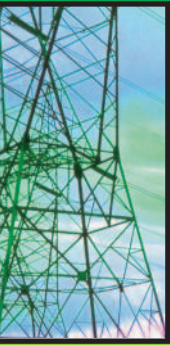
Canadian Nuclear Association

Innovating Today For A Brighter Future



Canada's
Nuclear Energy:
Reliable, affordable and clean energy

www.cna.ca

Nuclear Facts

This 2009 handbook is an update of our popular nuclear facts. Our spring edition reflects the most up-to-date information available on nuclear energy in Canada and worldwide.

Nuclear energy is already used every day in Canada and has the potential to help power us into the future. Find out why the world continues to explore the environmental, economic and medical benefits of nuclear technology.

- What exactly is nuclear energy?
- How much of our daily energy is nuclear?
- Where does it come from?
- Is it safe?
- Is it environmentally friendly?
- What does it mean to me?

Everyone can use this fact book to answer all these questions and others you might not have thought to ask about nuclear energy and energy matters in general.

Students – challenge your assumptions and explore the aspects of nuclear energy that matter to you. Visit the CNA Website at **www.cna.ca** under "Education Resources" and learn more about the history, science and safety of nuclear technology, plus other energy sources.

Teachers – learn about the history and evolution of nuclear technology and take advantage of the CNA web-based curriculum-approved lesson plans at **www.cna.ca** under "Education Resources" developed with Ministries of Education from across the country and by leading scientists and educators, for grades 9–12. Curriculum tie-ins include science, environmental science, biology, physics, history, social studies and world issues.

June 2009

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2009 Edition 1

Canada's Nuclear Industry

- Canada: 61 years in nuclear; Nobel Prize in Physics — 1994: Dr. Bert Brockhouse.
- Nuclear energy in Canada is for peaceful purposes: used only in electricity generation, medicine, agriculture, research and manufacturing.
- Nuclear energy is a $6.6 billion/year industry generating $1.5 billion in federal and provincial revenues through taxes: 21,000 direct jobs, 10,000 indirect jobs (contractors to the industry) plus 40,000 spin-off jobs, 150 firms and $1.2 billion in exports (Source: Canadian Energy Research Institute (CERI) 2008).
- In 2008: 22 CANDU Reactors — 18 in service until April 2008 generating 14.8% of the country's electricity, cleanly and safely, in Ontario (53%), Quebec (3%), and New Brunswick (6.1%).
- On April 1, 2008, New Brunswick Power began refurbishing Point Lepreau. Prior to the refurbishment, it provided up to 30% of New Brunswick's electricity.
- In 2008 in Ontario: 20 reactors — 16 in service providing 53% of the province's electricity coming from 12,024 MW (Gross) of installed electrical nuclear capacity (Source: CANDU Owners Group (COG)/Pressurized Heavy Water Reactor (PHWR) Performance Indicators, Dec 2008).
- Canada has operated CANDU nuclear power reactors safely for 47 years.
- Canada has the world's largest known high-grade natural uranium deposits in Saskatchewan.
- Canada provides over 50% of the global supply of medical isotopes for nuclear medicine used in 60,000 procedures per day — 5,000 of those in Canada.
- The total amount of used nuclear fuel produced in 47 years from nuclear power plants in Canada would fill six hockey rinks up to the height of the boards.



Canada is the World's Leader in Uranium

- Canada is the world's largest producer of natural uranium providing about 21% of total world production from its Saskatchewan mines in 2008.
- Canadian uranium is used exclusively for the generation of electricity at nuclear power plants with end use strictly enforced by international non-proliferation agreements and export restrictions.
- The two major uranium mining companies in Canada are Cameco Corporation and AREVA Resources Canada Inc.
- Electricity generated from Canadian uranium worldwide avoids nearly 700 million tonnes of CO_2 emissions annually (Sources: Canadian Nuclear Association (CNA) & World Nuclear Association (WNA) 2009).
- Uranium is a metal, common and abundant in nature, found in most rocks, soil, rivers, oceans, food and the human body. It is a unique element because of its potential to generate huge amounts of energy.
- Saskatchewan's uranium reserves contain about four times more energy than all known Canadian conventional oil reserves (not including the Athabasca tar sands).
- Saskatchewan's McArthur River and Cigar Lake deposits are the world's richest with average ore grades more than 100 times the global average for uranium mines. The energy contained in these deposits is equivalent to 15 billion barrels of oil or more than four billion tonnes of coal.
- Saskatchewan-based Cameco alone accounted for 15% of the world's uranium production in 2008. The company is also involved in exploration projects in Saskatchewan, Nunavut, the Northwest Territories and Quebec and operates a uranium refining facility at Blind River, Ontario and conversion and fuel manufacturing facilities at Port Hope and Cobourg, Ontario.

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Canada is the World's Leader in Uranium

- AREVA Resources Canada based in Saskatoon, mines and mills uranium in Saskatchewan and is exploring for uranium in several provinces as well as in Nunavut.
- There is ample uranium in the world to fuel nuclear power plants today and in the future. Higher uranium prices will encourage investment in exploration, mine expansion and new mine development that will expand uranium production to meet increasing demand.
- The Canadian Energy Research Institute (CERI) has found that the mining and fuel production, operation and waste disposal of nuclear plants produces just 1.8 grams of carbon dioxide per kilowatt-hour (g/kWh), compared to 540 g/kWh for gas-fired generation, and 1,050 g/kWh for coal-fired generation in Ontario. (Source: Comparative Life-Cycle Assessment of Electricity Generation in Ontario, CERI, 2008)
- The uranium mining industry in Canada generates the employment of 5,000 people (Source: Economic Impact of the Nuclear Industry in Canada, CERI, 2008) and is a leading employer of aboriginal people.
- Eight pellets of uranium, each smaller than an average adult thumb, contain enough energy to power an average home for about one year.

Nuclear Reactors in Canada

In 2008, 18 nuclear reactors provided 14.8% of Canada's electricity.

2008 Operating Reactors

• Pickering A (ON)	2 reactors	542 MW each	(Gross)
• Pickering B (ON)	4 reactors	540 MW each	(Gross)
• Darlington (ON)	4 reactors	934 MW each	(Gross)
• Bruce A (ON)	2 reactors	805 MW each	(Gross)
• Bruce B (ON)	1 reactor	845 MW	(Gross)
• Bruce B (ON)	3 reactors	872 MW each	(Gross)
• Gentilly-2 (QC)	1 reactor	675 MW	(Gross)
• Point Lepreau (NB)	1 reactor	680 MW	(Gross) (Jan 1-Mar 31, 2008)

2 CANDU Reactors Being Placed in Safe Storage in 2008

• Pickering A (ON)	Units 2 & 3	542 MW each	(Gross)

3 CANDU Reactors Being Refurbished 2008

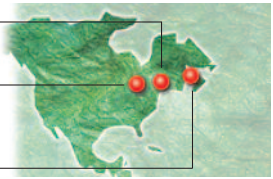
• Bruce A (ON)	Units 1 & 2	805 MW each	(Gross)
• Point Lepreau (NB)	1 reactor	680 MW (Gross)	(Beginning April 1, 2008)

2 CANDU Reactors Refurbishment Completed

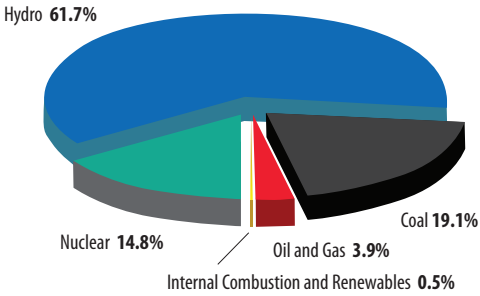
• Pickering A (ON)	Unit 1	542 MW (Gross) Returned to Service 2005
• Pickering A (ON)	Unit 4	542 MW (Gross) Returned to Service 2003

CANDU Reactors in Canada 2008

Quebec	
Gentilly-2	1 unit
Ontario	
Darlington	4 units
Pickering	8 units
Bruce	8 units
New Brunswick	
Point Lepreau	1 unit

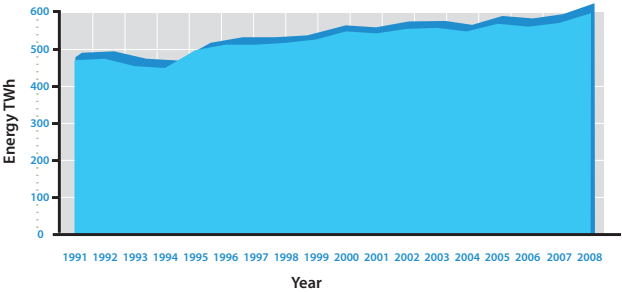


Electricity Generation in Canada 2008



Source: Natural Resources Canada (NRCan), 2009

Electricity Consumption in Canada 2008



Source: Statistics Canada, Energy Statistics Handbook 2008

CANDU Nuclear Reactor Performance 2008

Reactor	In Service	Actual Capacity (Gross) (MW)	Performance In 2008 (%)	Lifetime Performance (%)
Point Lepreau	1983	680	22.5*	79.5
Gentilly 2	1983	675	65.8	78.9
Wolsong 1	1983	622	93.0	85.7
Wolsong 2	1997	730	92.2	94.2
Wolsong 3	1998	729	93.0	95.6
Wolsong 4	1999	730	94.5	97.3
Embalse	1984	648	83.0	84.8
Cernavoda 1	1996	706	84.8	88.1
Cernavoda 2	2007	705	96.9	96.4
Qinshan 4	2002	700	93.5	88.8
Qinshan 5	2003	700	89.3	89.2
Pickering 1	1971	542	62.3	63.0
Pickering 4	1973	542	81.3	66.6
Pickering 5	1983	540	89.7	74.0
Pickering 6	1984	540	95.9	77.9
Pickering 7	1985	540	34.0	77.5
Pickering 8	1986	540	65.0	76.0
Bruce 3	1978	805	77.8	63.4
Bruce 4	1979	805	83.4	62.3
Bruce 5	1985	845	77.5	83.2
Bruce 6	1984	872	95.2	80.5
Bruce 7	1986	872	80.0	83.5
Bruce 8	1987	845	93.5	82.1
Darlington 1	1992	934	79.7	83.4
Darlington 2	1990	934	98.5	76.9
Darlington 3	1993	934	99.4	86.1
Darlington 4	1993	934	97.9	86.0
Total/Average		**19,655**	**82.2**	**81.5**

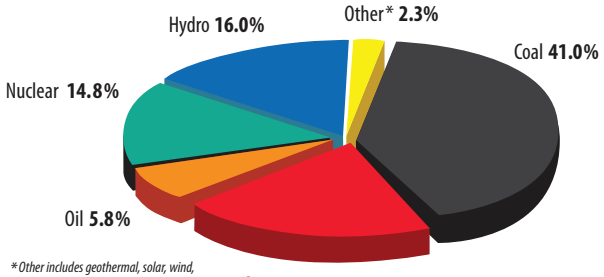
Source: COG CANDU/PHWR Performance Indicators, December 2008

** Point Lepreau Performance from January 1 to March 31, 2008. Effective April 1, 2008 - this reactor is under refurbishment.*

Nuclear Generation Worldwide

- There were 436 operable nuclear power reactors in 30 countries on April 1, 2009. The world total includes 6 reactors operating in Taiwan.
- As of April 1, 2009, there were 44 nuclear reactors under construction, another 108 being planned and 272 being proposed (Source: World Nuclear Association, April 1, 2009).
- Nuclear power is the only large-scale generation option, other than hydro, that does not release greenhouse gas emissions that contribute to global warming.
- Nuclear power produces 14.8% of global electricity and is the world's fourth largest source of electricity (Source: (OECD/IEA), World Energy Outlook 2008).
- Around the world scientists in more than 50 countries use nearly 300 research reactors to investigate nuclear technologies and to produce radioisotopes for medical diagnosis and cancer therapy.

Global Electricity Generation



*Other includes geothermal, solar, wind, combustible renewables & waste.

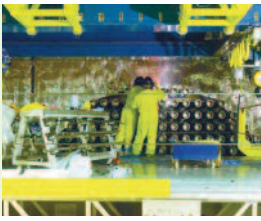
Source: OECD/IEA Key World Energy Statistics (2008)

CANDU Technology

- Advanced CANDU reactor under development: **ACR-1000®**
- World record for longest non-stop operation: **Pickering 7** (894 days –1994)
- Top lifetime performance by a CANDU: **Wolsong 4** (97.3%)
- Top annual performance by a CANDU in 2008: **Darlington 3** (99.4%)
- Percentage of electricity generated by CANDUs (2008):

In Canada	14.8%
In Ontario	53.0%
In New Brunswick	6.1%*
In Quebec	3.0%

** In New Brunswick nuclear accounts for up to 30% of electricity generation. As of April 1, 2008 the Point Lepreau Generating Station is under refurbishment.*



- Number of tonnes of emissions of carbon dioxide (CO_2) avoided by CANDU produced nuclear energy in Canada since 1972: **2.4 billion tonnes** (Source: CNA/CANDU Owners Group (COG)).
- Number of tonnes of emissions of sulphur dioxide (SO_2) avoided by nuclear energy in Canada since 1972: **48.9 million** (Source: CNA 2009)
- Annual production of goods and services: **$6 billion**
- Total annual value of electricity from nuclear: **$5 billion**
- Total direct and indirect employment from nuclear power production in Canada **67,000 jobs** (full-time equivalent not including 5,000 in uranium mining) (Source: The Canadian Nuclear Industry: Contributions to the Canadian Economy, Canadian Research Institute (CERI) 2008).

CANDU Reactors Worldwide 2008

Quebec, Canada
Gentilly-2 1 unit

Ontario, Canada
Darlington 4 units
Pickering 8 units
Bruce 8 units

New Brunswick, Canada
Point Lepreau 1 unit

Argentina
Embalse 1 unit

Romania
Cernavoda 2 units

Pakistan
KANUPP 1 unit

India
RAPS 2 units

China
Qinshan 2 units

Republic of Korea
Wolsong 4 units

Nuclear Facts — Ontario

- In 2008, electricity in Ontario was generated from nuclear (53%), hydro (24.1%), coal (14.5%), oil and gas (6.9%), wind (0.9%) and other alternative sources (0.6%) (Source: IESO, 2009).
- By 2020, Ontario will need to replace about 80% of its electrical generation (25,000 MW) because of growth in demand and aging plants, about half of which are nuclear.
- Load growth1999-2008—Ontario's electricity demand has increased from 150 TWh to 159 TWh over the last 10 years. A 6% overall increase, approximately 0.6% per year (Source: Statistics Canada).
- In 2008, Ontarians electricity consumption was 148.4 TWh, a decrease of 4 TWh from 2007.
- By 2015, by refurbishing or replacing existing nuclear capacity, Ontario will ensure 14,890 MW of electrical generating capacity.
- Bruce Power is refurbishing Bruce A (ON) Units 1 & 2 (805 MW each) with a return to service date in 2010 and will refurbish Bruce A Units 3 & 4 upon completion of 1 & 2.
- The top two performing nuclear reactors in Ontario in 2008 were: Darlington 3 (934 MW) with 99.4% performance and Darlington 2 (934 MW) with 98.5% performance.
- In June 2008, the Government of Ontario selected the Darlington Nuclear Site as the location for new nuclear plant construction.


Pickering, ON


Darlington, ON


Bruce, ON

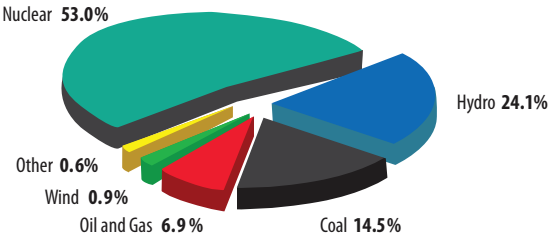
Nuclear Generation in Ontario

Pressurized Heavy Water CANDU reactors provide 53% of Ontario's electricity.

Unit	Status	Design Capacity (MW)	Actual Capacity (MW)		In-Service Date
			Net	Gross	
Bruce A–1	Restart 2010	905	750	805	09/01/1977
Bruce A–2	Restart 2010	905	750	805	09/01/1977
Bruce A–3	Operational	905	750	805	02/01/1978
Bruce A–4	Operational	905	750	805	01/18/1979
Bruce B–5	Operational	915	795	845	03/01/1985
Bruce B–6	Operational	915	822	872	09/14/1984
Bruce B–7	Operational	915	822	872	04/10/1986
Bruce B–8	Operational	915	795	845	05/22/1987
Darlington 1	Operational	935	878	934	11/14/1992
Darlington 2	Operational	935	878	934	10/09/1990
Darlington 3	Operational	935	878	934	02/14/1993
Darlington 4	Operational	935	878	934	06/14/1993
Pickering A–1	Operational	542	515	542	07/29/1971
Pickering A–2	Safe Storage	542	515	542	12/30/1971
Pickering A–3	Safe Storage	542	515	542	06/01/1972
Pickering A–4	Operational	542	515	542	06/17/1973
Pickering B–5	Operational	540	516	540	05/10/1983
Pickering B–6	Operational	540	516	540	02/01/1984
Pickering B–7	Operational	540	516	540	01/01/1985
Pickering B–8	Operational	540	516	540	02/28/1986
Total Installed Capacity			**13,870**	**14,718**	

Source: CANDU Owners Group (COG), Bruce Power and Ontario Power Generation 2008

Electricity Generation in Ontario 2008



Source: Independent Electricity System Operator (IESO), 2009

Nuclear power was Ontario's principal source of electricity in 2008.

Ontarians consumed 148,400 GWh (148.4 TWh) of electricity in 2008, lower than consumption in 2007 (152 TWh). Ontario exported a net total of 10.9 TWh in 2008.

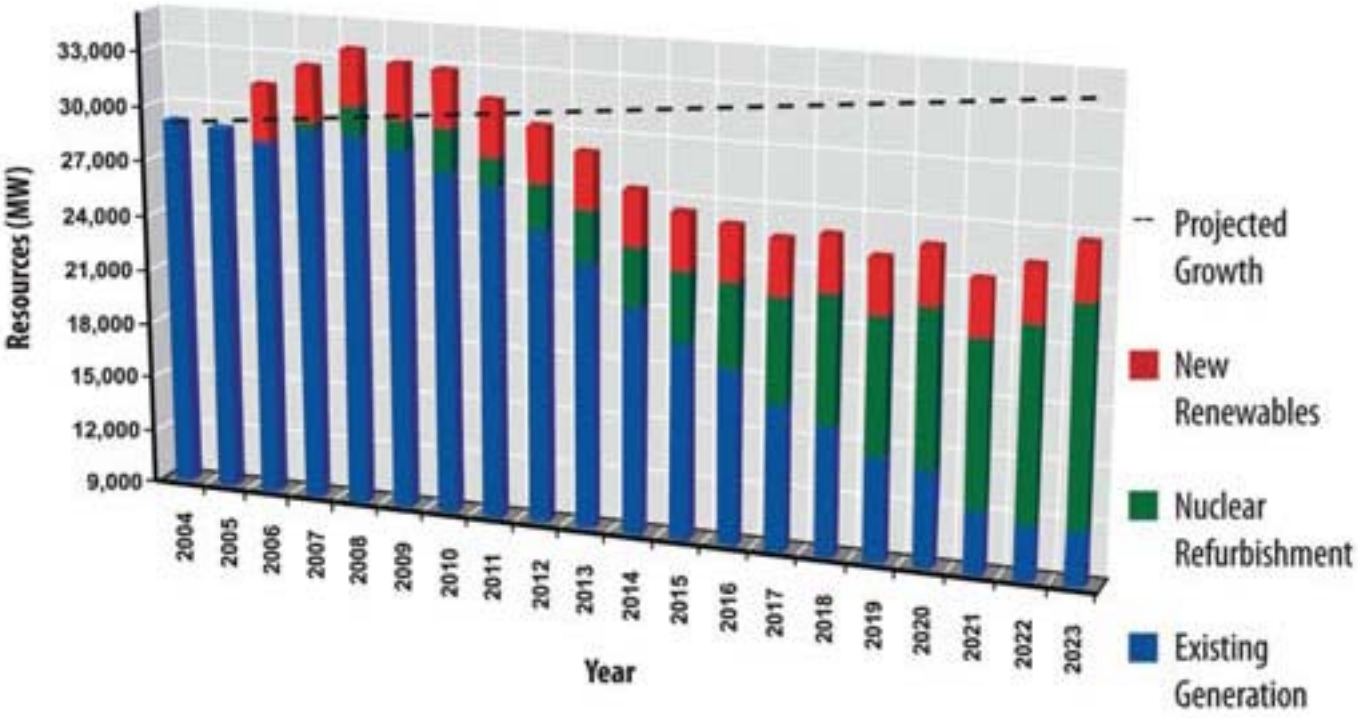
Nuclear facilities continue to provide the majority of supply for Ontario at 84.4 TWh, or 53% of the total in 2008, which is up from 51% or 81 TWh in 2007. The portion of Ontario's electricity production from hydroelectric generators increased to 24.1% or 38.3 TWh from 21%, or 33.4 TWh.

Sources of electricity in 2008:

Nuclear	53.0%	84.4 TWh
Hydro	24.1%	38.3 TWh
Coal	14.5%	23.2 TWh
Oil and Gas	6.9%	11.0 TWh
Wind	0.9%	1.4 TWh
Other	0.6%	1.0 TWh
Total	**100 %**	**159.3 TWh**

Note: Values are rounded. Source: IESO, January 12, 2009

Renewable Potential Added to Nuclear Refurbishment or Replacement



Nuclear Facts — Quebec

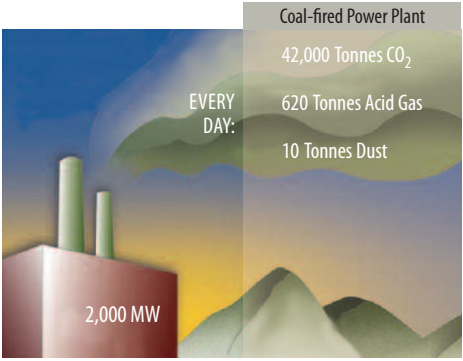
- Hydro-Québec has efficiently managed its nuclear program for more than 30 years.
- In 1971, the 250 MW Gentilly-1, a prototype reactor, came into operation near Trois-Rivières on the south shore of the St. Lawrence River. Built and owned by AECL and operated by Hydro-Québec staff, the reactor had design and operational problems and was not economical. It was taken out of service in 1979.
- Quebec has only one nuclear power station in operation: Gentilly-2, owned by Hydro-Québec. Equipped with a 675 MW CANDU 6 reactor, the plant was constructed on the same site as Gentilly-1 and came into commercial operation in 1983.
- In 2008, Gentilly-2 achieved a gross capacity factor (performance rate) of 65.8%; it has a lifetime gross capacity factor of 78.9%.
- In 1995, one of Canada's first dry storage facilities for used nuclear fuel commenced operation at the Gentilly site.
- Gentilly-2 generates around 3% of the energy in the Hydro-Québec grid and plays an important part given its excellent performance and profitability. As a result of its location close to the main load centres, it also contributes to the stability of the network.
- Hydro-Québec made the decision in 2008 to refurbish Gentilly-2. The work would be carried out in 2011–12 to allow continued operation until 2035.

Gentilly-2, QC

Nuclear Facts — New Brunswick

- New Brunswick Power Nuclear Corporation is a subsidiary of New Brunswick Power Corporation (NB Power), the largest electricity utility in Atlantic Canada. It operates Atlantic Canada's only nuclear facility, Point Lepreau Generation Station.
- Point Lepreau started generating nuclear power commercially in February 1983 and built the first CANDU 6 in the world to be licensed for operation with a gross capacity of 680 MW.
- The Point Lepreau Generating Station CANDU 6 provides up to 30% of New Brunswick's electricity and is one of the lowest cost generators on NB Power's electrical system.
- On April 1, 2008 NB Power began refurbishment of Point Lepreau to extend the station's life to 2032.
- Since 1983, the station's in-service lifetime capacity factor has been 79.5%.
- Point Lepreau became NB Power's first ISO 14001 registered generating station, demonstrating that advanced systems are in place to manage environmental issues.
- In 2006, the Canadian Nuclear Safety Commission approved proposed modifications to the Solid Radioactive Waste Management Facility at Point Lepreau.
- Low and stable uranium fuel costs contribute to a reliable supply of economical electricity for New Brunswick.

Point Lepreau, NB



- **Nuclear energy does not pollute the air.**
- Nuclear energy produces virtually none of the pollutants that contribute to smog and acid rain.
- Nuclear energy produces virtually no greenhouse gases—gases that trap solar energy and contribute to global warming.
- Greenhouse gases, as listed in the Kyoto Protocol, are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).
- By using nuclear energy to produce electricity in Canada, we avoid the emission of about 90 million tonnes of greenhouse gases per year, equivalent to the greenhouse gases produced by 18 million cars or trucks — about 12% of Canada's total greenhouse gas emissions.
- Using nuclear power to produce electricity in Canada, we avoid the emission of an additional 10% of smog and acid rain-producing gases.

Environment: The Kyoto Protocol

- By ratifying the Kyoto Protocol, Canada committed to lowering its emissions of six man-made greenhouse gases to 6% below emission levels in 1990: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Canada will not meet its Kyoto objectives.
- Greenhouse gases trap solar energy, reflecting some of it back to the earth.
- There is a concern that man-made greenhouse gases have raised temperatures and are changing the global climate. Fossil fuel combustion is the largest source of greenhouse gas emissions.
- To meet the reduction objectives set by the Government of Canada for 2025, Canada will need to rely on nuclear energy, which does not emit man-made greenhouse gases.
- Canada's energy demand is projected to increase by 34% by 2025, creating an increased requirement for reliable, clean electricity.
- Nuclear electricity generation in Canada saves us from emitting about 90 million tonnes of greenhouse gases a year—about 12% of Canada's total emissions.
- If all nuclear power plants in the world were replaced by modern fossil-fuelled power plants, CO_2 emissions from the world energy sector would rise by about 8%.

Electricity Generation and Greenhouse Gas Emissions

Life–Cycle Analysis of Base Load Electricity in Ontario (Nuclear, Coal and Natural Gas)

- All forms of electricity generation produce some greenhouse gas emissions (GHG) whether from mining or milling fuel, building electrical plants, transportation, releases of gases or pollutants during the burning of fuel and/or in the disposal of by-products or wastes.
- The Canadian Energy Research Institute (CERI) conducted a Life-Cycle Analysis (LCA) to identify and analyze current and potential life-cycle environmental impacts (GHG emission, other air pollutants, water pollutants and radiation) of base load electricity generation from nuclear, coal and natural gas in Ontario.
- Life-Cycle Analysis (LCA) is a systematic approach used to evaluate environmental impacts associated with electricity generation from different sources over their life-cycle (cradle to grave).
- The LCA took a snapshot of electricity generation activities in 2005 and 2006 in Ontario looking at the fuel supply chain and the operations of the electrical facility within the system boundaries.
- This LCA did not include CO_2 from plant construction of coal, gas or nuclear plants because CO_2 emissions in the construction phase of these various electricity generation technologies is roughly the same for each and proportional to the size of the plant and quantity of materials used.

Construction Emissions of Various Electricity Generation Technologies[1]

Power Generation Technology	Kilo Tonnes of CO_2 per TWh	Ratio of Construction CO_2 to Operations CO_2 (%)
IGCC (coal)	1.10	0.14
SUPC (coal)	1.49	0.18
CCGT (gas)	0.95	0.22
SXC (nuclear)	2.22	6.89

Notes: CCGT: Combined Cycle Gas Turbine, IGCC: Integrated Gasification Combined Cycle, SUPC: Supercritical Coal, SXC: Sizewell C (PWR)
Source: [1]Estimating life-cycle from Table 2 of: S. Andeseta et al., "CANDU Reactors and Greenhouse Gas Emissions" www.computare.org/Support%20documents/Publications/Life%20Cycle.htm, retrieved October 20, 2008.

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Electricity Generation and Greenhouse Gas Emissions

- The LCA did consider CO_2 emissions in the construction phase of other electricity generation technologies (hydro, wind, biomass) and concluded that construction-related emissions are negligible when compared to the emissions related to plant operations and their fuel life-cycles. CERI concluded that the inclusion or exclusion of construction-related CO_2 emissions does not significantly effect the outcome of the LCA.

Material Quantities for Construction of Various Electricity Generation Technologies, circa 1983[2] (Thousands of tonnes per EJ/year)

Generation Technology	Steel	Concrete	Other Metals
Coal - Electric	1500	5500	30
Coal - Synfuel	600	*	30
CANDU 900Mwe (1995)	1600	14000	*
LWR	2500	15000	125
CANDU 600Mwe (1995)	1400	18000	*
Hydro	3500	60000	200
Wind	8000	35000	1000
Biomass	4500	12000	*

*Notes: * Indicates data not available; - Indicates value is negligible; LWR, Light Water Reactor*

Source: [2]Estimating life-cycle from Table 2 of: S. Andeseta et al., "CANDU Reactors and Greenhouse Gas Emissions" www.computare.org/Support%20documents/Publications/Life%20Cycle.htm, retrieved October 20, 2008.

- Ontario power plants included in this study: three nuclear, four coal-fired and fifty-two natural gas-fired.
- LCA analyses, completed in accordance to international standards (ISO 14040 series), can assist with future electricity generation mix decisions.

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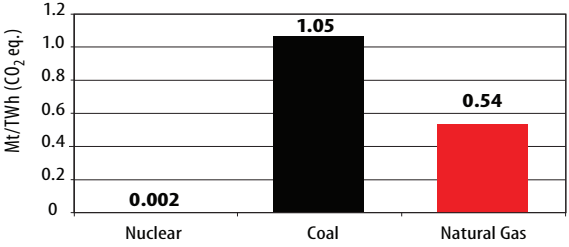
Electricity Generation and Greenhouse Gas Emissions

- The study of the complete life-cycle of nuclear power in Ontario found that nuclear power results in the emissions of 1.8 grams of carbon dioxide per kilowatt-hour (g/kWh) of electricity generated. These emissions occur mainly in the mining and refining of uranium fuel, not in the operation of the reactor.
- The study of the complete life-cycle of coal in Ontario results in the emissions of 1050 g/kWh, mostly in the burning of coal in the power plant.
- The study of the complete life-cycle of natural gas in Ontario to make electricity creates emissions of 540 g/kWh, mostly in the burning of natural gas in the power plant.

Comparative Life-Cycle GHG Emissions for Ontario Electricity Generation Sector



- This study concludes that life-cycle GHG emissions per one TWh of nuclear electricity are so small, that they are simply not comparable to other types of base load electricity generation.

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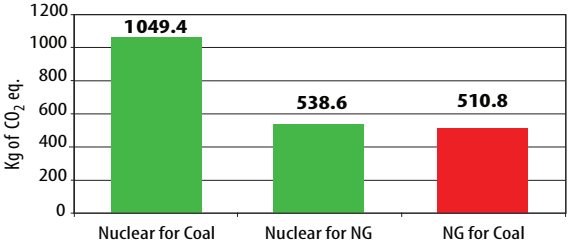
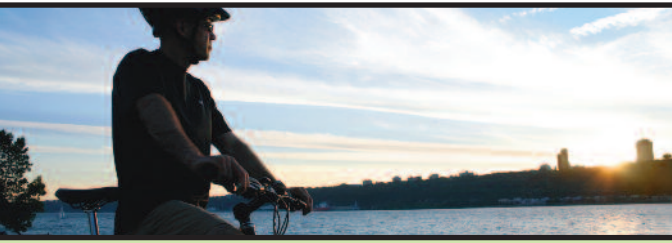
Electricity Generation and Greenhouse Gas Emissions

GHG Emissions Avoided by Replacing One MWh by Switching Fuels



- If one MWh of coal-fired or natural gas-fired electricity capacity is replaced by one MWh of nuclear electricity, Ontario could have avoided 1049 kg or 539 kg of GHG emissions, respectively.

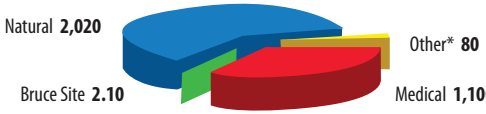
For complete information and the full "Comparative Life-Cycle Assessment (LCA) of Base Load Electricity Generation in Ontario" report please go to **www.cna.ca** under "Publications".



Radiation

- Radiation is natural and everywhere. Radioactivity has been in all rocks, soils, waters and air since the earth was formed, and is responsible for the formation of mountains.
- X-rays are invisible and were discovered accidentally in 1895 by Wilhelm Roentgen in Germany when he noticed a crystal would glow whenever he turned on an electric current in a vacuum tube.
- In France, Henri Becquerel discovered nuclear radiation accidentally in 1896 when he noticed a photographic plate would darken after he put a piece of uranium rock on it.
- The radiation dose to the public as a result of radioactivity from all nuclear power plants in Canada is much less than regulatory limits and the radiation dose from naturally-occurring sources.
- All Canadians are exposed to naturally-occurring radiation, mostly from the sun and from radon which is found in soil as well as man-made sources such as X-rays and air flight. As an example, a person flying one-way from Toronto to Vancouver will receive about 15 to 20 times the amount of radiation exposure as a person living at the perimeter of a nuclear plant for a whole year.

Breakdown of Radiation Dose to Public in µSV (microsieverts)



** Includes a number of manufactured goods, technologies, or human activities such as air travel, construction materials, televisions, smoke detectors, luminous dial watches, coal combustion products, etc.*

Nuclear Regulation in Canada

- The Canadian Nuclear Safety Commission (CNSC) is the federal regulator mandated to regulate the use of nuclear energy and materials to protect the health, safety and security of persons and the environment; and to respect Canada's international commitments on the peaceful use of nuclear energy.
- The CNSC, Canada's nuclear watchdog, is a quasi-judicial tribunal and is independent of, but not isolated from, government.
- The CNSC regulates all nuclear facilities and activities in Canada including: nuclear power plants, uranium mines and mills, uranium fuel fabricators and processing, nuclear substance processing, industrial and medical applications of nuclear substances, such as nuclear medicine and cancer treatment centers, research and educational facilities, import/export of nuclear and dual-use substances, equipment and technology, and waste management facilities.
- Before any person or company can prepare a site for, construct, operate, decommission or abandon a nuclear facility; or possess, use, transport or store nuclear substances, they must obtain a license issued by the CNSC.
- CNSC staff is located on-site at each of Canada's five nuclear power plants and across Canada in four regional offices.
- The CNSC has a longstanding history of international bilateral and multilateral cooperation. International peer reviews and shared practices are frequently conducted through the International Atomic Energy Agency and the World Association of Nuclear Operators.
- The CNSC strives to be the best nuclear regulator in the world, and for 2009-2010, is focused on: commitment to ongoing improvements, clarity of requirements, capacity for action and communications.

Long-term Care of Canada's Used Nuclear Fuel

- All of the used fuel (waste) produced by Canadian nuclear power plants is safely managed at licenced interim storage facilities at the reactor sites.
- Used fuel is initially stored in water-filled bays at the site of the nuclear power plants for 5–10 years and then placed in large concrete canisters safely stored on site.
- Designs have been developed for a deep underground repository, but a site for the facility has not yet been identified.
- The total amount of used fuel produced by Canada's nuclear power plants could be stored in six hockey rinks up to the height of the boards.
- In 2006, Ontario Power Generation began the environmental assessment for a deep geological repository to store low and intermediate level waste at the Bruce nuclear site.
- In Canada's 47 years of using nuclear energy, no member of the public has been harmed as a result of a radiation leak from a nuclear power plant or waste storage facility.
- The Nuclear Waste Management Organization (NWMO) was established in 2002 to collaboratively develop with Canadians a management approach for the long-term care of Canada's used nuclear fuel.
- In 2007 the Government of Canada accepted the NWMO's recommendation for an **Adaptive Phased Management** approach which incorporates new learning and knowledge at each step to guide a process of phased decision-making. The plan is now being implemented by the NWMO.

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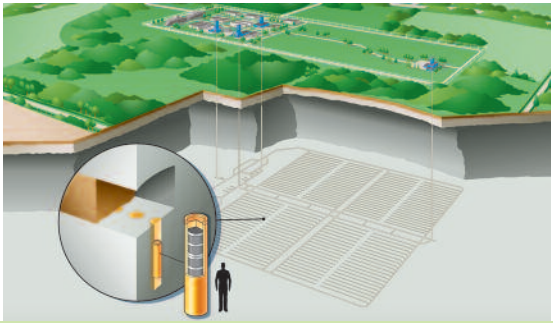
Long-term Care of Canada's Used Nuclear Fuel

Adaptive Phased Management involves:

- Ultimate centralized containment and isolation of used nuclear fuel in a repository deep underground in a suitable rock formation;
- Moving to this ultimate goal through a series of steps and clear decision points, which can be adapted over time as may be required;
- Providing opportunities for citizens to be involved throughout the implementation process;
- Allowing for optional temporary shallow storage at the central site, if needed;
- Ensuring long-term stewardship through continuous monitoring of the used fuel and maintaining the ability to retrieve it over an extended period should there be a need to access the waste or take advantage of new technologies which may be developed; and
- Providing financial surety and long-term program funding to ensure the necessary money will be available for the long-term care of used nuclear fuel when it is needed.



Advancing Global Health

- Global nuclear medicine largely started in Canada in 1951, when the first two cancer-treatment machines using cobalt-60 (radioisotopes) were built. One was built by Dr. Harold Johns of Saskatoon and one by Eldorado Mining and Refining Ltd., later to become part of Atomic Energy of Canada and then later again to become part of MDS Nordion.
- Today in Canada, MDS Nordion is a global leader providing innovative technologies for medical imaging, targeted cancer treatments, and sterilization of medical devices. Their innovation touches the lives of millions of people in more than 50 countries around the world.
- MDS Nordion supplies over half of the world's medical isotopes used in capturing molecular images. These images enable physicians to diagnose and treat a multitude of diseases including cardiac and neurological conditions, in addition to several types of cancers.
- MDS Nordion provides innovative targeted cancer treatments for a variety of conditions including liver and brain cancer, and non-Hodgkins lymphoma. Many of these treatments target cancer from within the body to deliver a higher concentration of treatment to the tumour.
- Canadian-produced medical isotopes for nuclear medicine are used in over 60,000 procedures a day world-wide, 5,000 in Canada.
- Canada's nuclear infrastructure is essential to the global medical isotope supply. MDS Nordion processes materials from Atomic Energy of Canada Limited (AECL) at the Chalk River Laboratories to produce 50% of the world's medical isotopes.

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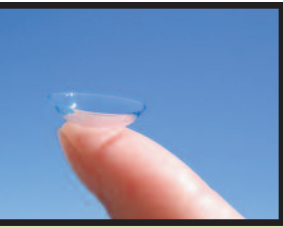
Advancing Global Health

- Through a partnership with the TRIUMF Laboratory and MDS Nordion, medical isotopes are also produced by three cyclotrons on the University of British Columbia campus. Radioisotopes are also produced at McMaster University in Ontario.
- Canada supplies 60% of the world's cobalt-60 used to sterilize more than 40% of the world's single-use medical supplies. This technology is also used to sterilize a vast array of consumer products, such as food packaging materials and cosmetics.
- Canada's cobalt-60 is produced in nuclear reactors at Bruce Power and Pickering in Ontario and Gentilly-2 in Quebec.
- Canada is a leader in the development of gamma technology used to eliminate food-borne pathogens, such as harmful E.Coli and Salmonella, to make food safer and as a quarantine treatment for fruits and vegetables to reduce post-harvest losses caused by spoilage, pest infestation and contamination.
- MDS Nordion is collaborating with the University of Ottawa Heart Institute (UOHI), Canada's largest cardiovascular health centre, to establish a Molecular Imaging Centre of Excellence to advance cardiology research. The new centre enables the two organizations to collaborate on joint cardiology research, using the latest in molecular imaging technology.



Resources

American Nuclear Society
www.ans.org

AREVA Canada
www.arevacanada.ca

AREVA Resources Inc.
www.arevaresources.ca

Atomic Energy of Canada Limited
www.aecl.ca

Australian Uranium Association
www.aua.org.au

Bruce Power
www.brucepower.com

Cameco Corporation
www.cameco.com

Canadian Nuclear Association
www.cna.ca

Canadian Nuclear Safety Commission
www.nuclearsafety.gc.ca

Canadian Nuclear Society
www.cns-snc.ca

Canadian Nuclear Workers Council
www.cnwc-cctn.ca

CANDU Owners Group
www.candu.org

Centre for Energy
www.centreforenergy.com

European Nuclear Society
www.euronuclear.org

Foratom–European Atomic Forum
www.foratom.org

Half-Lives: A Guide to Nuclear Technology in Canada
Hans Tammemagi, David Jackson, Oxford University Press, 2009
www.cna.ca/english/publications.asp

Hydro-Québec
www.hydroquebec.com

Independent Electricity Systems Operator (IESO)—Ontario
www.ieso.ca

International Atomic Energy Agency (IAEA)
www.iaea.org

International Commission on Radiological Protection
www.icrp.org

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Resources

International Energy Agency
www.iea.org

McMaster University
www.mcmaster.ca

MDS Nordion
www.mds.nordion.com

Natural Resources Canada – Nuclear Energy Division
www.nuclear.nrcan.gc.ca

New Brunswick Power
www.nbpower.com

Nuclear Energy Institute (U.S.)
www.nei.org

Nuclear Waste Management Organization
www.nwmo.ca

Ontario Power Generation
www.opg.com

Organisation for Economic Co-operation and Development Nuclear Energy Agency
www.nea.fr

Organization of CANDU Industries
www.oci-aic.org

Power Workers' Union
www.pwu.ca

Society of Nuclear Medicine
www.snm.org

United Nations Scientific Committee on the Effects of Atomic Radiation
www.unscear.org

University of Ontario Institute of Technology
www.uoit.ca

Women in Nuclear Canada
www.wincanada.org

World Nuclear Association
www.world-nuclear.org

World Nuclear University
www.world-nuclear-university.org

Nuclear technology
Exploring Possibilities
Educational Resources

www.cna.ca

Nuclear Energy *is efficient*

CANDU nuclear power plants produce 14.8% of Canada's electricity including 53% of Ontario's power using small pellets like these. Eight of these tiny uranium fuel pellets contain enough energy to power an average 2000-square-foot home for almost a year. And all that electricity is clean with none of the emissions that contribute to smog, acid rain or global warming.

Canadian Nuclear Association

THE VOICE OF CANADA'S NUCLEAR INDUSTRY

The Canadian Nuclear Association (CNA) is a non-profit organization established in 1960 to represent the nuclear industry in Canada and promote the development and growth of nuclear technologies for peaceful purposes.

130 Albert Street, Suite 1610
Ottawa, Ontario K1P 5G4
T: 613-237-4262
F: 613-237-0989
www.cna.ca