricity generation, but also own mines and are involved in other steps of the production process. In this way, the mining and processing of coal provides jobs for many individuals, more so than any other energy source. • New technologies are improving coal's efficiency and environmental performance, and may some day lead to practical carbon capture and sequestration.	• Coal has moderate capital costs (lower than nuclear or hydro, and higher than gas). • If carbon capture and sequestration becomes a requirement of new coal plants, capital and operating costs will rise significantly. • Many activities associated with the mining of coal are related to environmental problems. The mining of coal often leads to the removal of vegetation, construction of roads, blasting and reclamation of land, and disturbing habitats. • Hundreds of millions of tons of waste products are generated from the use of coal. These include several types of ash, heavy metals such as mercury and uranium, and sulphur, as well as arsenic. • Coal contributes to sulfur dioxide, nitrogen oxide, and carbon dioxide emissions in

	Canada, with coal representing 20% of CO_2 emissions in Canada. • Coal is considered the #1 source of carbon emissions worldwide.

In Ontario/Canada:

- Coal accounts for 17% of Canada's electrical energy generation.
- Coal is mined in almost every Canadian province, with most production occurring in British Columbia, Alberta, Saskatchewan and Nova Scotia.
- Despite Canada's great coal reserves, coal is imported to eastern Canada for the generation of electricity. This is because it is more cost-effective to import coal to this region from the United States, than to ship it across from the Western provinces.
- Coal has been mined in Canada since 1639, when the first mine was opened in New Brunswick.
- The Canadian steel industry is heavily dependent on coal for the production of steel, and coal is our largest export to Canada's second largest trading partner, Japan.
- Canada exports 28 millions of tones of coal annually to over 20 countries worldwide. Canada itself produces enough coal to fill up the Roger's Centre (SkyDome) in Toronto every week.
- Ontario's use of coal has decreased by 73% since 2003, with investment in other energy sources. The province of Ontario has also agreed to gradually phase out coal-firing plants by the year 2014.

Internationally:

- Coal is the planet's most abundant fossil fuel. 50% of the world's electricity comes from coal.
- Worldwide consumption of coal is expected to grow up to 40% between 2001 and 2025. To offset this, new technologies are increasing the efficiency of this resource. Also, in many places, coal is slowly being replaced with increasingly environmentally-friendly technologies.
- OECD countries which produce coal without carbon-capture technologies are approximately 7% less efficient in energy use than those who do.

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Oil/Gas

Summary of Oil:

- Oil is formed from organic matter that is millions of years old, which, when combined with heat and pressure, turns into hydrocarbons such as oil and gas.
- Oil is held in rock or permeable stone, and trapped with geological movements such as the formation of mountains.
- Oil sands are grains of sand surrounded by a layer of water and then a film of bitumen, which is a heavy oil that has to be treated before it can be used by refineries.
- In addition to CO_2 emissions from its use, the production and delivery of oil also can impact negatively on the environment due to spills.
- Global oil production is rising as our overall supplies are depleting: worldwide reserves of oil give us only 40 to 60 more years of its use, and the total amount of the Earth's oil resources is predicted to dwindle by the middle of the 21st century.

Summary of Natural Gas:

- Natural gas is primarily composed of methane, and small presences of other hydrocarbons such as ethane, propane and butane. It is found in oil fields, coal beds, and in natural gas fields, or trapped in shale formations. Natural gas is produced when coal and oil are exposed to heat and pressure. It is also produced from the natural decay of biomass.
- Natural gas has several uses – it is a feed stock for plastics and fertilizers, it is used for cooking and space heating and it is used to produce electricity.
- Natural gas is extracted, treated and transported to customers. Wells are drilled into the ground, and once extracted, impurities are removed through treatment. Treated natural gas is shipped through pipelines to power plants and other consumers.
- It is becoming increasingly popular to burn the gas in a combustion turbine to turn a generator to make electricity, and then use the exhaust from this turbine to make steam, which drives a steam turbine and generator to make additional electricity. This achieves higher levels of efficiency from natural gas (typically 50%), as less energy is discharged with the exhaust gases.
- Depending on their design efficiency, construction costs for gas plants range between 500-1800 USD/kWe of capacity, and are expected to last approximately 30 years.
- Gas plants operate at efficiencies from 25% (simple cycle peaking plants) to 70% efficiency (co-generation plants).

Advantages	Disadvantages
• Natural gas burns more cleanly than other fossil fuels, and produces less carbon dioxide than any other fossil fuel. Thus, it is the cleanest fossil fuel. • The transformation of natural gas into electrical energy produces no solid waste.	• The extraction of oil has considerable negative environmental impacts, as presently configured. • When crude oil is spilled into water, it spreads across the surface, destroying migration and nesting habitats, coral reefs and swamps.

• Over 200 000 Canadians work in the oil and gas industry, with 93 000 of those working in the province of Alberta. • Oil and gas power plants cost less to operate and maintain than coal or nuclear power plants, excluding fuel costs.	• Oil produces much of the world's air pollution. The use of oil causes emissions of nitrogen oxide, carbon dioxide, carbon monoxide, ozone, sulfur oxide, volatile organic compounds, methane and other toxic compounds. These compounds contribute to pollution, acid rain and global warming, causing health problems in humans and animals, destroy forests, food sources and habitats, and ultimately degrade the quality of life for many people. • At current rates of production, worldwide oil supplies are predicted to expire within approximately 40 to 60 years. • Burning natural gas releases nitrogen oxides, methane, and carbon dioxide into the atmosphere. It's extraction, treatment and transport cause additional emissions, and water is used in boiler and combustion systems for cooling purposes. • The extraction of natural gas can destroy natural habitats for plants and animals, contributing to soil erosion and changes in soil composition.

In Ontario/Canada:

- Natural gas accounts for 6% of Canada's electric energy generation and about 35% of Canada's energy production.
- Oil represents about 40% of Canada's energy production.
- Canada has the second largest oil reserves in the world, smaller only than Saudi Arabia.
- There is over 87 trillion cubic feet of natural gas below Alberta, accounting for 63% of all revenue for the Province of Alberta. 15 billion cubic feet of this gas is produced every day.
- Most of Canada's crude oil and natural gas production occurs in Saskatchewan and Alberta.
- Alberta's oil sands (called the Athabasca deposit) is the largest and most technologically advanced oil sands deposit in the world.
- Natural gas and oil have higher costs than other types of electricity; however, because of their widespread use, they often set the price of electricity in open and competitive markets.
- The cost of electricity from natural gas and oil is approximately 7.6-9 US cents/kWe (including a 30 USD/ton carbon tax).

Internationally:

- Out of the total amount of oil produced and consumed, the United States uses 25% while producing approximately 13%.
- Automobiles that are nearly emission-free have been engineered in recent years, however, these vehicles remain cost-prohibitive for widespread public use.
- The country with the largest available natural gas resources is Russia, with Iran being second.

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Geothermal

Summary:

- Geothermal power is extracted from heat stored in the Earth, originating from the original formation of the planet as well as the radioactive decay of materials.
- Geothermal energy harnesses the escaping heat from the Earth's core and uses it to produce electricity. This is done by injecting cold water into hot rock formations at significant depths, and then collecting the hot water that returns.
- Electricity is produced from geothermal heat when the high temperature, high pressure water is brought to the surface, enters a low pressure chamber and changes into steam. This steam is then channeled through a turbine that turns a generator to make electricity. The steam is then condensed to get water that is easier to pump back into the hot rock formation.
- The temperature of the Earth increases closer to its centre, so the deeper the drill, the more energy may be extracted. Every kilometer of drilling increases temperatures by approximately 30 degrees Celsius.
- Historically, the use of geothermal energy has been located near boundaries of tectonic plates. However, modern developments in drilling and extraction technologies have increased the geographical range of geothermal plants.
- The United States leads the world in geothermal energy development, with over 77 plants. The Philippines is the second highest producer of geothermal energy.
- Costs of geothermal energy vary according to site, starting at approximately 1750 USD/kWe.
- The planet's geothermal energy capacity greatly surpasses human energy needs; however, technology and infrastructure does not exist to allow individuals to harness even a small fraction of it.

Advantages	Disadvantages
• Geothermal power does not use any fuel. • Materials in geothermal production may be re-used. Cooled geothermal fluids are injected back into the Earth, to stimulate further production of geothermal fluids. • Geothermal power has many uses besides the simple generation of electricity. For example, hot fluids may be pumped below city sidewalks or into buildings to provide heat. • Emissions per use of energy output are much lower from a geothermal plant compared to gas, oil or coal plants.	• Geothermal wells release greenhouse gases trapped deep within the earth. However, these emissions are much lower than the use of fossil fuels. • The efficiency of geothermal energy plants is low, reaching highs of only around 23%, because geothermal plants operate at lower temperatures than fossil fired plants. • Fluids from geothermal energy may contain gases such as hydrogen sulfide, carbon dioxide, and methane. • Additionally, hot water from geothermal sources may hold trace amounts of toxins such as arsenic, boron, and mercury, which may cause environmental damage if released. • Large capital investments are needed for geothermal power, due to the costs of drilling.

	• The construction of geothermal plants can affect the stability of the surrounding land. For example, a project in Switzerland was abandoned because it caused minor earthquakes (3.4 on the Richter Scale) over the first week of operation.

In Ontario/Canada:

- Canada does not currently have any geothermal energy plants.
- Due to high capital costs and difficulties in connecting the grid to geothermal energy plants in remote areas , few economic sites exist in Canada.

Nuclear
Summary: • Uranium is a natural radioactive metal found in rocks and to a lesser extend in soil, water and the human body. Uranium in Canada is mined in Saskatchewan. • In nuclear fission, the nucleus of an atom (of an element like uranium) splits into its smaller parts when neutrons collide with the nucleus. This produces additional neutrons and photons. The fission of heavy elements releases large amounts of energy as both electromagnetic energy and kinetic energy. • For fission, or splitting, to produce energy, the total energy of the starting element has to be higher

than that of the fission fragments.

- When an atom is split, both pieces and heat energy (radiation) are created. The resulting pieces, or fragments, are different elements.
- Isotopes are atoms that have the same number of protons, but different numbers of neutrons. Different isotopes of an element produce different nuclear properties of that element, and their behaviour differs when included in a nuclear reaction.
- The available energy contained in a given amount of nuclear fuel is millions of times that of the same amount of a conventional fuel, such as natural gas or oil.
- Uranium used in nuclear reactions is formed into fuel bundles. The heat from the nuclear reaction is used to heat water into steam, which then turns a turbine/generator to generate electricity.
- Spent fuel is stored in water-filled bays for 5 to 10 years, and then moved to large concrete canisters. The canisters are then shipped to secure warehouses (usually on the reactor's site), where they are constantly monitored.
- Nuclear power plants employ significant protections to ensure that the public is not harmed from accidents or spills. For example, plants have at least three layers of concrete and steel to prevent radiation leakage. Modern plants are also designed to withstand a number of design basis events such as earthquakes, plane crashes, tornados, etc.
- Nuclear plants cost approximately 4,000 to 6,000 USD/kWe to construct and have a life-cycle of approximately 60 years if a mid-life refurbishment is performed. The mid-life refurbishment costs approximately 30% of the cost of a new plant.
- The cost of electricity from nuclear power plants is approximately 4.8 US cents/kWh which includes a charge for long term spent fuel storage and decommissioning.

Advantages	**Disadvantages**
• Eight pellets of uranium, each smaller than a thumb of an adult, contain enough energy to power a Canadian home for a year. • The fueling cost of nuclear power is extremely cheap. Natural uranium fuel in our CANDU reactors costs only about ½ cents per kWh. • Electricity generated from Canada's nuclear plants eliminates up to 700 million tones of emissions, annually. • Other than hydro power, nuclear power is the only large-scale, continuous generator of power that does not release emissions that contribute to global warming. • Nuclear energy produces very little high level (spent fuel) waste. The total amount of used nuclear fuel in Canada over the past 50 years could be stored in six hockey rinks, up to the boards. • The use of Canada's nuclear power plants is strictly governed by domestic and international nuclear power regulations, in order to ensure the safety and security of Canadians.	• Public concerns over the accumulation and storage of dangerous nuclear waste often hampers the development of nuclear technology. • Mining, transporting and enriching uranium poses many security risks. Currently, Canada does not use enriched uranium in its power reactors nor does it reprocess spent fuel. • Development of nuclear infrastructure requires billions of dollars of investment for building and upkeep, often requiring significant support from federal and provincial governments such as financial guarantees and for front-ending development costs and project risks on the first reactor of a given design. • The development of nuclear capabilities is a politically controversial topic due to concerns over proliferation of nuclear weapons. This is true, especially when countries which are not allowed under international treaties to develop nuclear weapons, develop nuclear energy technologies for peaceful purposes.

• The nuclear industry worldwide has significantly improved the safety of nuclear reactors since the Three Mile Island accident in 1979. • CANDU natural uranium reactors do not use enriched uranium nor is spent fuel re-processing performed.	• Nuclear fuel takes tens of thousands of years to deteriorate to levels of radiation that are safe for human exposure. Consequently, spent fuel must be isolated from the environment and its storage monitored and managed. • Public concern about terrorism is often directed at nuclear plants.

In Ontario/Canada:

- Canada has been developing nuclear technologies for over 60 years, and mostly for peaceful purposes such as medicine, energy, agriculture and research.
- Canada is the largest producer of uranium in the world, most which is in Saskatchewan.
- Canada produces 22% of the world's uranium supplies. Most of this is exported.
- The 20 nuclear power reactors in Canada provided 15% of Canada's electricity in 2008 and 6% of Canada's energy.
- Over 60 000 people work in the nuclear industry in Canada.
- Domestic nuclear energy production represents 53% of Ontario's electrical energy sources. Ontario has 18 CANDU (natural uranium, pressurized heavy water) reactors.
- Canada provides over 50% of the global supply of medical isotopes for nuclear medicine, which are used in over 60 000 procedures per day (5000, on average, of which occur in Canada).
- Nuclear irradiation technology is used to treat fruits, vegetable and meat to eliminate possible food-borne illness and disease.

Energy Storage Systems

Summary – Geothermal Storage Systems:

- Geothermal storage systems do not create new energy, but instead store existing energy for later use. When used with heat pumps (essentially reversible air conditioners), geothermal storage can provide efficient space heating and cooling. The ground stores heat from the building in summer, and feeds it back to the building in the winter.

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Summary – Hydrogen Systems:

- Hydrogen is not available in free form in our environment, so it must be manufactured. Consequently, hydrogen is really a form of stored energy that is obtained from some other energy source.
- Steam can be reacted with carbon (usually coal) at high temperatures to produce hydrogen, carbon monoxide and carbon dioxide.
- Hydrogen can be produced in a petrochemical facility by cracking larger hydrocarbon molecules such as methane.
- Hydrogen can also be produced by electrolysis, using either electricity on its own, or in combination with heat to reduce the electrical energy required. The electricity and heat can be produced by any power plant, but the most attractive environmentally is wind and nuclear, which do not emit greenhouse gases. They also produce power during off-peak periods when it is not needed by electrical consumers.
- Hydrogen has not yet progressed to a practical transportation fuel but research and development on fuel cells, and direct hydrogen-fueled engines, is being conducted.

Advantages	Disadvantages
Geothermal Storage: • Geothermal heat pumps are more cost-effective than standard furnaces and air conditioners on a long- term basis (over the 20-year lifetime of the equipment). • Closed geothermal storage systems can provide both heating and cooling. • The effective environmental emissions are that of the electrical system to which they are connected. **Hydrogen:** • Hydrogen transportation fuel can be produced during off-peak periods using surplus generation capacity, including nuclear, resulting in better utilization of generating plants. • Hydrogen fuel enables nuclear plants and wind turbines to power automobiles and displace oil.	**Geothermal Storage:** • Installing geothermal systems in private homes is capital cost-prohibitive for most individuals, because it is about five times the cost of a traditional gas furnace and air conditioner. • Requires land around the structure for existing buildings. **Hydrogen:** • Conversion of nuclear and wind energy to hydrogen fuel energy involves additional inefficiencies that increase costs. • Currently not competitive with other forms of transportation fuel. • No infrastructure currently exists for distributing Hydrogen fuel in Ontario at convenient locations that would meet with public acceptance.

In Ontario/Canada:

- Complete geothermal storage systems for typical residential applications cost approximately $15,000 to $30,000 CAD, depending on the site.

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