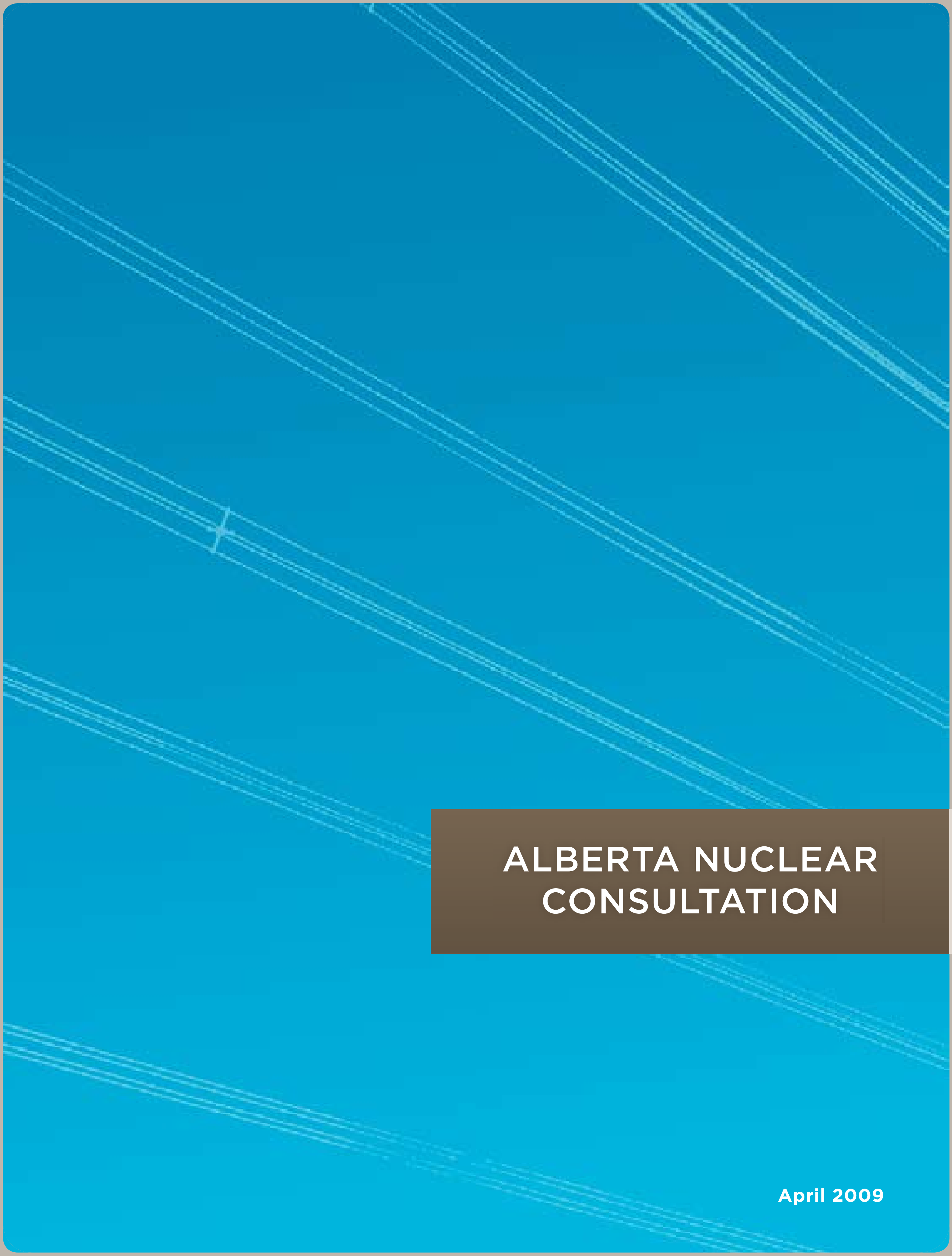


ALBERTA NUCLEAR CONSULTATION

April 2009

Table of Contents

LIST OF FIGURES

LIST OF TABLES

i Introduction

The Alberta government is looking for the public's views on whether or not nuclear power should be considered as an option for meeting Alberta's energy needs. While no organization has proposed building a nuclear power plant in Alberta in the past, it now appears there will be at least one nuclear proposal before government in the near future. As a result the government needs to decide whether or not nuclear power is an appropriate addition to the energy options available to Alberta today.

This workbook is designed to provide information to Albertans and collect your input. The key part of this workbook is the survey. By completing the survey, you can ensure the government considers your views as it develops its official position.

While there is a nuclear reactor at the University of Alberta used for research purposes – the SLOWPOKE Nuclear Reactor Facility [www.ualberta.ca/~slowpoke], the issues related to nuclear power plants will be new information for many Albertans.

Nuclear energy is regulated by, and under the constitutional responsibility of the federal government. The provincial government regulates resources which any major plants are dependent upon such as land-use, water-use, and air emissions.

In anticipation of a public consultation process, the Alberta government created a "Nuclear Power Expert Panel" in 2008 to gather information and present their findings on nuclear energy to Albertans. The Expert Panel's report was released in March 2009 and presents information to help provide a clear understanding of the nature of nuclear power generation, and its relative risks/benefits for Alberta compared with alternatives. The information discussed in this workbook is based on the report of the Expert Panel.

Nuclear energy is a controversial topic and many issues and concerns are often raised when considering it as an energy option. This workbook is dedicated to providing basic background information on Alberta's electricity system, Alberta's energy options, how nuclear energy works, and what the experience with nuclear energy has been elsewhere.

This information has been organized by key questions and topics often raised in discussions about nuclear energy. Throughout the workbook, you will see links to Canadian and international sources of information that can be pursued for further study on the issues. You can read it all, you can use the questions listed in the table of contents to turn directly to the topics in which you are most interested, or you can go directly to the survey.

This public consultation process is being managed by an independent research company. They will receive the results of all surveys and report to government at the conclusion of the process. Your responses will be combined with others to protect your privacy. The report with the combined results will be submitted to the Alberta Government.

Copies of the Expert Panel's report can be viewed at Alberta public libraries, or requested by phoning toll-free 310-0000, then 780-427-0265. To view the Expert Panel report online, visit: www.energy.alberta.ca

Who were the members of the Expert Panel?

Chair, Honourable Dr. Harvie Andre, BSc, MSc, PhD, FEIC, PC

Dr. Joseph Doucet, B.Mgt.Sc., MSc, PhD (University of Alberta)

Dr. John Luxat, BSc, MSc, PhD (McMaster University)

Dr. Harrie Vredenburg, BA, MBA, PhD, ICD.D (University of Calgary)

See Appendix A of the Expert Panel report for biographical details.

1 Electricity in Alberta Today

This chapter looks at how much electricity is currently being generated and consumed in Alberta each year, what sources Alberta's electricity is being generated from, and how much electricity Alberta is projected to need in the future.

Who consumes Alberta's energy supply?

In 2007, the total energy used by the Alberta electric system was just under 52,000 gigawatt-hours (GW.h). Different sectors of the Alberta economy have different needs for energy. Figure 1 shows how each sector contributes to the total energy demand:

- Industrial users account for over half of Alberta's energy consumption (55%) while commercial users consume about 25% of Alberta's electricity.
- Residential demand tracks population growth very closely and accounts for about 17% of annual electricity consumption in Alberta.

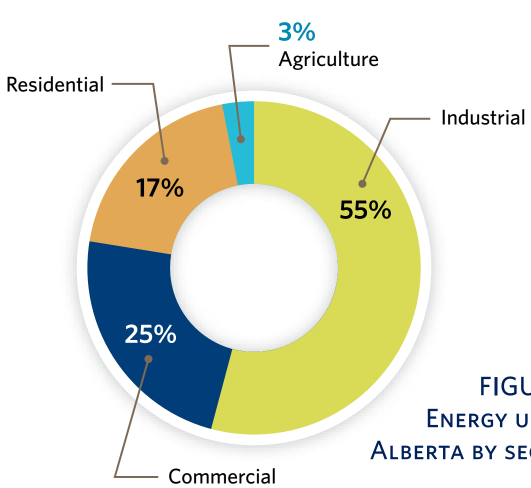


FIGURE 1
Energy use in Alberta by sector

How much energy is consumed in Alberta during peak periods?

In 2007-08, the peak demand at any one moment for the Alberta electricity system was 9,806 megawatts (MW). Between 2000 and 2007, peak demand increased on average by 3.7% a year.

How much electricity is generated in Alberta each year?

Alberta's energy is generated from more than 280 units with a combined capacity of about 12,150 MW that can be generated at any one time. Between 2000 and 2007, generation capacity expanded at an average rate of 3.4% a year.

Who is responsible for generating new sources of electricity for Alberta?

The decision to build new generating capacity is made by a private-sector owner. This decision to build a plant – whether powered by thermal combustion, renewable energy, or nuclear – is taken by a company, based on its assessment of the project's economic viability. The cost and economic risk of building and operating an electricity generating plant is borne by the private investor.

All such plants must obtain approval from relevant government and regulatory authorities regarding its impacts or consequences.

What sources of energy is Alberta's electricity generated from?

Not all power is the same. Each energy option has different characteristics.

In terms of capacity, coal accounts for 50% of Alberta's energy capacity while natural gas accounts for 38%; however, coal-fired power plants generally operate throughout the year as base-load power while natural gas fired plants tend to be used more on short notice to satisfy peaks in demand and therefore operate fewer hours.

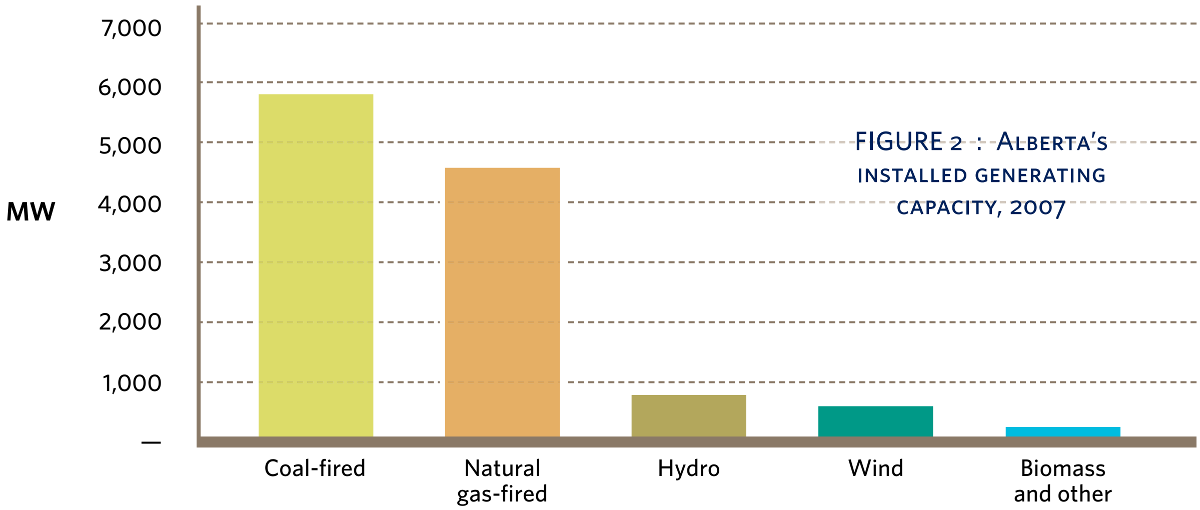


FIGURE 2 : ALBERTA'S INSTALLED GENERATING CAPACITY, 2007

In 2007, 62% of electricity consumed in Alberta was generated from coal and 32% from natural gas power plants. The remainder was generated by a combination of hydro, wind, biomass, and other power projects.

Some types of power are intermittent and dependent on external factors. For example, the amount of wind power generated depends on wind conditions, the amount of solar energy generated depends on the amount of sunlight.

How much energy does Alberta need in the future?

Alberta's demand for electricity has been growing at one of the fastest rates in North America.

The most recent forecast by the Alberta Electric System Operator (AESO, www.aeso.ca), carried out in 2007, indicates that by 2024, Alberta's peak demand for energy could be over 16,800 MW – a 74% increase over 2007. This would reflect an increase of 3.3% a year on average.

It is difficult to forecast electricity growth precisely. However, demand for power is reliably linked to underlying economic activity, driven to a large extent by industrial expansion. Global economic conditions may slow growth in the near term but are less likely to affect longer term projections. Over the period 2007-2024, AESO estimates:

- A 91% increase for the industrial sector, driven largely by growth in the oilsands.
- A 71% increase for the commercial sector.
- An increase in Alberta's population of 1.6% per year between now and 2020. This is the equivalent of an average addition of 25,000 residential customers per year.

While supply is considered adequate in the near term, an additional 3,800 MW will be required by 2016 – an increase of 31% over today's capacity. To meet the need by 2024, a total additional installed generation capacity requirement of between 4,600–9,500 MW is projected.

For more information on electricity in Alberta today, please refer to Section 2 of the Expert Panel report.

2 Options for Meeting Alberta's Future Electricity Needs

This chapter discusses the major options available to Alberta in responding to the need for new electricity supply outlined in the previous section. Nuclear energy is summarized and compared with other energy options in the energy options chart on page 7, and more thoroughly examined in Chapter 3.

Who decides which energy options are pursued?

Though the choice of which energy option to pursue is made by private, investor-owned companies, government has a role to play as a regulator. Each electricity supply option has its pros and cons on a list of characteristics that are relevant to evaluating its ability to meet Alberta's needs, which include reliability, availability, cost, and environmental impact.

What role does conservation play in meeting Alberta's future electricity needs?

The Alberta government is actively encouraging Albertans to conserve energy where possible and to wisely use energy. Energy efficiency, conservation and management measures can yield benefits for residential and industrial users. These measures alone may not counter the need for additional capacity. It may be important to consider implementing energy efficiency, conservation, and management programs in combination with new generation capacity, to ensure adequate supply.

For further information see www.energy.alberta.ca/Initiatives/strategy.asp

What is "base-load" power?

When Albertans flick on the light switch or turn up the heat, they expect that the power will be there for them. Base-load power plants generally operate on a continual basis over the course of the year. They are often units with inexpensive fuel and/or less operating flexibility in terms of being turned on and off.

Not all power sources can provide a steady supply of power. For example, wind power is dependent on the amount of wind and hydroelectric power varies depending on water flows. Coal and nuclear are almost always operated as base-load power, whereas natural gas units have traditionally been considered peaking plants, which means they can be used on shorter notice to satisfy peaks in demand.

Where can I review more detailed information on Alberta's energy options?

The energy comparison chart on pages 7 to 9 compares Alberta's energy options and their unique characteristics, such as cost, dependability, environmental impact, and operating considerations.

A detailed discussion of Alberta's energy options is found in Section 3 of the Expert Panel report.

Additional information on each of the energy options can be found at the following web sites:

- Coal
  - » www.energy.alberta.ca/OurBusiness/coal.asp
- Natural Gas
  - » www.energy.alberta.ca/OurBusiness/Gas.asp
- Renewable Energy (including Wind, Bioenergy, Hydroelectricity, Solar, and Geothermal)
  - » www.nrcan.gc.ca/eneene/renren/aboaprren-eng.php
  - » Wind: www.energy.alberta.ca/Electricity/pdfs/FactSheet_Wind_Power.pdf
  - » Bioenergy: www.energy.alberta.ca/OurBusiness/bioenergy.asp
  - » Micro-generation: www.climatechangecentral.com/publications/c3-views/c3-views-issues/january-2009

Energy Options Chart

RESOURCE	NUCLEAR	COAL – CONVENTIONAL	COAL – CARBON CAPTURE AND STORAGE
TECHNOLOGY	Fissioning (splitting) uranium atoms to produce heat that drives conventional steam turbines.	Uses coal combustion to produce heat that drives conventional steam turbines.	Uses coal combustion to produce heat that drives conventional steam turbines. CO_2 removed from air emissions and stored underground. Technology is evolving.
ENERGY QUALITY	Firm, base-load energy.	Firm, base-load energy.	Same as coal - conventional.
CAPABILITY	Dependable capacity (operates 90-95% of the time).	Dependable capacity (operates 85-90% of the time).	Same as coal - conventional.
COST	High up-front cost. Cost of energy typically ranges from 3.5 to 6.0 cents per kilowatt-hour (kW.h).	High up-front cost. Cost benefits come from abundance of Alberta's sub-bituminous coal. Energy costs typically are 6.3 cents per kW.h.	Carbon capture and storage could increase cost of energy from coal to 11.9 cents per kW.h.
ENVIRONMENTAL IMPACT AIR	• Very low CO_2 emissions (has no other emissions such as particulates and NO_X and SO_X compounds).	• Releases more CO_2 than other forms of fossil fuel per MW hour of energy produced. • Has other emissions such as particulates and NO_X and SO_X compounds.	• Capable of removing a significant proportion of the CO_2 produced by burning coal. • Has the potential to reduce other emissions such as NO_X and SO_X compounds.
ENVIRONMENTAL IMPACT WATER	• Must be sited near supply of cooling water. • Depending on cooling system, can draw and return substantial quantities of water, similar to coal plant. Impact on aquatic life through intake, discharge and temperature change of water. • Water used for cooling not radiated.	• As with any thermal plant, coal plants require water for cooling. Impact on aquatic life through intake, discharge and temperature change of water.	• Same as coal - conventional.
ENVIRONMENTAL IMPACT LAND / SITING	• Low impact of land required per amount of energy generated. • Nuclear waste currently stored on site at nuclear power plants. • Long-term sites being investigated.	• Coal is extracted through surface mines and transported to coal-fired power plants. • Plants must be sited where there is a combination of coal and water.	• Same as coal - conventional.

More information on health and nuclear safety in Section 3 of this workbook

CO_2 – Carbon Dioxide, NO_X – Nitrogen Oxide, SO_X – Sulphur Oxide

MORE ENERGY OPTIONS ON THE NEXT 2 PAGES:
Natural Gas Combined Cycle (NGCC),
Integrated Gasification Combined Cycle (IGCC),
Hydro-electricity, Wind, Solar, Biomass, Geothermal

RESOURCE	NATURAL GAS COMBINED CYCLE (NGCC)	INTEGRATED GASIFICATION COMBINED CYCLE (IGCC)	HYDRO-ELECTRICITY
TECHNOLOGY	Natural Gas Combined Cycle (NGCC) is a mature technology that also employs a two-step process to use waste heat.	New technology that involves turning coal (or other sources such as biomass) into a synthetic gas. Gas is burned to run a turbine generator, then waste heat from this combustion generates additional electricity via a steam turbine. Relatively few IGCC plants are in operation world-wide.	Water flow passes through dam, driving turbines, thereby generating electricity.
ENERGY QUALITY	Flexible, firm energy (strong "on/off" capacity).	Flexible, firm energy.	Large hydro – flexible, firm energy. Small hydro – intermittent, seasonal.
CAPABILITY	Dependable capacity (viability depends on natural gas prices which vary more than coal prices).	Dependable capacity, however, technology not proven and operational issues may arise in early years.	Large hydro – dependable. Small hydro – low dependable capacity.
COST	The cost of electricity from NGCC is 6.8 cents per kW.h without carbon capture and 9.7 cents per kW.h with carbon capture. (This assumes a market rate of $7.10 per gigajoule for natural gas).	More expensive than conventional coal plants, however, less expensive to add carbon capture to an IGCC plant. The cost of electricity from an IGCC plant without carbon capture is about 7.8 cents per kW.h, and with carbon capture it is 10.3 cents per kW.h.	High upfront costs. Low operating costs.
ENVIRONMENTAL IMPACT AIR	• Natural gas has significantly lower CO_2 emissions compared to conventional coal. • Cleaner burning fuel with few other emissions.	• IGCC plants can be fitted with carbon capture technology. They are more effective at removing other pollutants such as sulphur, nitrous oxides, and particulates • Overall environmental performance is better.	• Very low CO_2 emissions.
ENVIRONMENTAL IMPACT WATER	• Require significantly less water than coal.	• Water use impacts are similar to conventional coal.	• Large hydro – changes portion of river, flooded; may affect flows downstream and fish habitat. • Small hydro – diverts a portion of stream flow; may impact recreational uses.
ENVIRONMENTAL IMPACT LAND / SITING	• Impacts related to the plant site.	• Mining impacts are similar to conventional coal.	• Large hydro – may flood land for reservoir, potential loss of agricultural land, water course changes. • Large and small – may affect fishery and wildlife habitat, traditional and recreational uses.

CO_2 – Carbon Dioxide, NO_X – Nitrogen Oxide, SO_X – Sulphur Oxide

RESOURCE	WIND	SOLAR	BIOMASS	GEOTHERMAL
TECHNOLOGY	Wind drives turbines, thereby generating electricity.	Large solar plants focus a large amount of solar power in a small area using reflectors, to produce steam to drive turbines. Photovoltaic systems are used mostly off-the-grid and smaller applications.	Biomass-based electricity is fuelled by wood, agricultural residue, waste or dedicated energy crop, and, potentially, municipal waste. It is generally most effective where the feedstock is readily and continuously available.	Alberta has moderate sources of geothermal energy in the Western Canada Sedimentary Basin as well as in the northwest portion of the province. The promising sources identified are remote from any current demand for power or transmission lines.
ENERGY QUALITY	Intermittent.	Intermittent.	Firm, base-load energy.	
CAPABILITY	Low dependable capacity (operational 30-40%).	Low dependable capacity.	Dependable capacity (provided there is consistent supply of fuel).	
COST	Cost of wind-generated electricity varies from 4.6 to 14.4 cents per kW.h.	Cost of solar energy ranges from 20.9 to 74.3 cents per kW.h.	The current cost depends on factors such as proximity and cost of feedstock, scale of plant, and accessibility to the grid.	
ENVIRONMENTAL IMPACT **AIR**	• Very low CO_2 emissions.	• Very low CO_2 emissions.	• Considered CO_2 neutral but has other emissions such as particulates and NO_X and SO_X compounds. • Transporting of feedstock generates emissions.	
ENVIRONMENTAL IMPACT **WATER**	• No water requirements during operation.	• Large solar plants require water to operate the steam turbines.	• Require water to operate the steam turbines and minor requirements for processing.	
ENVIRONMENTAL IMPACT **LAND / SITING**	• Require adequate land to site windmills. • May create “visual pollution”, impact recreational, tourism, and residential areas. • Potential impacts on bats and birds.	• Solar plants produce less electricity per acre than fossil-fuel plants.	• Depends on fuel supply. Crop-based fuel requires substantial land.	

CO_2 – Carbon Dioxide, NO_X – Nitrogen Oxide, SO_X – Sulphur Oxide

3 Understanding Nuclear Energy

This chapter provides background specifically on nuclear power and is divided into the following sections:

A. Nuclear Energy – how it works
B. The Nuclear Industry in Canada and around the World
C. Environmental Impacts of Nuclear Energy
D. Nuclear Fuel Management
E. Nuclear Safety
F. Lessons from Past Nuclear Accidents
G. Nuclear Energy and Regulation in Alberta

Explaining nuclear energy involves scientific terms, some which may not be familiar to all readers.

A. Nuclear Energy – how it works

How is nuclear power used to generate energy?

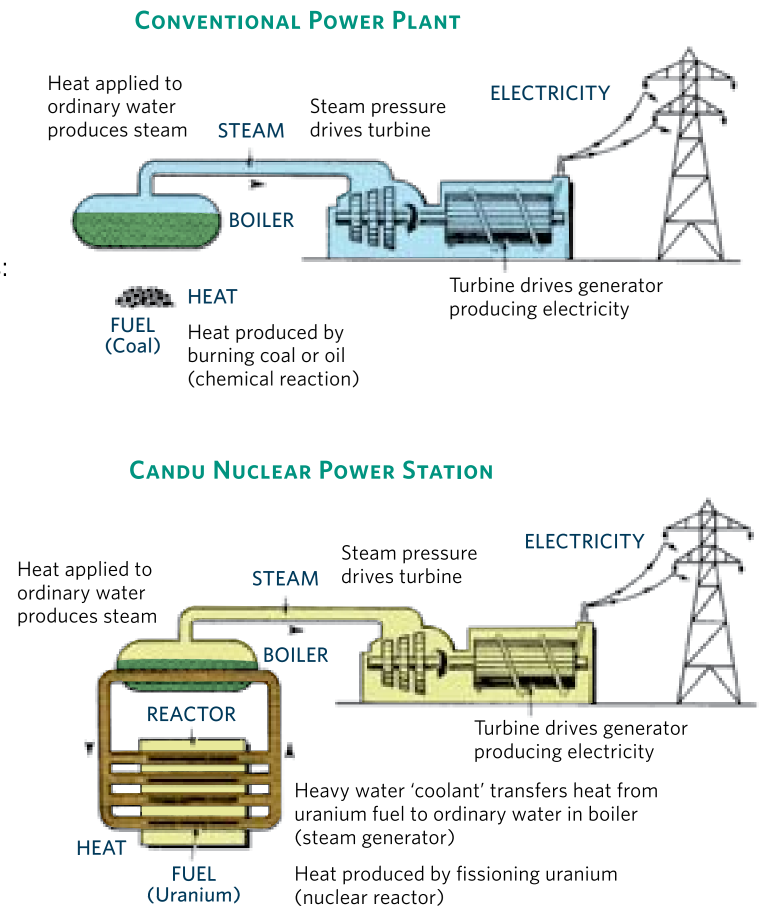
Nuclear power is based upon energy generated by fissioning (splitting) heavy elements such as uranium. This energy is transported away from the reactor to a conventional steam-generating thermal cycle [Figure 3]. The nuclear fuel is either enriched uranium or, in the case of the Canadian CANDU reactors, un-enriched, natural uranium. CANDU stands for "**CAN**ada **D**euterium **U**ranium".

What is nuclear fission?

At the heart of each atom of any element is a nucleus made up of neutrons and electrons. In one naturally occurring form of uranium, known as U-235, the nucleus is likely to undergo fission when bombarded by neutrons with low kinetic energy.

"Fission" means the nucleus breaks into two fragments [Figure 4].

FIGURE 3 : COMPARISON OF NUCLEAR PLANTS WITH CONVENTIONAL GENERATING PLANTS



NOTE: HEAVY WATER COOLANT DOES NOT MIX WITH ORDINARY WATER USED TO PRODUCE STEAM.

HEAVY WATER IS WATER CONTAINING A HIGHER-THAN-USUAL PERCENTAGE OF DEUTERIUM, A HYDROGEN ISOTOPE, RATHER THAN TYPICAL HYDROGEN.

How does nuclear fission create energy?

When fission takes place, and the nucleus is broken into two fragments, these fragments release energy (in the form of radiation) and also release at least two more neutrons.

When the mass of all the products left after fission has taken place is added up, the result is very slightly less than the mass of the original neutron. Part of the mass has become energy. Einstein's famous equation, $E=mc^2$, determines just how much energy can be released by a very small mass.

Under the right conditions, the neutrons released by the break-up of the nucleus go on to bombard other nuclei, causing more fission to take place, and therefore, more energy. By arranging material appropriately, a self-sustaining, controlled chain reaction can be produced.

Nuclear power plants are designed to produce energy by harnessing the energy created from nuclear fission.

How does nuclear fission work in a power plant?

Almost all commercial nuclear reactors are thermal reactors. The neutrons released by fission are 'slowed down' by passing them through a relatively light material such as hydrogen, deuterium, or carbon. In turn, this makes the neutron more likely to contact another uranium nucleus and cause it to fission.

These lighter materials are called moderators. They can be light water, heavy water, or graphite.

Energy released from fission causes the uranium fuel elements to heat up. A flow of liquid or gas fluid – the coolant – flows over the fuel elements, picking up heat from the fuel and using it to boil water into steam to power the generator.

Nuclear reactor types vary according to types of moderator and coolant used, and the degree of uranium enrichment in the nuclear fuel. These characteristics are inter-related. For example, if un-enriched, natural uranium is used, the reactor will need a more effective moderator, such as heavy water, that can slow neutrons to a speed where fission will take place.

For more information on nuclear fission, see Section 4.2 of the Expert Panel report

B. The Nuclear Industry in Canada and around the World

Where are nuclear reactors located in Canada?

Canada has a total of 22 nuclear power reactors currently in service, of which 20 are in Ontario (with 18 operating and 2 being refurbished) and one each in Quebec and New Brunswick (being refurbished).

In addition to the SLOWPOKE facility at the University of Alberta, there are research reactors located at Atomic Energy Canada Ltd.'s (AECL) Chalk River Laboratory in Ontario, at McMaster University in Hamilton (the second largest research reactor in North America), and other SLOWPOKE reactors located at Canadian universities such as the University of Toronto, Dalhousie University, Polytechnique Montreal, and the Royal Military College in Kingston, Ontario.

What type of reactor is used in Canada?

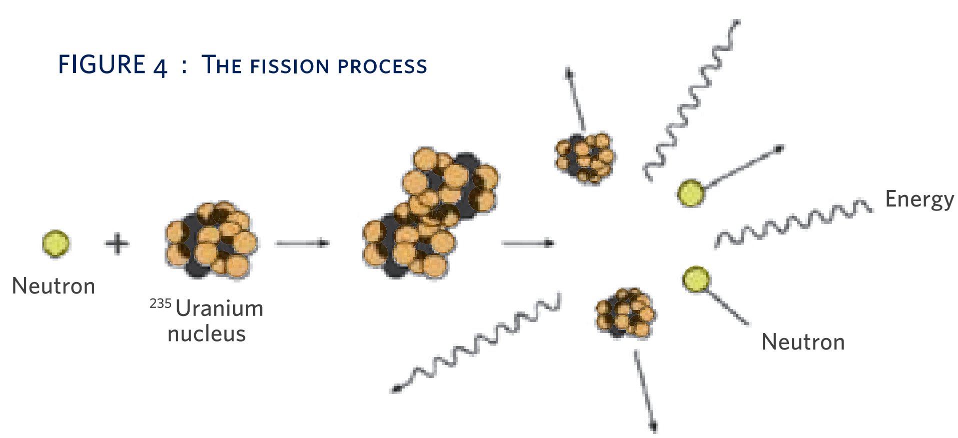
Canadian nuclear power plants are **Pressurized Heavy Water Reactors (PHWR)**, based on CANDU technology. It's a Canadian-designed power reactor that uses heavy water for moderator and coolant, and natural uranium for fuel.

While designed for Canada, CANDU reactors are also exported to other countries. Approximately 11% of the world's reactors are of this type.

There are 443 reactors operating around the world today.

Most common are **Pressurized Water Reactors (PWR)**, which account for about 60% of reactors world-wide, and **Boiling Water Reactors (BWR)**, which account for about 20%.

FIGURE 4 : The fission process



Do all nuclear reactors in Canada have to be CANDU reactors?

There is no requirement to use CANDU reactors. A private company could propose a nuclear power plant using Pressured Water Reactors (PWR) or Boiling Water Reactors (BWR), and use light water and enriched uranium in contrast to existing Canadian reactors.

How long has nuclear power been used to generate electricity in Canada and around the world?

Globally, commercial nuclear power development started after World War II. In the United States, nuclear power plant designs focused on the more common PWR and BWR reactors.

Canada installed 12 nuclear units between 1979 and 1992, when the Darlington, Ontario reactors were brought into service. There have been no new reactors built in Canada since then largely because of cost issues and low demand growth.

Since the early 1990s no new reactors have been brought into service in the United States, reflecting the financial impact of the Three Mile Island accident (which is discussed in Section E of this chapter). Much of the growth in the nuclear energy industry over the last twenty years has taken place in Asia.

A new generation of nuclear reactor designs, often referred to as Generation III reactors, are about to be deployed over the next decade, including the Advanced CANDU Reactor (ACR-1000) designed by Atomic Energy of Canada Ltd. (AECL) – a federal Crown corporation.

Are other provinces in Canada, besides Alberta, anticipating new proposals for nuclear power plants?

The Ontario government has committed to increasing nuclear power generation. Nuclear power currently generates just over 50% of Ontario's annual electricity needs.

A second nuclear reactor is proposed for the Point Lepreau facility in New Brunswick.

The Saskatchewan government has indicated its support for nuclear power generation. The province is a major producer of uranium in the world.

For more information on the types of nuclear reactors and the development of nuclear power, see Sections 4.2.1 to 4.2.4 of the Expert Panel report

C. Environmental Impacts of Nuclear Energy

What impact does nuclear energy have on CO_2 emissions?

Nuclear power has attracted renewed interest recently because it does not emit CO_2 during operation, unlike fossil-fuel-based forms of electricity generation. Considering the entire life-cycle (including mining, processing, uranium enrichment, fuel fabrication and transport), the emission of CO_2 from nuclear power generation is similar in magnitude to the life-cycle emissions from renewable energy sources such as wind power.

How is water used in a nuclear power plant?

The volumes of water required by various cooling systems and the environmental impacts are similar to those for fossil-fuelled plants.

Nuclear power plants, like fossil-fuelled power plants, require cooling to condense the steam exiting the large turbines. This cooling is provided by cold water flowing through the tubes of the turbine condenser.

- Once-through cooling extracts water from a river, lake, or ocean then returns almost all of it back to that body of water. Once-through water cooling has various effects on the environment: damage to aquatic life at intakes, discharge of warmer water into the parent body of water, and the impact of chlorine. The discharge of water would need to meet federal/provincial requirements as with any industrial plant.
- Cooling towers use less water than once-through cooling, but with more water lost to evaporation through the cooling towers.
- Dry air fan cooling does not require any water but consumes more electricity to drive the fans, making it less efficient. This system is a good option where there is a limited water supply.

For more information on the cooling process, see Section 4.4.2 in the Expert Panel report.

When water is discharged back into the environment, is it contaminated?

Cooling water is not in contact with nuclear fuel and so cannot release radioactivity into the environment.

A nuclear power plant uses a small amount of water to cool used fuel that has been removed from the reactor. This small amount of water (enough to fill a swimming pool) is not released to the environment.

D. Nuclear Fuel Management

Where does the fuel for nuclear power plants come from?

The fuel for reactors principally comes from uranium. Countries with the largest reserves of uranium are Australia, Kazakhstan, and Canada. Substantial reserves are available for future nuclear plant operations (www.gov.sk.ca/adx/aspx/adxGetMedia.aspx?mediaId=767&PN=Shared).

Canada is the only country in the world to possess high-grade ore bodies. The MacArthur River mine in Saskatchewan has the highest-grade ore found anywhere on earth (on average, 100 times the world-wide average).

How is uranium made into fuel?

Typically, mining and milling involves extracting the uranium-bearing ore, crushing and grinding it to coarse particle form and leaching it with an acid to extract the uranium as a solution. After further refining impurities, the uranium is precipitated as U_3O_8 powder, referred to as yellowcake because of its colour. The yellowcake is made into uranium pellets which are encased by zirconium alloy tubes.

How is the fuel utilized in the reactor?

Inside the reactor, once it is operating, uranium in the fuel pellets undergoes fission, as described earlier in this workbook. Fission occurs in two types of uranium isotopes: uranium-235 and uranium-238. A key difference between them is that uranium-238 'captures' a neutron during the fission process to form a new element called plutonium-239. Plutonium-239 then undergoes fission just like uranium-235.

What is enriched uranium?

The U-235 isotope, necessary for nuclear fission, makes up 0.711% of the uranium found in nature. CANDU reactors use natural uranium. The enrichment process increases this concentration to between 3% and 5%, as required by light water reactors.

How much waste is generated from nuclear power?

According to the Nuclear Waste Management Organization, the nuclear industry in Canada generates about 85,000 fuel bundles of waste each year. A fuel bundle is about the size and shape of a fireplace log. Based on current rates of nuclear electricity generation, it is estimated there will be 3.6 million fuel bundles in storage by 2033. This would fill a soccer field to a height of about 3 metres.

For more information: www.nwmo.ca/Default.aspx?DN=aa143ada-af90-4b11-a4d9-8b807cv69b9ce

How is radioactive waste dealt with?

Radioactive waste in Canada is regulated by the Canadian Nuclear Safety Commission (www.cnsc-ccsn.gc.ca).

Once spent fuel is removed from the reactor, it is highly radioactive and continues to produce heat through decay of the fission products. It requires further cooling in a pool of water (about the size of an Olympic swimming pool). This pool is called a 'spent fuel bay'. (Water provides an effective shield against radiation.)

The water that is used in spent fuel bays is not discharged back into the environment. It is retained in the plant and handled as nuclear waste in accordance with Canadian Nuclear Safety Commission requirements.

About 10 years after discharge, the heat has decayed to a sufficiently low level that the fuel can be transferred to concrete dry-storage structures in which the fuel is air-cooled.

Most fission products (or waste) decay away to the natural background levels of radioactive materials found in the earth's crust within approximately 500 to 1000 years.

Used fuel can be recycled to separate the waste fission products from the heavy metals (i.e. uranium and plutonium), thereby reducing the amount of waste and the amount of mined uranium required.

In Canada, the recommended approach for nuclear waste disposal is *Phased Adaptive Management.*

This approach involves initial dry-storage of used fuel at generating station sites, as is the current practice, with later transfer to a centralized underground storage fuel facility in which the fuel is retrievable. The fuel can be retrieved for reprocessing and recycling or it can be prepared for permanent burial in a deep geological repository. Typically, fuel will be stored between 50 to 100 years in an interim repository.

This approach is being implemented by the Nuclear Waste Management Organization of Canada (NWMO). Canada's nuclear waste is stored at interim repositories at generating facilities. There are no permanent storage facilities in Canada at this time. For more information on Phased Adaptive Management and nuclear waste disposal in Canada (www.nwmo.ca). The NWMO was established in 2002 by Ontario Power Generation Inc., Hydro-Québec and New Brunswick Power Corporation in accordance with the Nuclear Fuel Waste Act (NFWA) to assume responsibility for the long-term management of Canada's used nuclear fuel.

For more information on nuclear fuel management, see Section 5 in the Expert Panel report.

E. Nuclear Safety

This section will discuss concerns with nuclear safety related to the possible impacts on public health and the environment due to the release of radioactive material, an overview of safety goals and approaches, and safety design at nuclear plants. All incidents related to nuclear safety are investigated by the CNSC.

What is radioactivity?

Radioactivity is the release of energy from an unstable element from both natural and man-made causes.

Radiation naturally occurs in the environment. All living objects – human, animal, and plant – are continuously exposed to radiation from natural sources, such as cosmic radiation that enters the earth's atmosphere from outer space.

Most of us experience man-made radiation in everyday life, from such things as dental and medical examinations, diagnostic tests, and therapeutic treatments.

How much radiation are people exposed to each year, on average?

The average annual radiation exposure (or radiation dose) that individuals receive worldwide is 2.8 milli-Sieverts (mSv) – a unit for expressing dosages of radiation. The natural background radiation varies from location to location. The average annual exposure of individuals in Canada is approximately 3.4 mSv. On a world-wide basis, natural background radiation accounts for approximately 86% of annual radiation exposure.

How much radiation are people who live close to nuclear power plants exposed to?

The maximum dose to an individual living next to a nuclear power plant for one year is approximately 0.02 mSv additional exposure, which is approximately $1/170^{th}$ of the average Canadian's annual radiation dose.

By comparison, the maximum radiation dose to a person living next to a coal plant for one year 0.2 mSv/yr. The increased dose from the natural radioactivity in coal is ten times higher than that from living next to a nuclear power plant for the same period of time, yet still well within accepted levels.

TABLE 1 : Exposure to radiation and associated responses

DOSE [mSv]	Effects on humans
4500 to 5500	Lethal dose: 99% of those exposed will succumb within 60 days of exposure
3000 to 3500	Lethal dose: 50% of those exposed will succumb within 60 days of exposure
1000 to 2000	Nausea and vomiting and hematological (blood) changes. Recovery very likely especially for healthy individuals.
500 to 1000	Mild effects only in first day of exposure with slight depression of blood counts
250 to 500	Minimal dose detectable by changes in white cell count
10	Approximate dose of abdominal CT Scan
3.4	Average annual exposure of individuals in Canada

What level of radiation has identifiable impacts on health?

The majority of hard data has been accumulated from acute exposures of individuals and a group of individuals – i.e., people who have received relatively large doses over short time intervals. These data have been the subject of detailed analysis by many experts and radiological protection organizations, including the International Committee for Radiological Protection (ICRP, www.icrp.org).

As Table 1 indicates, the levels of acute doses that cause perceptible changes in human health are hundreds to thousands times larger than the doses people receive from natural sources. They are also orders of magnitude larger than the doses to persons living in the vicinity of nuclear power plants.

How are nuclear power plants designed to be safe?

Three basic safety functions are incorporated into nuclear power plants to either prevent or mitigate radioactive fission products being released during accident events. These functions are Control, Cool, and Contain, often referred to as the “3 Cs”.

The primary design of the control safety function is to ensure that the first two barriers to radioactivity release – the fuel ceramic pellet and the metal cladding – do not fail.

Heat generated by fission is constantly transported away by a coolant fluid. The cooling safety function includes systems designed for normal operation at either high or low power and also systems designed to provide reliable alternate means of removing heat from the reactor.

Containment is typically a large reinforced concrete structure surrounding the reactor which is designed to accommodate the discharge of steam from a ruptured pipe. It also limits the release of radioactive material outside the plant to safe levels. Many new designs have a steel lining inside the concrete structure, while other designs have double-walled concrete structures.

How are nuclear power plants designed to withstand extreme weather events?

Nuclear power plants are designed to be very robust against naturally occurring external events. This is achieved by a variety of means, such as the physical separation of important groups of safety functions to prevent simultaneous damage.

How is electricity generation from nuclear power related to the proliferation of nuclear weapons?

The nuclear proliferation issue concerns the possibility that nations will surreptitiously develop technology and facilities that allow the development of material for nuclear weapons. This can involve the enrichment of uranium to very high levels of purity – material referred to as Highly Enriched Uranium – or reprocessing spent fuel to remove plutonium-239. However, reprocessing/recycling reactor fuel does not produce weapons-grade plutonium, since power reactor fuel contains different isotopes of plutonium that reduce its effectiveness for explosions.

Currently, the main means of limiting the proliferation of weapons-grade material are the international safeguarding of nuclear materials by the International Atomic Energy Agency (IAEA, www.iaea.org) and development of new technologies. Used fuel is stored either in water pools or in dry storage structures made of high-strength reinforced concrete. These structures provide high levels of protection against possible hostile actions aimed at disrupting safe storage of the used fuel. Modern safety analysis evaluates the capability of these structures to withstand hostile attacks from a wide range of threats. In addition special seals are used by the IAEA to establish safeguarded facilities in conjunction with random inspections to verify that there has been no tampering with stored used fuel.

What is being done to protect nuclear power plants from terrorist attacks?

Concerns regarding security have increased since the events of September 11, 2001. Specific measures have been taken in Canada, such as increased security and on-site armed response, to address potential security threats. The Canadian Nuclear Safety Commission outlines steps taken since September 11, 2001 and discusses other potential emergencies at the following link: www.nuclearsafety.gc.ca/eng/about/nuclearsafety/actionspost911/faq/index.cfm#5

Can a nuclear reactor explode like an atomic bomb?

No. The technologies for nuclear power are fundamentally different than nuclear weapons. A nuclear weapon is designed to release energy extremely quickly and in enormous quantities. It would be physically impossible to generate such large and rapid energy releases using the arrangement of fuel required to sustain a controlled fission chain reaction in a nuclear power plant.

For more information on nuclear safety, see sections 6.1 to 6.4 in the Expert Panel report

F. Lessons from Past Nuclear Accidents

Over the past 56 years, a number of accidents have occurred in nuclear reactors, some of which have resulted in off-site release of radioactive material.

What are the most serious accidents that have occurred at nuclear power plants and what was learned?

- 1952: NRX, Chalk River, Ontario

An uncontrolled power increase occurred in the National Research Experimental reactor (NRX), badly damaging the reactor.

Lessons learned included: that lack of separation between the control and shutdown functions was a major contributor to the accident. This led to a requirement in Canada that these two functions be totally separate and shutdown be provided by an independent fast-acting system.

For more information see section 6.5.1 of the Expert Panel report.

- 1961: SL-1 Accident, Idaho, USA

The Stationary Low Power Reactor Number One (SL-1) was a small military test reactor that was damaged as a result of technician error in the handling of fuel rods.

Lessons learned: changes were made to the design of control rods, automatic safety shutdown procedures in reactors with manual rod movement, and the use of water in the reactor to limit the release of radiation.

For more information see section 6.5.2 of the Expert Panel report.

- 1979: Three Mile Island Unit 2, Pennsylvania, USA

This accident in the Pressurized Water Reactor (PWR) at Three Mile Island nuclear power station involved a major loss of cooling function for a sustained period of time.

Lessons learned included: the importance of containment in limiting the release of radioactive materials; the need for better training, cooperation, communication, and emergency response; and the need to better understand accidents which cause severe damage to reactor cores.

One important outcome was the establishment of the Institute for Nuclear Power Operations (INPO, www.inpo.info), an organization whose role is to coordinate and promote safe operation and practices, improve information sharing, and provide for industry benchmarking among North American utilities.

For more information see section 6.5.3 of the Expert Panel report.

- **1986: Chernobyl Unit 4, Ukraine**

On April 26, 1986 the worst commercial nuclear power reactor accident in history occurred in the Fourth Unit of the Chernobyl Nuclear Power Station in Ukraine, which at that time was part of the Soviet Union. A large uncontrolled power increase occurred in the reactor during a safety system test. This destroyed the reactor and a large quantity of radioactive material was ejected to the environment during the initial stage of the accident. For the next five days the graphite moderator in the reactor core continued to burn, resulting in an ongoing release of radioactivity to the environment.

Lessons Learned: the main contributor to the accident's severity was the lack of fast-acting shutdown systems, while the main contributor to the large release was the lack of any containment structure around the reactor. Other factors involved included poor safety culture, poor design and poor communication between designers and operators.

In responding to the accident a large number of station operating staff and firefighters were exposed to very high doses of radiation and over a period of a number of months 28 of these individuals died from the effects of radiation exposure. The population in the nearby town of Pripyat was evacuated and permanently relocated. The radiation plume spread around Europe causing great concern. Subsequently the reactor was encased in a concrete vault where it remains awaiting final cleanup and decommissioning.

A large epidemiological study was initiated and continues to this day with reports at ten-year intervals following the accident. These studies are conducted by the Chernobyl Forum, led by the International Atomic Energy Agency and the World Health Organization and involve many other agencies of the United Nations. They address the health consequences including cancer and reproductive effects, environmental consequences including agricultural food or farming and forest contaminants and the socioeconomic impacts.

They estimate that the total number of individuals that could eventually die from radiation exposure from this accident to be about 4000 out of an exposed population of 600,000. The detailed studies have identified a total of 56 persons in this exposed population whose deaths in the past twenty years following the accident can be attributed to the effects of radiation released from the accident. This number includes 28 individuals who died within four months in 1986 as a result of high exposures received in responding to the event, 19 subsequent deaths between 1986 and 2004 of persons involved in responding to the consequences of the accident and 9 individuals who died of thyroid cancer.

As a result of the intense international focus on nuclear safety following the Chernobyl accident the World Association of Nuclear Operators (www.wano.org.uk) was formed with headquarters in London, UK, to promote safe operations an information exchange amongst nuclear operators world-wide.

For more information on Chernobyl see Section 6.5.4 of the Expert Panel report.

- Chernobyl Forum: www-ns.iaea.org/meetings/rw-summaries/chernobyl_forum.htm
- World Health Organization news release (2005) and background information: www.who.int/mediacentre/news/releases/2005/pr38/en/index.html
- www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf

G. Nuclear Electricity and Regulation in Alberta

In many respects a large base-load nuclear power plant is very much like a large base-load coal-fired plant (with respect to integration in the power grid and regional impacts) or to other large industrial projects (with respect to socioeconomic impacts). Like any large industrial proposal, nuclear power plants would have to undergo licensing, regulatory, and environmental approvals.

Can nuclear power be integrated into Alberta's electricity transmission grid?

The transmission grid is the "highway" over which electrical energy travels, connecting supply with customer demand, and electrical generation plants must be integrated safely and reliably into the transmission grid.

A nuclear plant does not affect the cost of transmission differently from any other plant of similar size. Like any other generator, owners of a nuclear plant would pay for the costs of interconnecting their facility to the grid.

The size of the nuclear units could create some operating issues. The transmission system requires reserve capacity should any one unit be unavailable. Adding an individual nuclear unit of 800 MW or more could require increased operating reserves or, alternatively, additional transmission interconnections with neighbouring jurisdictions.

What infrastructure and resources are required for a nuclear power plant?

The selected site will require a power supply; access to technological, community, and service support; earthquake, meteorological and hydrological monitoring; working space for project management activities; and living accommodations for workers if the site is remotely located.

A significant siting consideration would be the availability of sufficient quantity and temperature of cooling water.

Access to the site needs to accommodate the transportation of large reactor components by road, rail, or barge.

The construction of the power plant will also require such resources as engineering expertise, skilled labour, and steel, to name only a few.

What would be the socioeconomic impacts of nuclear plant construction?

The construction and operation of a nuclear power plant would have a significant socioeconomic impact on the province and particularly on the region where it is located. In general, the impacts would be similar to those of any of the large energy industrial projects currently underway in Alberta.

The number of jobs created during construction depends on the size and scale of the plant. A study by the US Department of Energy assessed construction requirements for a smaller Generation III plant (approximately 1300 MW) and found that its construction would require nearly 700 person-years for pipefitters alone. Peak construction requirements of a project of this size would exceed 10% of the Alberta workforce in trades such as ironworking, boilermaking and pipefitting.

The operational staffing level of a power reactor is well-established. The Canadian Energy Research Institute (CERI) has assessed the 17 CANDU reactors operating in Canada and finds a direct workforce at about 949 employees per reactor, on average. This is somewhat higher than is expected for the advanced CANDU, or Generation III, reactors.

For comparison, a typical coal-fired plant (with two 450 MW units) employs a significantly smaller number – 100 to 200 employees (excluding mine operations), depending on the plant.

Like any large industrial project, a nuclear plant will add to the province's economy, as well as contributing to tax revenues and labour income.

What are the community impacts of plant construction?

Absorbing a nuclear plant, like any large industrial project, presents challenges as well as opportunities for local communities, particularly during the construction phase when several thousand workers may be added to a community for a relatively short time.

As found with the oil sands, community impacts in high growth rate areas include:

- Shortages of housing, and affordable housing in particular
- Difficulties in attracting additional public sector workers to handle shorter-term increases in the population.
- An inability to expand infrastructure because capital expenditures are needed before additional tax revenues from a development project are realized.

Which agency oversees nuclear regulation?

The Canadian Nuclear Safety Commission regulates the use of nuclear energy and materials to protect health, safety, security and the environment, and to respect Canada's international commitments on the peaceful use of nuclear energy. It is an independent quasi-judicial agency which reports to Parliament through the Minister of Natural Resources.

What is the environmental review process for new nuclear power plants?

A requirement of licensing is that an Environmental Assessment must meet the requirements of the *Canadian Environmental Assessment Act (CEAA).*

While nuclear jurisdiction is solely and entirely a federal jurisdiction, there is provision for the Federal Minister of Environment to enter into agreements with provincial and territorial governments where both governments have interests in an environmental assessment. In such cases, a Joint Review Panel may be appointed.

How long does it take for a nuclear power plant to receive approvals and start construction?

From the start of the process to the beginning of operation, the licensing process and construction can take nine years.

For more information on the licensing process for new nuclear plants, see Section 8.3 in the Expert Panel report.

www.nuclearsafety.gc.ca/eng

TABLE 2 : Estimated time frame for nuclear power plant licensing

Activity	Duration
Aboriginal consultation	Ongoing
Environmental assessment and license to prepare site	~ 36 months
Site preparation	~ 18 months
License to construct	~ 30 months (minimum 6-month overlap with the previous activities)
License to operate	~ 24 months
Applicant's activities (e.g., plant construction)	~ 48–54 months
Total duration	~ 9 years

4 Glossary of terms

AECL	Atomic Energy of Canada Limited, the Crown Corporation that designs and sells CANDU reactors.
AESO	Alberta Electric System Operator, responsible for planning and operating Alberta's transmission system.
BWR	Boiling Water Reactor, a design that uses a single coolant loop in which water reaches boiling temperature to produce steam.
CANDU	Canada deuterium uranium, a reactor design based on natural uranium fuel with heavy water (deuterium) as a moderator.
CNSC	Canadian Nuclear Safety Commission, the federal nuclear regulator.
CO_2	Carbon dioxide.
Depleted uranium	Uranium from which U-235 has been removed, usually as part of the process of making nuclear fuel.
Deuterium	An isotope of hydrogen that includes one proton and one neutron (compared with the more usual form of hydrogen that has no neutron.)
Fission	The splitting of a heavy atom into smaller fragments when it is hit by a neutron.
Fission products	Unstable isotopes of lighter elements created when the nucleus of a heavier element is split.
GW	Gigawatt, one billion watts.
GWh, GWd	Gigawatt-hour and gigawatt-day, respectively. The energy equal to one gigawatt of generating capacity operating over one hour or one full day.
Heavy water	Water containing a higher-than-usual percentage of molecules made up of deuterium rather than typical hydrogen.
IAEA	International Atomic Energy Agency.
IEA	International Energy Agency.
IGCC	Integrated Gasification Combined Cycle, a technology for creating synthetic gas from coal or other sources and burning it to produce energy.
Kinetic Energy	The energy possessed by a body because of its motion equal to one half the mass of the body times the square of its speed.
Life-cycle analysis	Considers the environmental impacts of all the components throughout the life of a facility, from manufacturing equipment, through construction, installation, and operations to eventual decommissioning.
MW	Megawatts, a million watts.
MWh	Megawatt hours.
Neutron	A subatomic particle with no electric charge. The nucleus of any atom is made up of protons and neutrons.
NGCC	Natural gas combined cycle.
NO_X	Nitrogen oxides.

NWMO	Nuclear Waste Management Organization, an organization created by the owners of used nuclear fuel to manage Canada's nuclear waste.
Person-years	A person-year represents the amount of work done by one person employed for a full year.
PBMR	Pebble bed modular reactor.
PWR	Pressurized Water Reactor.
PHWR	Pressurized Heavy Water Reactor.
SO_2	Sulphur dioxide.
Sievert	A unit for expressing dosages of radiation. It reflects the biological effects of radiation received. A milli-Sievert is one one-thousandth of a Sievert.
U-235	Uranium-235, an isotope of uranium made up of 92 protons and 143 neutrons. It is naturally fissile and releases neutrons.
U-238	Uranium-238, the most common isotope of uranium, made up of 92 protons and 146 neutrons.
V	Volts.
W	Watts.
WANO	World Association of Nuclear Operators.
Wh	Watt hours.
WNA	World Nuclear Association.

For more nuclear terms not mentioned in this workbook, see the Glossary in the Expert Panel report.

Participant Survey

Please fill out the following survey and mail to:

Alberta Nuclear Consultation – Survey Return
suite #425
11215 jasper ave.
Edmonton, ab t5k 0l5

Completed surveys must be postmarked no later than June 1, 2009 in order to be considered as part of the report on the Alberta Nuclear Consultation

Survey Participant Information

In order to have your views considered as part of this public consultation process, please enter your name and address in the form below. This information is being requested to ensure that participants in the nuclear consultation process are Alberta residents. See privacy policy below.

Name: ____

Address: ____

____

City: ____

Province: ____________________ Postal Code: ____________________

❍ I am a full-time resident of Alberta

PRIVACY NOTE:

The Government of Alberta (GOA) has commissioned Innovative Research Group Inc., an independent research firm, to carry out this public consultation related to Albertans' views on the subject of nuclear energy. Only residents of Alberta are permitted to participate in this voluntary survey, therefore, **names and addresses are collected and used by Innovative Research Group Inc. solely for maintaining the integrity of the consultation by validating legitimate participation in the process.** The above-noted personal information shall remain under the custody and control of Innovative Research Group Inc. and will not be disclosed to any third parties, including the GOA.

Only information gathered in response to the 31 survey questions will be disclosed in a final report to the GOA. Survey responses may be supplied as part of a generalized assessment or may be quoted verbatim. **Individuals should not include any personal (identifying) information in their responses that they do not wish to have disclosed to the GOA or general public.** Should an individual choose to incorporate their own personal information within a response, they consent to the disclosure of their personal information contained therein.

Responses must not contain any information that violates the privacy rights of a third party; such information will render the response void and result in destruction of that response with no copy retained.

Reasonable security measures have been employed to prevent unauthorized access to the personal information. In the unlikely event of a privacy breach, Innovative Research Group Inc. will notify any affected parties as soon as realistically possible.

If you have questions regarding the handling of your personal information, please contact Innovative Research Group at privacy@innovativeresearch.ca or by phoning toll-free (888) 268-3419.

Alberta Nuclear Consultation: Survey

The questions in this survey follow the sections of the workbook – Electricity in Alberta Today, Options for meeting Alberta's Future Electricity Needs, and Understanding Nuclear Energy. There are also opportunities for you to write-in additional comments.

SECTION 1. Electricity in Alberta today

1. How familiar are you with Alberta's electricity system?

CHOOSE ONE OPTION

- I can explain the details of Alberta's electricity system to others ❍
- I am generally familiar with Alberta's electricity system but cannot explain it to others ❍
- I have some understanding of Alberta's electricity system but not sure of the details ❍
- I have a very limited knowledge of Alberta's electricity system ❍

2. How important do you think electricity supply is to Alberta's economic future?

CHOOSE ONE OPTION

- Extremely Important ❍
- Very Important ❍
- Somewhat Important ❍
- Not Very Important ❍
- Not Important At All ❍
- Don't Know ❍

3. Do you agree or disagree that, even after achieving all possible conservation, we will still need more electricity?

CHOOSE ONE OPTION

- Strongly Agree ❍
- Somewhat Agree ❍
- Neither Agree nor Disagree ❍
- Somewhat Disagree ❍
- Strongly Disagree ❍
- Don't Know ❍

4. How important is it that Alberta is self-reliant in terms of electricity, rather than depending on supply from other jurisdictions?

CHOOSE ONE OPTION

Extremely Important	❍
Very Important	❍
Somewhat Important	❍
Not Very Important	❍
Not Important At All	❍
Don't Know	❍

SECTION 2. Options for Meeting Alberta's Future Electricity Needs

How important are each of the following criteria to you, when evaluating potential power projects?

		Extremely Important	Very Important	Somewhat Important	Not Very Important	Not Important At All	Don't Know
5.	Air quality	❍	❍	❍	❍	❍	❍
6.	Impacts to water	❍	❍	❍	❍	❍	❍
7.	Impacts to land	❍	❍	❍	❍	❍	❍
8.	Dependable supply of electricity	❍	❍	❍	❍	❍	❍
9.	Low-cost electricity	❍	❍	❍	❍	❍	❍
10.	Reducing CO_2 emissions	❍	❍	❍	❍	❍	❍
11.	Job creation	❍	❍	❍	❍	❍	❍
12.	Impacts on local community	❍	❍	❍	❍	❍	❍
13.	Support of the local community	❍	❍	❍	❍	❍	❍
14.	Location of power plant	❍	❍	❍	❍	❍	❍
15.	Safety	❍	❍	❍	❍	❍	❍
16.	Health risks	❍	❍	❍	❍	❍	❍
17.	Disposal of waste	❍	❍	❍	❍	❍	❍

18. Are there any other criteria you believe are important when evaluating energy options?

SECTION 3. Understanding Nuclear Energy

19. What is your level of knowledge about nuclear energy?

CHOOSE ONE OPTION

- I can explain the details of nuclear energy to others ❍
- I am generally familiar with nuclear energy but cannot explain it to others ❍
- I have some understanding of nuclear energy but not sure of the details ❍
- I have a very limited knowledge of nuclear energy ❍

20. How easy or difficult to understand was the information in this workbook concerning how nuclear energy works?

CHOOSE ONE OPTION

- Very easy to understand ❍
- Somewhat easy to understand ❍
- Somewhat difficult to understand ❍
- Very difficult to understand ❍

21. Before you reviewed this workbook, how familiar were you about the history of nuclear use in Canada?

CHOOSE ONE OPTION

- I was very familiar with the history of nuclear use in Canada ❍
- I was somewhat familiar with the history of nuclear use in Canada ❍
- I was not familiar with the history of nuclear use in Canada ❍

22. When thinking about nuclear power as an energy option, how important of a consideration is CO_2 emissions?

CHOOSE ONE OPTION

- Extremely Important ❍
- Very Important ❍
- Somewhat Important ❍
- Not Very Important ❍
- Not Important At All ❍
- Don't Know ❍

23. Based on what you have read, seen, and heard about nuclear waste storage in Canada, how confident are you that Canada's nuclear waste is safely stored?

CHOOSE ONE OPTION

- Very Confident ❍
- Somewhat Confident ❍
- Not Very Confident ❍
- Not Confident At All ❍
- Don't Know ❍

24. The Expert Panel report states that radiation levels near nuclear power plants are within international and Canadian guidelines for safety. Based on what you have read, seen and heard, which statement best represents your view?

CHOOSE ONE OPTION

- I am comfortable with the level of radiation near nuclear power plants ❍
- I would like to hear more information about radiation levels near nuclear power plants before I make up my mind ❍
- I am not comfortable with the level of radiation near nuclear power plants ❍
- Don't Know ❍

25. Based on what you have read, seen, and heard, what is your view regarding the safety record of Canada's nuclear industry? Is its safety record…

CHOOSE ONE OPTION

- Excellent ❍
- Good ❍
- Needs Some Improvement ❍
- Needs Major Improvement ❍
- Don't Know ❍

Conclusion

26. Looking at the workbook and the Expert Panel's report, were your questions about Alberta's electricity options and nuclear energy answered?

CHOOSE ONE OPTION

Yes ❍
To Some Extent ❍
Not At All ❍
Don't Know ❍

27. What additional information would you have liked to have seen in the Expert Panel report and/or the workbook?

28. Which one of the following statements best represents your view?

CHOOSE ONE OPTION

- The province should encourage proposals to build nuclear plants in Alberta ❍
- Proposals to build nuclear power plants should be considered on a case-by-case basis ❍
- The province should oppose proposals to build nuclear power plants in Alberta ❍
- Don't Know ❍

29. And why do you say that?

30. If the provincial government decided to consider proposals to build nuclear power plants, what are the most important issues about nuclear power plants that should be reviewed?

31. Are there any additional comments you would like to make regarding the potential of generating electricity from nuclear energy in Alberta?

Government of Alberta

ISBN 978-0-7785-6337-2