CANADA

(July 2010)

1. GENERAL INFORMATION 4
1.1. Country overview 4
1.1.1. Governmental System 4
1.1.2. Geography and Climate 4
1.1.3. Population 4
1.1.4. Economic Data 4
1.2. Energy Information 5
1.2.1. Estimated available energy 5
1.2.2.Energy Statistics 6
1.2.3. Energy policy 6
1.3. The electricity system 7
1.3.1. Electricity policy and decision making process 7
1.3.2. Structure of electric power sector 7
1.3.3. Main indicators 8
2. NUCLEAR POWER SITUATION 9
2.1. Historical development and current organizational structure 9
2.1.1. Overview 9
2.1.2. Current organizational chart(s) 11
2.2. Nuclear power plants: Overview 12
2.2.1. Status and performance of nuclear power plants 12
2.2.2. Plant upgrading, plant life management and license renewals 15
2.3. Future development of Nuclear Power 15
2.3.1. Nuclear power development strategy 15
2.3.2. Project management 16
2.3.3. Project funding 16
2.3.4. Electric grid development 16
2.3.5. Site Selection 17
2.4. Organizations involved in construction of NPPs 17
2.5. Organizations involved in operation of NPPs 18
2.6. Organizations involved in decommissioning of NPPs 18
2.7. Fuel cycle including waste management 18
2.7.1. Nuclear Fuel Cycle 18
2.7.2. Mining and Milling 18

2.7.3 Uranium Conversion 18
2.7.4. Fuel Fabrication 19
2.7.5. Radioactive Waste Management 19
2.7.6. Responsible Institutions 19
2.7.7. Canada's Plan for the Long-Term Management of Nuclear Fuel Waste 20
2.7.8. Management of Low- and Intermediate- Level Radioactive Waste 21
2.8. Research and development 24
2.8.1. R&D organizations 24
2.8.2. Development of advanced nuclear technologies 24
2.8.3. International co-operation and initiatives 25
2.9. Human resources development 25
2.10. Stakeholder Communication 25
3. NATIONAL LAWS AND REGULATIONS 26
3.1. Regulatory framework 26
3.1.1. Regulatory Authorities 26
3.1.2. Licensing Process 27
3.2. Main National Laws and Regulations in Nuclear Power 28
REFERENCES (FURTHER READING) 30
APPENDIX 1: INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS 31
APPENDIX 2: DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NULCEAR POWER RELATED ACTIVITIES 33

LIST OF TABLES:

TABLE 1. POPULATION INFORMATION
TABLE 2. GROSS DOMESTIC PRODUCT (GDP)
TABLE 3. ESTIMATED AVAILABLE ENERGY SOURCES
TABLE 4. ENERGY STATISTICS
TABLE 5. ELECTRICITY PRODUCTION, CONSUMPTION AND CAPACITY
TABLE 6. ENERGY RELATED RATIOS
TABLE 7. STATUS AND PERFORMANCE OF NUCLEAR POWER PLANTS

LIST OF FIGURES:

FIGURE 1: STRUCTURE OF CANADIAN NUCLEAR INDUSTRY

FIGURE 2: CANADA'S MAJOR NUCLEAR FACILITES

1. GENERAL INFORMATION

1.1. Country overview

1.1.1. Governmental System

Canada's system of government is based on a Parliamentary Democracy and a Constitutional Monarchy. A member of the Commonwealth, Canada's Head of State is the Queen of England, Her Majesty Elizabeth II, who is commonly represented by the Governor General. Canada's laws are enacted by the Parliament, or the House of Commons, with 308 elected members, each representing a specific electoral district. These members commonly belong to one of five parties, and the party with the greatest number of seats won forms the Official Government, the leader of that party becoming the Prime Minister. There is also an unelected entity, the Senate, which approves laws previously passed in the House of Commons. See http://www.parl.gc.ca for more information.

1.1.2. Geography and Climate

Canada is the second largest country in the world, covering approximately 10 million km^2 on land, and borders upon three oceans, the Pacific, Arctic and Atlantic. It is made up of ten provinces and three territories. The type of geography ranges from prairie to boreal and rain forests, becoming tundra in the extreme northern areas. Canada enjoys a temperate climate with warm summers but can experience intensely cold winters, requiring reliable energy sources for heating, and for transporting goods and people across the country and into remote areas.

1.1.3. Population

There are more than 33 million people currently living in Canada. The population grew at an average of 1.0% between 2000 and 2008, with a large part of that increase being due to international immigration. Canada has one of the lowest population densities in the world, despite an increasing urban population, with 80% of Canadians now living in a city.

TABLE 1: POPULATION INFORMATION

	1970	1980	1990	2000	2005	2008	Average Annual Growth Rate (%) 2000 - 2008
Population (Millions)	21.3	24.6	27.7	30.8	32.3	33.3	1.0
Population Density (Inhabitants/km^2)	2.3	2.7	3.1	3.4	3.6	3.7	
Urban Population as % of Total	75.7	75.7	76.6	80.1	80.2	80.2	
Area (1000 km^2)	9093.5						

Sources: Statistics Canada Catalogue 46-668, and 2006 Census.

1.1.4. Economic Data

Canada's economy is based in a number of sectors, particularly natural resources, manufacturing, energy and a rapidly growing group of knowledge based or technology areas. The security and increase in value in resources directly related to energy (oil, uranium) and other natural resources have contributed significantly to the growth of Canada's Gross Domestic Product (GDP) in recent years and is likely to become an even more important sector in the future.

In the period 2000-2008, real GDP expanded on average by 1.9%. In 2006-07, Canada reported its 11th consecutive balanced budget and 10th consecutive budget surplus. The federal government and six of the provinces and territories recorded budgetary surpluses of 1.0 per cent of GDP or more.

Although Canada was affected by the global financial crisis, the Canadian economy has fared better than other major industrialized countries. Canada was the last Group of Eight (G8) country to enter into recession in 2008 and has experienced one of the smallest declines in output among major industrialized economies. Recognizing the challenges faced by the economic recovery going forward, Canada's 2009 Budget introduced an Economic Action Plan to provide a stimulus of almost $30 billion to support the Canadian economy. Though a fiscal deficit is projected for the next few years, it is expected that the federal budget will return to surplus within five years and that total government debt as a share of the economy will still be the lowest among G8 countries.

TABLE 2: GROSS DOMESTIC PRODUCT

	1970	1980	1990	2000	2005	2008	Average Annual Growth Rate (%) 2000 - 2008
GDP (Millions of Current CND$)	90,179	314,390	679,921	1,076,577	1,373,845	1,600,081	4.5
GDP (Millions of Constant 2000 CND$)	409,163	622,812	823,860	1,102,562	1,247,507	1,308,507	1.9
GDP Per Capita (Current CND$/Capita)	4,311.7	13,430.6	24,553.9	35,084.8	42,606.2	48,011.6	3.4

Sources: Statistics Canada, Table 380-0002; Energy Statistics Handbook Catalogue no. 57-601-X.

1.2. Energy Information

1.2.1. Estimated available energy

TABLE 3: ESTIMATED AVAILABLE ENERGY RESOURCES

	Fossil Fuels			*Nuclear*	*Renewables*
	Solid	**Liquid**	**Gas**	**Uranium**	**Hydro**
Total Amount in Specific Units*	606.00	3,021,772	120,173	431.00	72.00

*Solid, Liquid: Thousands of cubic metres/tons; Gas: Billion m3; Uranium: Metric tons; Hydro, Renewable: million KW

Sources: Statistics Canada/Natural Resources Canada

1.2.2. Energy Statistics

TABLE 4: ENERGY STATISTICS

*ENERGY CONSUMPTION***	1970	1980	1990	2000	2005	Year*	Average Annual Growth Rate (%) 2000 - XXXX
TOTAL	6.10	8.20	9.10	10.80	11.70	11.90	0.50
- Solids	0.70	0.90	1.10	1.30	1.60	1.50	0.30
- Liquids	3.30	4.00	4.00	4.30	4.60	4.70	1.40
- Gases	1.10	1.70	2.20	3.90	4.10	4.20	0.10
- Primary Electricity******	0.60	0.90	1.30	1.40	1.40	1.40	1.90
ENERGY PRODUCTION	**1970**	**1980**	**1990**	**2000**	**2005**	**2008**	**2000 - 2008**
TOTAL	6.20	7.80	10.60	15.70	16.70	16.90	0.60
- Solids****	0.30	0.80	1.70	1.50	1.70	1.70	0.90
- Liquids	3.30	3.40	3.90	4.90	6.30	6.80	2.30
- Gases	2.00	2.60	3.70	7.70	7.20	6.70	-1.40
- Primary Electricity	-0.40	-0.50	-3.10	-5.30	-5.90	-6.30	0.70
NET IMPORT (IMP - EXP)	**1970**	**1980**	**1990**	**2000**	**2005**	**2008**	**2000 - 2008**
TOTAL	-0.40	-0.50	-3.10	-5.30	-5.90	-6.30	0.70

* Latest available data
** Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.
*** Solid fuels include coal, lignite
**** Includes nuclear and hydro.
Sources: Natural Resources Canada, Statistics Canada (Table 128-0009)

1.2.3. Energy policy

Canadian energy policies rely primarily on competitive markets for determining supply, demand, prices, and trade, and are guided by the drive for cleaner energy, both in the production and use of energy across the country. Three of the underlying principles of Canadian energy policies are:

- market orientation: markets are generally the most efficient means of determining supply, demand, prices and trade while ensuring an efficient, competitive and innovative energy system that is responsive to Canada's energy needs.
- targeted interventions: when markets cannot achieve policy objectives, government should intervene, through regulation or other means. These policy objectives include issues of science and technology, health and safety (e.g., pipeline regulation) and environmental sustainability.
- respect for jurisdictional authority and the role of the provinces: provincial governments are the direct managers of most of Canada's natural resources and have responsibilities for resource management within their borders.

The Government of Canada (GoC) seeks to achieve a balance between the environmentally responsible production and use of energy, the growth and competitiveness of the Canadian economy, the availability of secure and competitively priced energy, and the protection of energy infrastructure. Canada is an energy intensive nation, and current energy policies focus on:

- cleaner fossil fuel applications and alternatives;
- promoting renewables and clean electricity generation; and,
- encouraging energy efficiency.

These efforts are supported by an emphasis on innovation – through research, development and deployment of clean technologies and practices.

1.3. The electricity system

1.3.1. Electricity policy and decision making process

Canada is the world's sixth largest producer of electricity. Canada has one of the most diversified bases of electricity generation in the world, which includes hydroelectricity, natural gas, oil, coal, nuclear, wind and other types of renewable energy.

Canada's electric power industry is made up of provincial Crown corporations, investor-owned utilities, municipal utilities and industrial establishments. The federal role is restricted to nuclear energy, international and inter-provincial trade.

Under the Canadian constitution, electricity is primarily within the jurisdiction of the provinces. The provincial governments own the natural resources and are responsible for most aspects of regulation and energy sector development within their geographical boundaries, including electricity policy and planning. The federal government is responsible for harmonizing energy policy at the national level, promoting regional economic development, frontier lands, offshore development, inter-provincial works (e.g., pipelines), international and inter-provincial trade. Both levels of governments are involved in energy research.

As a result of the divisions in energy policy jurisdiction, Canada's electricity industry is organized along provincial lines. In most provinces the industry is highly integrated, with the bulk of the generation, transmission and distribution provided by a few dominant utilities. Although some of these utilities are privately owned, most are Crown corporations owned by the provinces. Among the major electric utilities, seven are provincially owned, seven are investor owned, two are municipally owned, and two are territorial Crown corporations. Provincial electric utilities own about 80 percent of Canada's total installed generating capacity and produced around 75 percent of total generated electricity.

The electric power industry has a significant presence within the Canadian economy. In 2007, more than 76,000 people were directly employed by the industry. The total operating revenues of the electric utilities amounted to about $52 billion. Of this total, approximately $2.1 billion came from export earnings.

1.3.2. Structure of electric power sector

The generation, transmission and distribution of electricity in Canada have been primarily an area of provincial jurisdiction. Historically, electricity has been provided mainly by vertically integrated provincial crown corporations, which met growing demand by building large power projects. These projects were typically hydro in Newfoundland & Labrador, British Columbia, Manitoba and Quebec; hydro, coal and nuclear in Ontario and New Brunswick; and coal in Alberta, Saskatchewan and Nova Scotia. This industry model was highly successful, contributing to a high level of security of supply and relatively stable prices and in many cases was a core element in the development of provincial economies.

The federal government has played a supporting role by investing in research and development, supporting the commercialization of new technologies, and exercising federal responsibilities over electricity exports, international and designated interprovincial power lines and nuclear energy.

Over the past decade, the structure of the electricity industry has undergone significant change. Most provinces have moved from the traditional model of provincially regulated and vertically integrated monopolies towards a more competitive system with the private sector playing an increasing role. In Alberta and Ontario, a bid-based model exists between local distribution companies and both large and small generators, while in other provinces independent power producers are able to sell power only to the major utility that provides most of the generation, transmission and distribution services.

The main drivers for this type of restructuring include political support for competitive markets, technological developments (eg., gas turbines) that have led to smaller generating stations, and the need to seek lower electricity costs for industrial customers.

Utilities with nuclear plants in operation in Canada are: Ontario Power Generation (OPG), Bruce Power (a private consortium whose principal shareholders are Cameco Corporation (31.6%), TransCanada Corporation (31.6%), the BPC Generation Infrastructure Trust of Toronto (31.6%) and the remaining 5.5% is owned by two unions), New Brunswick Power and Hydro-Québec. Apart from Bruce Power, which is a relative newcomer in the electric power scene, the three provincial utilities, particularly OPG, have had critical roles to play in the development of Canada's nuclear programme. OPG (formerly Ontario Hydro) has worked closely with Atomic Energy of Canada Limited (AECL) in the design and construction of the power reactors in the province of Ontario.

1.3.3. Main indicators

TABLE 5: ELECTRICITY PRODUCTION, CONSUMPTION & CAPACITY

Capacity of Electrical Plants [GWe]	1970	1980	1990	2000	2005	2007	Average Annual Growth Rate (%) 2000 - 2007
TOTAL	42.80	82.00	104.20	111.30	121.50	124.20	1.60
- Thermal	14.30	28.40	31.20	31.60	33.80	34.30	1.20
- Hydro	28.30	47.80	59.40	67.40	72.00	73.40	1.20
- Nuclear	0.30	5.90	13.50	10.60	13.40	13.40	3.30
- Wind	0.00	0.00	0.02	0.10	0.70	1.60	141.60
- Biomass	-	-	-	1.50	1.70	1.60	3.70
Electricity Production (TWh)	**1970**	**1980**	**1990**	**2000**	**2005**	**2007**	**2000 - 2007**
TOTAL**	204.70	377.50	474.80	585.80	604.40	617.50	0.80
- Thermal	47.00	85.90	102.60	156.00	150.30	155.80	0.00
- Hydro	156.70	253.10	296.90	354.60	358.50	364.10	3.80
- Nuclear	1.00	38.50	73.00	68.70	86.80	88.20	3.60
- Wind	-	-	0.03	0.30	1.70	2.90	41.50
- Biomass	-	-	2.30	6.40	7.20	6.40	0.01
Total Electricity Consumption (TWh)	**1970**	**1980**	**1990**	**2000**	**2005**	**2007**	**2000 - 2007**
TOTAL	202.30	340.10	465.40	550.20	580.50	589.90	1.00

(1) Electricity transmission losses are not deducted.
Sources: Statistics Canada Catalogues 57-003, 57-202 and 57-206

TABLE 6: Energy Related Ratios

	1970	1980	1990	2000	2005	2007
Energy Consumption Per Capita (GJ/Capita)	271.7	331.8	330.2	353.8	309.3	314.0
Electricity Consumption Per Capita (kWh/Capita)	9,501	13,871	16,803	18,916	17,972	17,890
Electricity Production/Energy Production (%)	-	-	21.5	22.3	21.8	21.4
Nuclear/Total Electricity (%)	0.5	10.2	15.4	11.7	14.4	14.3
Ratio of External Dependency (%)**	-	-	-34.1	-61.2	-60.0	-62.5

(1) Net import / Total energy consumption.
Source: Statistics Canada, Catalogue 57-003

2. NUCLEAR POWER SITUATION

2.1. Historical development and current organizational structure

2.1.1. Overview

Canada was one of the first countries to develop a nuclear power programme after the Second World War and has since developed the Canada Deuterium Uranium (CANDU) system, which uses pressurized fuel channels instead of a pressure vessel, natural uranium instead of enriched uranium and heavy water instead of light water as a coolant/moderator found in the pressurized water reactor designs. CANDU reactors have been successfully sold in Canada, as well as abroad. It is currently supplying 15% of Canada’s electricity needs from within three different provinces.

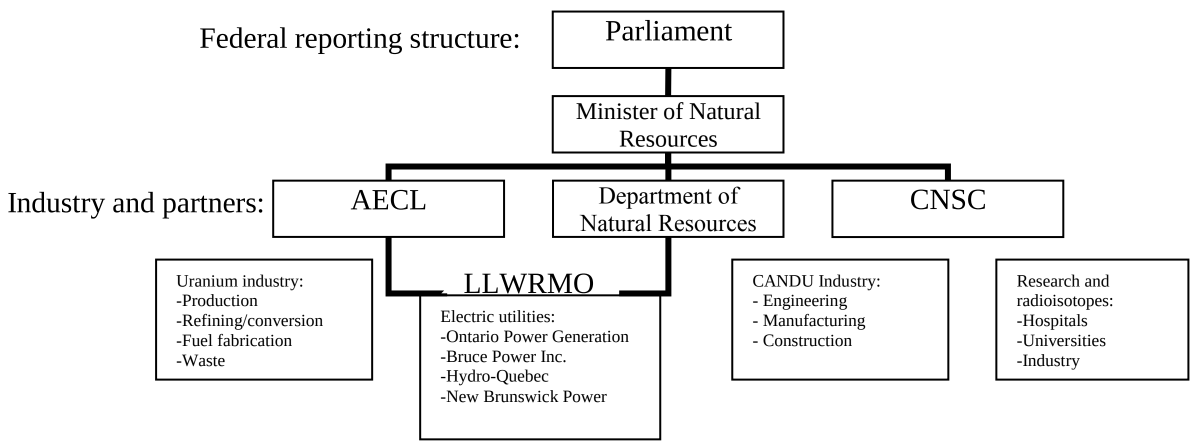
The many milestones of the Canadian nuclear programme are:

- In 1955, AECL, Ontario Hydro and Canadian General Electric made a commitment to build the first small-scale prototype 22 MW CANDU reactor at Rolphton, Ontario;
- A larger prototype was constructed at Douglas Point, Ontario. The 200 MW reactor went into service in 1967; these two reactors established the technological base for the larger commercial units to follow and for Canada's nuclear programme;
- Two 500 MW(e) reactors at Pickering, Ontario were committed under a tri-partite agreement between Ontario Hydro, AECL and the Federal government; Ontario Hydro later committed two more units to make an integrated 4-unit station; the units (Pickering A) came into operation between 1971 and 1973;
- Conceptual design studies on the Bruce A station were initiated in 1968; the 4x800 MW unit Bruce A station came into service from 1977 to 1979;
- AECL developed the CANDU 6 reactor design and was successful in selling four of these in the early to mid-1970's: Gentilly-2 (Hydro-Quebec, 1973), Point Lepreau (New Brunswick, 1974) and two abroad;
- In July 1974, Ontario Power Generation (OPG) decided to add 4 units at the Pickering A station; the 4 units (Pickering B) came into service from 1983 to 1986;
- Four additional units (Bruce B) came into service from 1984 to 1987;
- Four 900 MW(e) units at Darlington were committed in the early 1980's: these went into service in 1989-1994;
- Lay up of 8 units Bruce A and Pickering A (Bruce unit 2 in 1995 and the remaining 7 in 1998);
- Successful completion of the environmental assessment of the four units laid up at Pickering A and decision to return Pickering A to service in 2000/2001;
- Units 1 and 4 were subsequently refurbished and returned to service in 2005 and 2003, respectively. In 2005 OPG decided that units 2 and 3 would be decommissioned;
- In 2001, OPG entered into an agreement with Bruce Power to lease its Bruce A and Bruce B nuclear generation stations. Bruce Power was initially composed of British Energy, a UK company, the Canadian Cameco Corporation and two main unions on the Bruce site;
- Bruce Power successfully restarted units 3 and 4 of Bruce A in 2004 and 2003 respectively. In 2005, they undertook a multi-billion dollar project to refurbish and restart units 1 and 2, and the follow-on refurbishment of units 3 and 4. This project is progressing;
- In 2002, AECL launched the development of the ACR, now ACR-1000, a Generation III+ CANDU reactor; the Government of Canada began investing in ACR at this time;

- In 2008, AECL submitted the ACR-1000 for consideration to be built at the Darlington site in Ontario as part of an open bidding process, but that process was suspended by the province in June 2009;
- The storage of spent nuclear fuel has long been a concern, so in 2007, the Government of Canada accepted the Nuclear Waste Management Organization's – a not-for-profit entity funded by the nuclear utilities – recommendation of Adaptive Phased Management, which includes isolating and containing nuclear fuel waste in a deep geologic repository, with an option for temporary shallow underground storage;
- On November 29, 2007, the Minister of Natural Resources announced a review of AECL. In May 2009 the Government announced that it was moving forward with restructuring of the company and on December 17, 2009 that it was seeking investor proposals for the CANDU Reactor portion of the company;
- The Point Lepreau nuclear reactor in New Brunswick was taken off line for refurbishment in 2008, and in September 2009 AECL announced a planned completion date of October 15, 2010 for phase 2 of the project;
- In February 2010, OPG announced a two-part investment strategy for its nuclear generating stations. First, OPG announced that it will proceed with the mid-life refurbishment of its four nuclear power reactors at Darlington, with construction expected to start in 2016. Second, OPG announced that it will invest $300 million to ensure the continued safe and reliable performance of its Pickering B station for approximately 10 more years, which will then be decommissioned;
- In 2011, Hydro-Quebec is expected to start refurbishment of the Gentilly-2 reactor.

2.1.2. Current organizational chart(s)

Figure 1: Organizations Supporting the Canadian Nuclear Power Program



Abbreviations: CNSC - Canadian Nuclear Safety Commission

AECL - Atomic Energy of Canada Limited

2.2. Nuclear power plants: Overview

2.2.1. Status and performance of nuclear power plants

There are currently 22 nuclear power reactors in Canada which are operated by public utilities and private companies in Ontario (20), Quebec (1) and New Brunswick (1). Of the 22 reactors installed, 2 have been permanently shut down; 17 reactors are currently in full commercial operation and they generate about 15% of Canada's electricity and 50% in Ontario. Moreover, nine CANDU reactors are currently in operation outside of Canada. In 2008, CANDU reactors in operation in Canada and abroad performed very well. Their performance in 2008 averaged 82.1%, slightly lower than the lifetime average performance of 82.4%.

TABLE 7: STATUS AND PERFORMANCE OF NUCLEAR POWER PLANTS

Station	Type	Net Capacity	Operator	Status	Reactor Supplier	Construction Date+	Grid Date++	Commercial Date	Shutdown Date	Capacity Factor
BRUCE-1	PHWR	750	Bruce Power	Temporary Shutdown	OH/AECL	06-01-1971	14-Jan-77	01-Sep-77	16-Oct-97	--
BRUCE-2	PHWR	750	Bruce Power	Temporary Shutdown	OH/AECL	12-01-1970	04-Sep-76	01-Sep-77	08-Oct-95	--
BRUCE-3	PHWR	734	Bruce Power	Operational	NEI.P	07-01-1972	12-Dec-77	01-Feb-78	N/A	79.90%
BRUCE-4	PHWR	734	Bruce Power	Operational	NEI.P	09-01-1972	21-Dec-78	18-Jan-79	N/A	85.40%
BRUCE-5	PHWR	817	Bruce Power	Operational	OH/AECL	06-01-1978	02-Dec-84	01-Mar-85	N/A	78.00%
BRUCE-6	PHWR	817	Bruce Power	Operational	OH/AECL	01-01-1978	26-Jun-84	14-Sep-84	N/A	95.60%
BRUCE-7	PHWR	817	Bruce Power	Operational	OH/AECL	05-01-1979	22-Feb-86	10-Apr-86	N/A	80.30%
BRUCE-8	PHWR	782	Bruce Power	Operational	OH/AECL	08-01-1979	09-Mar-87	22-May-87	N/A	94.80%
DARLINGTON-1	PHWR	878	OPG	Operational	OH/AECL	04-01-1982	19-Dec-90	14-Nov-92	N/A	79.40%
DARLINGTON-2	PHWR	878	OPG	Operational	OH/AECL	09-01-1981	15-Jan-90	09-Oct-90	N/A	98.00%
DARLINGTON-3	PHWR	878	OPG	Operational	OH/AECL	09-01-1984	07-Dec-92	14-Feb-93	N/A	99.30%
DARLINGTON-4	PHWR	878	OPG	Operational	OH/AECL	07-01-1985	17-Apr-93	14-Jun-93	N/A	97.60%

DOUGLAS POINT	PHWR	206	OPG	Permanent Shutdown	AECL	02-01-1960	07-Jan-67	26-Sep-68	04-May-84	--
GENTILLY-1	HWLWR	250	OPG	Permanent Shutdown	AECL	09-01-1966	05-Apr-71	01-May-72	01-Jun-77	--
GENTILLY-2	PHWR	635	OPG	Operational	BBC	04-01-1974	04-Dec-82	01-Oct-83	N/A	65.40%
PICKERING-1	PHWR	515	OPG	Operational	OH/AECL	06-01-1966	04-Apr-71	29-Jul-71	N/A	61.70%
PICKERING-2	PHWR	515	OPG	Long-term Shutdown	OH/AECL	09-01-1966	06-Oct-71	30-Dec-71	31-Dec-97	--
PICKERING-3	PHWR	515	OPG	Long-term Shutdown	OH/AECL	12-01-1967	03-May-72	01-Jun-72	29-Dec-97	--
PICKERING-4	PHWR	515	OPG	Operational	OH/AECL	05-01-1968	21-May-73	17-Jun-73	N/A	80.80%
PICKERING-5	PHWR	516	OPG	Operational	OH/AECL	11-01-1974	19-Dec-82	10-May-83	N/A	88.80%
PICKERING-6	PHWR	516	OPG	Operational	OH/AECL	10-01-1975	08-Nov-83	01-Feb-84	N/A	95.40%
PICKERING-7	PHWR	516	OPG	Operational	OH/AECL	03-01-1976	17-Nov-84	01-Jan-85	N/A	33.80%
PICKERING-8	PHWR	516	OPG	Operational	OH/AECL	09-01-1976	21-Jan-86	28-Feb-86	N/A	64.40%
POINT LEPREAU	PHWR	635	HQ	Temporary Shutdown	AECL	05-01-1975	11-Sep-82	01-Feb-83	N/A	20.60%
ROLPHTON NPD	PHWR	22	HQ	Permanent Shutdown	CGE	01-01-1958	04-Jun-62	01-Oct-62	01-Aug-87	--

Source: PRIS database, accessed December 7, 2009 (www.iaea.org/pris), * 2008.

Figure 2: Canada's Major Nuclear Facilities

2.2.2. Plant upgrading, plant life management and license renewals

Refurbishment projects, estimated in value at over $9 billion CDN, are currently underway or have been announced in Ontario, New Brunswick and Québec. In Ontario, Bruce Power's restart and refurbishment program of Bruce A units 1 and 2 has been underway for a few years. New Brunswick Power began the refurbishment of Point Lepreau in March, 2008. These refurbishment projects are progressing, although they have encountered some delays and cost overruns. In 2008, Hydro-Québec announced that it will proceed with the refurbishment of Gentilly 2 in 2011-2012. In 2010, OPG announced that the Darlington Units would also be refurbished.

2.3. Future development of Nuclear Power

2.3.1. Nuclear power development strategy

The Government of Canada (GoC) recognizes that nuclear energy can play an important role in achieving global energy security, climate change mitigation and sustainable development goals.

There are currently no firm commitments from any province or territory within Canada to build a new nuclear power reactor. However, new nuclear build projects have been considered by public and private companies in Canada over the past several years. The actual number of new reactor units to be built will hinge largely on refurbishment plans for existing units, demand for electricity and economics.

The province of Ontario held an open tendering process in late 2006 to build two new units. In June 2009 the government suspended the selection process. The Province noted that the proposal put forth by AECL was the only one compliant with the terms of the Request for Proposals and the objectives of the Ontario government.

In 2008, Bruce Power expressed interest in constructing new nuclear power plants in Alberta and Saskatchewan, a first for either province. As a result of Bruce Power's interest, both provinces held public consultations on the issue and in December 2009 announced their findings. Alberta announced it was not opposed to nuclear power development but would not invest any public funds into such a program, while Saskatchewan will not be considering nuclear power developments until after 2020.

Finally, with respect to nuclear fuel waste, the Government of Canada accepted in 2007 the recommendation of the Nuclear Waste Management Organization (a not-for-profit organization supported by funding from the nuclear utilities) for Adaptive Phased Management, which includes isolating and containing nuclear fuel waste in a deep geologic repository, with an option for temporary shallow underground storage. Site selection for this project is still ongoing.

2.3.2. Project management

The provinces are responsible for electricity generation, and in this context, decide on the construction of power reactors in the provinces by wither private or public entities. As indicated earlier, the regulation of nuclear power plants in Canada fall under federal jurisdiction. They are regulated by the Canadian Nuclear Safety Commission (CNSC) during all stages starting from site selection to decommissioning, including nuclear fuel and waste management.

In 2007, the Government established the Major Projects Management Office (MPMO) to improve the performance of the federal regulatory system for major natural resource projects, in collaboration with other federal departments and agencies, which includes the licensing process for construction of new nuclear power plants. The mandate of the MPMO is to advance the principles of transparency, predictability, timeliness and accountability, in the government's approach to the review of major resource project applications, maximizing the efficiency and effectiveness of the regulatory review process.

The CNSC signed a Memorandum of Understanding (MOU) with the MPMO committing to improving the performance of the regulatory system for major resource projects and is working closely with the MPMO. The CNSC, as the responsible authority for new nuclear projects under the Canadian Environmental Assessment Act, is working pro-actively with the MPMO, the provincial authorities and the Canadian Environmental Assessment Agency to harmonize the federal and provincial environmental processes for new reactors.

2.3.3. Project funding

Different financing models exist for financing nuclear plants and the decision on the approach taken rests with the provinces and relevant public and private entities in the provinces. The federal government does not provide financial support for the construction of nuclear power reactors.

2.3.4. Electric grid development

In the case of Ontario, any new or re-commissioned units would use an existing grid. It is unknown what grid developments would be required for proposed units in either Saskatchewan or Alberta.

2.3.5. Site Selection

Although the reactor bid process is currently on hold, Ontario is continuing with the environmental assessment process at Darlington in order to obtain the necessary approvals for new build at the site.

2.4. Organizations involved in construction of NPPs

The Canadian nuclear industry consists of a mixture of private sector firms and public sector organizations at both the federal and provincial levels. The federal government provides leadership, support and a regulatory framework for the nuclear industry through AECL and the CNSC, two federal government agencies which report to the Canadian Parliament through the Minister of Natural Resources. The Minister relies directly on the Department of Natural Resources for policy advice on nuclear matters including issues pertaining to AECL and the CNSC. The CNSC is established/mandated by the Nuclear Safety and Control Act to regulate all nuclear activities in Canada to protect health, safety, security and the environment, and to ensure conformity with Canada's international obligations.

The Canadian nuclear industry is not vertically integrated. It covers all phases of the nuclear fuel cycle. The industry's activities are focused on the design, engineering, construction and servicing of CANDU reactors in Canada and abroad; on fuel and component manufacturing; and, on the mining, milling, refining and conversion of uranium. The most significant members of the industry are AECL, the CNSC, provincial utilities (Ontario Power Generation, Bruce Power, New Brunswick Power and Hydro Quebec), and private sector firms involved in equipment manufacturing, engineering and the mix of private and publicly -owned (both domestic and foreign) firms involved in uranium production. In addition, there are about 125 hospitals and universities across Canada performing isotope studies in research and/or nuclear medicine. In summary, there are over 150 companies that supply products and/or services to AECL and the utilities. In 2008, annual employment, direct and indirect, associated with the nuclear industry in Canada was estimated at over 30,000.

AECL, which has both a public and commercial mandate, is responsible for engineering, nuclear design, business management, and construction of CANDU reactors in Canada and abroad. It leads the marketing and sales initiatives on behalf of Canada's nuclear industry. It also manages contracts for building the reactors and servicing them. AECL's CANDU operations are mainly based in Mississauga and Chalk River, Ontario. The Government of Canada is pursuing the reorganization of AECL by separating the CANDU commercial operations division from the Research and Technology Division (LabCo).

> ***Manufacturing:*** Because of the cyclical nature of the nuclear industry, most of the firms are also active suppliers to other industries in Canada and abroad.
>
> ***Engineering:*** A number of Canadian engineering consulting firms, working closely with AECL, assume the conventional design responsibilities as well as project and construction management and other services, which are often required during plant construction.

Operation and Maintenance: A number of private sector suppliers work as sub-contractors for provincial utilities for some of the O&M work.

Construction: This business is cyclical in nature and the impact on employment can be significant. The construction of reactors is usually undertaken by the reactor vendor with the help of general construction contractors.

2.5. Organizations involved in operation of NPPs

As electricity in Canada is a provincial responsibility, all electric utilities, including nuclear power, fall under provincial jurisdiction. The provinces, in consultation with the utilities, are responsible for business decisions relating to electrical power, including nuclear stations. The utilities are responsible for the planning, construction, operation and decommissioning of nuclear power plants. There are currently four nuclear power utilities in Canada: Ontario Power Generation, Bruce Power, Hydro-Quebec and New Brunswick Power.

The utilities are members of the CANDU Owner's Group (COG) which provides some funding to AECL for nuclear R&D work. COG was formed in the early 1980s to promote closer co-operation in matters relating to plant operations and other programs as a means to improve plant performance. Some private sector suppliers work as sub-contractors to the utilities for specific work.

2.6. Organizations involved in decommissioning of NPPs

The decommissioning of a NPP is a shared responsibility between its operator and a number of Federal and Provincial bodies, including the CNSC and LLRWMO who ensure that any stored wastes and portions of the plant proper which are contaminated are dealt with in a safe manner.

2.7. Fuel cycle including waste management

2.7.1. Nuclear Fuel Cycle

The Canadian nuclear industry covers the entire nuclear energy fuel cycle from nuclear R&D, uranium mining and fuel fabrication to nuclear reactor design, nuclear plant construction, maintenance, waste management and decommissioning.

2.7.2. Mining and Milling

In 2008, Canadian uranium production amounted to 9000 tU (tonnes of uranium metal), representing more than one-fifth of total global production. All Canadian uranium mining currently takes place in northern Saskatchewan. Cameco Corporation and AREVA Canada Resources Inc. (AREVA) are the majority owners and operators of the uranium mines and mills now in operation. Cameco owns and operates the Rabbit Lake mill and the Eagle Point mine. It is also the joint venture operator of the McArthur River mine and the Key Lake mill. AREVA is the joint venture operator of the McClean Lake mine and mill. McArthur River and McClean Lake are the newest uranium production facilities in Canada.

2.7.3. Uranium Conversion

Cameco Corporation operates Canada's only uranium refining and conversion facilities, located at Blind River and Port Hope, Ontario, respectively. At the Blind River refinery, which is the world's largest facility, uranium mine concentrates from Canada and abroad are refined to uranium trioxide (UO3), an intermediate product. The bulk of the UO3 is then trucked to the Port Hope facility, which has about one-quarter of the Western World's annual uranium hexafluoride (UF6) conversion capacity and currently provides the only commercial supply of fuel-grade natural uranium dioxide (UO2). UF6 is enriched outside Canada for use in foreign light-water reactors, while natural UO2 is used to fabricate fuel bundles for CANDU reactors in Canada and abroad.

2.7.4. Fuel Fabrication

In Canada, there are two fuel fabrication companies, GE-Hitachi Nuclear Energy Canada and Cameco Fuel Manufacturing Inc., a wholly owned subsidiary of Cameco Corporation, which produce fuel pellets and fuel bundles for power reactors. Both of these companies operate in the province of Ontario. GE-Hitachi produces fuel pellets and fuel bundles at facilities in Toronto and Peterborough, Ontario respectively. Cameco produces fuel pellets and fuel bundles at its facilities in Cobourg and Port Hope, Ontario. The fuel fabrication process involves forming the uranium dioxide into pellets, followed by a process of sintering and sheathing in zirconium to make fuel bundles for use in power reactors.

2.7.5. Radioactive Waste Management

Canada has policies, legislation and responsible institutions that govern the management of all types of radioactive wastes. The Government's 1996 Policy Framework for Radioactive Waste outlines the national context for the management of radioactive waste and lays out a set of principles to ensure that it is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner.

Under the framework the federal government has the responsibility to:

- develop policy and regulate;
- oversee owners to ensure that they comply with legal requirements; and,
- ensure they meet their funding and operational responsibilities in accordance with approved waste management plans.

Consistent with the framework, waste owners are responsible for the funding, organization, management, and operation of long-term waste management facilities and other facilities required for their wastes.

2.7.6. Responsible Institutions

Natural Resources Canada (NRCan) is the lead for the development and implementation of the GoC's policy on radioactive waste management and oversight to ensure obligations under the Policy Framework are met. NRCan is also responsible for the administration of the Nuclear Fuel Waste Act (NFWA) to ensure that the nuclear utilities and the Nuclear Waste Management Organization (NWMO) comply with the legislative requirements of the NFWA.

The CNSC, established under the Nuclear Safety and Control Act, is Canada's independent nuclear regulator with a mandate to protect health, safety, security and the environment and to respect Canada's international commitments on the peaceful use of nuclear energy.

AECL, a Crown Corporation wholly owned by the GoC, manages federal legacy and historic waste obligations on behalf of the Government.

Canada's nuclear operators are responsible for managing their own wastes and are well suited to develop and implement safe, secure solutions. The nuclear industry is safely managing its radioactive wastes and there are several initiatives underway to develop long-term radioactive waste management facilities.

2.7.7. Canada's Plan for the Long-Term Management of Nuclear Fuel Waste

In Canada, nuclear fuel waste consists of irradiated CANDU fuel bundles removed from commercial and research nuclear reactors. Nuclear fuel waste from power reactors is currently stored safely in pools and/or dry storage containers in waste management facilities at each of the operating power reactor sites. There are three provincial nuclear utilities (i.e. Ontario Power Generation (OPG), Hydro-Québec and New Brunswick Power) who own about 98 percent of the nuclear fuel waste in Canada, while the remainder is owned by AECL[1].

Consistent with the Policy Framework for Radioactive Waste, the GoC introduced the NFWA in 2002 to address the long-term management of nuclear fuel waste. The NFWA made owners of nuclear fuel waste, the nuclear utilities, responsible for the development of long-term waste management approaches. The NFWA required the corporations to establish a waste management organization, named as the Nuclear Waste Management Organization (NWMO), as a separate legal entity to manage the full range of long-term nuclear fuel waste management activities. It also required the nuclear energy corporations to establish trust funds with independent third-party trust companies to finance their long-term waste management responsibilities.

The NFWA requires the NWMO to submit a study to the GoC on the proposed approaches for the long-term management of nuclear fuel waste. On November 3, 2005, the NWMO submitted its study, Choosing a Way Forward. Following careful review and consideration of the study, on June 14, 2007, the Government selected the Adaptive Phased Management (APM) approach, as recommended by the NWMO, for the long-term management of nuclear fuel waste in Canada.

The APM approach is Canada's solution to the long-term management of nuclear fuel waste. The APM involves three phases each marked by explicit decision points and continuing participation of stakeholders. The three phases of the APM approach include:

- maintaining the waste at the reactor sites while preparing for centralization at a site within an interested community;
- determining whether an optional shallow-underground storage facility at the central site is required; and

[1] Percentages derived from data presented in the Nuclear Waste Management Organization's Annual Report 2007.

- containing the waste in a deep repository at the central site.

A key element of the implementation of the APM approach is to find a suitable site in a willing host community to construct a long-term waste management facility.

The NWMO is required to implement the Government's decision in accordance with the NFWA and with ongoing Government oversight. Following the Government's announcement in 2007, the NWMO has been designing a process for siting a long-term waste management facility. The actual siting process is expected to begin by mid 2010. For information about the NWMO's siting process and how it will implement the APM approach, refer to the following website address www.nwmo.ca.

Nuclear fuel waste is also produced at a research reactor at AECL's Chalk River Laboratories and at a number of Canadian universities. Nuclear fuel waste generated by AECL is currently managed on site; while nuclear fuel waste produced by research reactors at universities is normally returned to the United States, through the Department of Energy, to its Savannah River facility. It was recently announced that all U.S. originating HEU fuel used at the Chalk River Laboratories is to be repatriated to the Savannah site by 2018. Nuclear fuel waste generated from three AECL prototype power reactors, which are no longer in operation, are either in dry storage at the facilities or has been transferred to AECL's waste management facility at Chalk River, Ontario.

2.7.8. Management of Low- and Intermediate- Level Radioactive Waste

Low and intermediate-level radioactive wastes are grouped into three broad categories: ongoing waste; legacy waste; and, historic waste.

Ongoing Waste: is generated by the ongoing activities of companies currently in operation, such as nuclear power plants, uranium processing and conversion facilities, nuclear fuel fabrication facilities, radioisotope processing facilities, hospitals, universities, and small radioisotope users.

Legacy Wastes: are wastes at AECL sites that date back to the Cold War and the birth of nuclear technologies in Canada. These include shutdown buildings and affected lands, and are managed by AECL on behalf of the Government of Canada. The nuclear legacy liabilities include some high-level waste, in particular used research reactor fuel and high-level liquid waste from the production of medical isotopes and Cold War-era fuel processing experiments, which are being addressed under the Nuclear Legacy Liabilities Program, as described below.

Historic Waste: is waste that was managed in the past in a manner that is no longer considered acceptable and for which the current owner cannot reasonably be held responsible. Canada's historic waste inventory consists largely of radium and uranium contaminated soils. The GoC has accepted responsibility for the long-term management of this waste.

Management of Ongoing Waste

Nuclear utilities' L&ILRW are safely stored on an interim basis at their respective reactor sites. AECL accepts L&ILRW from a number of small producers and users of radioactive materials for long-term management.

Consistent with the Radioactive Waste Policy Framework, waste owners of ongoing L&ILRW are responsible for managing and operating storage facilities for their wastes. OPG is moving ahead with the process to site a deep underground facility at Kincardine for its L&ILRW. In 2004, the Municipality of Kincardine and OPG entered into a hosting agreement that would enable OPG to prepare a site, construct, and operate a deep geologic repository (DGR). This repository will be located on the Bruce Nuclear Site and would manage L&ILRW from the existing nuclear reactors at the Bruce, Pickering, and Darlington generating stations, all located in Ontario. The DGR will be designed to contain and isolate all of OPG's L&ILRW that is generated from the 20 nuclear power reactors, including L&ILRW arising from the refurbishment of OPG reactors. For information about OPG's DGR visit the website address http://www.opg.com/power/nuclear/waste/dgr/index.asp.

On January 1, 2009, the NWMO was contracted to manage the development of the DGR. The NWMO, acting as the project manager via a contractual agreement with OPG, is currently working through the environmental assessment and regulatory approvals process for the proposed DGR.

Management of AECL's Legacy Waste

The GoC's nuclear legacy liabilities have resulted from 60 years of nuclear research and development (R&D) carried out on behalf of Canada by the National Research Council (1944 to 1952) and AECL (1952 to present). These liabilities are largely located at AECL sites, and consist of shutdown research buildings (including several prototype and research reactors), a wide variety of buried and stored wastes, and affected lands. The shutdown buildings and affected lands need to be safely decommissioned to meet federal regulatory requirements, and long-term solutions need to be developed and implemented for the wastes. More than half of the liabilities are the result of Cold War activities during the 1940s, 50s and early 60s. The remaining liabilities stem from research and development for nuclear reactor technology, the production of medical isotopes and national science programs.

About 70 percent of the liabilities are located at AECL's Chalk River Laboratories (CRL) in Ontario, and a further 20 percent are located at AECL's Whiteshell Laboratories in Manitoba. The Whiteshell facility is being decommissioned. The remaining 10 percent relate largely to three shutdown prototype reactors in Ontario and Quebec, which have been partially decommissioned and are currently in safe storage.

The inventory of legacy waste includes spent fuel, high-level, intermediate-level and low-level solid and liquid radioactive waste, and waste (largely contaminated soils) from site cleanup work across Canada.

In 2006, the GoC adopted a new long-term strategy to deal with the nuclear legacy liabilities over a 70-year period. The overall objective of the long-term strategy is to safely and cost-effectively reduce the liabilities and associated risks based on sound waste management and environmental principles in the best interests of Canadians. The estimated cost to implement the strategy over 70 years is about $7 billion (current-day Canadian dollars).

The GoC has committed $520 million to fund the 5-year start-up phase of the Nuclear Legacy Liabilities Program. The 5-year plan, which was initiated in 2006, focuses on:

- addressing immediate health, safety, and environmental priorities;
- accelerating the decommissioning of shutdown buildings; and,
- laying the groundwork for subsequent phases of the strategy,

while continuing necessary care and maintenance activities to maintain the liabilities in a safe state until they can be fully addressed in future phases of the program. Further development and refinement of the strategy will be informed by public consultations.

The 5-year plan is being implemented through a Memorandum of Understanding between NRCan and AECL whereby NRCan is responsible for policy direction and oversight, including control of funding, and AECL is responsible for carrying out the work.

Management of Historic Waste

The GoC established the Low-Level Radioactive Waste Management Office (LLRWMO) within AECL in 1982 as the federal agent for the cleanup and management of historic low-level radioactive waste in Canada. NRCan provides policy direction and funding to the LLRWMO to carry out its work. Over the course of its existence, the LLRWMO has completed historic waste cleanups across Canada.

The bulk of Canada’s historic low-level radioactive waste is located in the southern Ontario communities of Port Hope and Clarington. These wastes and contaminated soils amount to roughly 2 million cubic metres and relate to the historic operations of a radium and uranium refinery in the Municipality of Port Hope dating back to the 1930s. While there is neither urgent health nor environmental risks, the Government of Canada determined that intervention measures are required to deal with the impacts of past waste management practices in the Port Hope area.

In March 2001, the GoC and the local municipalities entered into an agreement on community-developed proposals to address the cleanup and long-term management of these wastes, thereby launching the Port Hope Area Initiative (PHAI). From its inception to 2009, the LLRWMO was the proponent of the PHAI on behalf of the GoC. In 2009, the PHAI Management Office was established as the GoC’s federal implementing agent for the delivery of the project.

The PHAI will involve the long-term management of these historic wastes in two above-ground mounds to be constructed in the local communities. The current phase of the PHAI involves environmental assessment and regulatory review, and is expected to be completed in 2011. Ongoing public consultation remains a priority as municipal support is required for successful completion of the planning phase. The environmental assessments for the Port Hope and Port Granby waste management facility were completed in March 2007 and August 2009, respectively. Both municipalities have given their consent to continue project implementation.

In October 2009, a licence was issued for the Port Hope Project by the CNSC. The licensing process for the Port Granby Project will proceed in 2011. Cleanup, waste facility construction and waste emplacement will take place in the following years, after which the facilities will continue to be monitored and maintained for the long term.

Most of the remaining historic waste to be dealt with in Canada is located along the Northern Transportation Route between Port Radium, Northwest Territories and Fort McMurray, Alberta. The waste results from the past transport of radium and uranium bearing ore and concentrates from the Northwest Territories to Fort McMurray. In 2003, the Government of Canada completed a cleanup of contaminated sites in Fort McMurray, and the resulting contaminated soils are safely stored in a long-term, above-ground mound at the local municipal landfill. Strategies are currently being developed for the cleanup of the remaining contamination along the Northern Transportation Route, which is estimated to consist of about 14,000 cubic metres of contaminated soils.

2.8. Research and development

2.8.1. R&D organizations

Nuclear research and development in Canada began in the 1940s as a responsibility of the federal government. The federal government has funded a research and development programme at AECL since its creation in 1952. AECL is responsible for Canada's nuclear research and development programme, which includes activities in support of CANDU technology as well as basic science activities to support AECL's applied programmes in the nuclear, biological and material sciences.

AECL's research centre at the Chalk River Laboratories (CRL), Ontario plays a critical role in the development of the CANDU reactor, safety and environmental protection, nuclear medicine, health sciences, in nuclear fuel waste management and the basic sciences that spawn technological advances in these areas.

Early CRL pursuits were in the "new" sciences at the time - nuclear physics, nuclear chemistry and radiation biology - and the creation of the National Research Experimental (NRX) reactor.

The NRX facility and the National Research Universal (NRU) reactor (brought on stream a decade later) were critical to CRL's early programmes of basic science and isotope production as well as to the development of the CANDU reactor system. CRL supported federal government initiatives to develop national radiological health and safety regulations and to contribute to international efforts to control the proliferation of nuclear weapons.

The CANDU nuclear energy system is unique in concept among nuclear systems in the world. This is because the Canadian research reactors were designed to use natural (rather than enriched) uranium as fuel and heavy (rather than light) water as a moderator.

Activities at CRL have included the development of CANDU design methods, experimental verification of CANDU reactor components and design characteristics, as well as detailed safety analyses. Work continues on improved durability and reliability of CANDU components, and flexibility of fuel cycles. Significant research in basic and applied science, not necessarily related to nuclear energy, has also been conducted in these laboratories.

2.8.2. Development of advanced nuclear technologies

AECL is pursuing the development of a Generation III+ CANDU reactor – the Advanced CANDU Reactor (ACR-1000) – an evolutionary technology based on the CANDU 6 design. Funding has been provided by the government to AECL over the last several years for the completion of the ACR. Moreover, in September 2009, the CNSC announced that it had completed phase 2 of the Pre-Project Design Review and concluded that there were no fundamental barriers to licensing the ACR in Canada. However, it should be noted that the conclusions of this review is subject to the successful completion of AECL's planned activities, in particular those related to R&D.

2.8.3. International co-operation and initiatives

Canada is a member country of both the Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA). It is also a member of the Generation IV International Forum (GIF) and Global Nuclear Energy Partnership (GNEP). Canada has 27 bilateral Nuclear Cooperation Agreements in force covering 44 countries.

2.9. Human resources development

To support its nuclear energy program, a strong human resources development framework has been developed in Canada. At least four universities are currently offering a nuclear engineering program in Canada. In 2002, the University Network of Excellence in Nuclear Engineering (UNENE) was created through the partnership of three leading Ontario universities, namely, the University of McMaster, University of Waterloo, and the University of Western Ontario. UNENE is an alliance of universities, nuclear power utilities, research and regulatory agencies for the support and development of nuclear education, research and development capability in Canadian universities. It presents a unique, innovative learning experience through a Master's Degree Program in Nuclear Engineering Design with emphasis on nuclear power reactor technology. The UNENE program is designed to provide practicing engineers the enhanced knowledge, tools, technology as well as business and management skills, necessary to keep them at the forefront of their profession.

AECL's Chalk River Laboratories have been used for educational development and many scientists and students, both Canadian and International, have conducted nuclear research there. Moreover, the Chalk River Laboratories hosts the Canadian Neutron Beam Centre (CNBC), operated by Canada's National Research Council. It includes a centre for the training of highly qualified personnel. It supports graduate student research and projects by post-doctoral and other young researchers from universities across Canada and abroad.

2.10. Stakeholder Communication

The Government of Canada keeps the public informed on national nuclear policy and events through responsible Departments/Ministers and by reporting to Parliament or to the public via the media, and through other means of correspondence. The individual owners or power organizations inform their own customers and the press about project details. There are also other organization in Canada who have an interest in communication information on nuclear power to the public, including the Canadian Nuclear

Association, the Canadian Nuclear Society, the CANDU Owners Group and the Organization of CANDU Industries.

3. NATIONAL LAWS AND REGULATIONS

3.1. Regulatory framework

3.1.1. Regulatory Authorities

The Canadian Nuclear Safety Commission

On 31 May 2000, the CNSC was created as the successor to the Atomic Energy Control Board (AECB), which had served as the regulator of Canada's nuclear industry for more than 50 years. The Commission's creation followed the coming into force of the Nuclear Safety and Control (NSC) Act and its regulations. The NSC Act represented the first major overhaul of legislation governing Canada's nuclear regulatory regime since the AECB was established in 1946. It established a seven-member tribunal (the CNSC) to regulate the nuclear industry and authorized to hire technical and support staff. The CNSC reports to Parliament through the Minister of Natural Resources.

The CNSC's mission is to regulate 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. Under the NSC Act, the CNSC's mandate involves four major areas:

- Regulation of the development, production and use of nuclear energy in Canada;
- Regulation of the production, possession and use of nuclear substances, prescribed equipment and prescribed information;
- Implementation of measures respecting international control of the use of nuclear energy and substances, including measures respecting the non-proliferation of nuclear weapons; and
- Dissemination of scientific, technical and regulatory information concerning the activities of the CNSC and the effects on health and safety and the environment arising from the development and use of nuclear energy and nuclear substances.

The Canadian regulatory system is designed to protect people and the environment from the risks associated with the development and use of nuclear energy and nuclear substances. Companies and medical or academic institutions wishing to operate nuclear facilities or use nuclear substances for industrial, medical or academic purposes must first obtain a licence from the CNSC. It is a fundamental tenet of Canada's regulatory regime that licensees are primarily responsible for safety. The CNSC's role is to ensure that the applicants live up to their responsibility. The onus is therefore on the applicant or the holder of the licence to justify the selection of a site, design, method of construction, and mode of operation of a facility, etc. When issuing a licence, the CNSC must be satisfied that the companies have taken adequate measures to protect health and safety, the environment, security and to respect international commitments, and that the companies are qualified to carry out the licensed activities. Licensing matters for major facilities are carried out in public hearings by the seven-member tribunal. This is one of the most visible functions of the CNSC in the regulation of the nuclear industry.

The CNSC controls the import and export of nuclear materials, nuclear technology and equipment that might be used to develop nuclear weapons (including so-called "dual use items"). CNSC staff also plays an important role in international activities aimed at the non-proliferation of nuclear weapons. As well, the CNSC participates in IAEA activities and ensures compliance with Canada's Nuclear Non-Proliferation policy and the Treaty on the Non-Proliferation of Nuclear Weapons.

CNSC staff inspects licensed activities, enforces compliance with regulations, and develops safety standards. Standards for radiological protection have been developed over the years at both national and international levels. The basis for the Canadian regulatory radiation dose limits originates from the recommendations of the International Commission on Radiological Protection (ICRP).

3.1.2. Licensing Process

There are many stages in the lifecycle of nuclear 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 corresponding license from the CNSC. A separate license is needed for each of these stages.

There are four major steps in the licensing process:

1. *Applicant submits a license application*

   The licensing process begins when an application is received by the CNSC. An Assessment Plan and timeline is then developed for each individual application. The Assessment Plan identifies the scope and depth of the technical assessment needed to evaluate the application. It takes historical licensing information, licensing experience, performance and compliance reports, and CNSC staff recommendations into account.

2. *Environmental Assessment*

   The CNSC has strict obligations and responsibilities under the CEA Act, which is the basis for federal Environmental Assessments in Canada. An Environmental Assessment (EA) is used to predict the environmental effects of a specific project, and to determine whether these effects can be mitigated, before a project is carried out.

3. *Technical Assessment*

   The CNSC undertakes a variety of Technical Assessments according to the prescribed Assessment Plan to ensure that each application complies with all regulatory criteria as defined by the NSC Act, relevant regulations, international and domestic standards, and international obligations.

4. *CNSC renders its decision*

   The final step in the licensing process is the Commission Tribunal decision, which takes into account all CNSC staff recommendations and the views and concerns expressed at public hearings. The hearings provide interested stakeholders opportunity an opportunity to participate in the process of establishing regulatory policy and form an important part of informing licensing decisions and implementing programs.

3.2. Main National Laws and Regulations in Nuclear Power

While Canada's provinces have constitutional responsibility for resource and industrial development, including authority for decisions regarding the development of uranium resources and the commercial development and use of nuclear power, regulation of the nuclear industry is a federal responsibility and has been since the inception of the Canadian nuclear industry in the mid-40s. While the CNSC has sole responsibility for licensing nuclear facilities and nuclear activities, a number of other federal agencies are involved in the regulation of the industry. Provinces may also have regulations that deal with off-site activities of licensees, such as provisions for off-site emergency preparedness.

The main national laws relevant to Canada's nuclear programme are the NSC Act, which came into force in 2000, the Nuclear Liability (NL) Act of 1976, the Nuclear Energy Act of 1985 and the Nuclear Fuel Waste (NFW) Act of 2002. Other federal legislation of significant importance to the Canadian nuclear industry include the Canadian Environmental Assessment (CEA) Act, which came into force in January 1995, and the Canada Labour Code, which governs conventional occupational health and safety issues, labour standards and labour relations.

As noted above, the NSC Act replaced the Atomic Energy Control Act of 1946 and established the Canadian Nuclear Safety Commission in place of the former Atomic Energy Control Board with regulatory responsibilities for nuclear matters. The NSC Act received Royal Assent in March 1997, and came into force on 31 May 2000, after new regulations in support of the Act were approved.

In addition to the powers and responsibilities of the CNSC outlined above, the NSC Act authorizes the Commission to require that operators of nuclear facilities provide financial guarantees as a condition of their licence. This is a discretionary power that the Commission has used to require operators of uranium mines and mills, uranium refineries and fuel fabrication facilities, nuclear power plants and research reactors and facilities to provide financial guarantees to support decommissioning activities and the long-term management of nuclear waste. The financial guarantees are based on decommissioning plans accepted by the CNSC, using conservative cost estimates for implementing those plans. Financial guarantees ensure that the costs for decommissioning will be borne by licensees, not taxpayers.

The NL Act, which came into force in 1976, establishes liability for third-party injury and damage arising from nuclear accidents and provides for a well-defined compensation system for victims. The NL Act is modelled closely after the Vienna and Paris nuclear third-party liability conventions. The Act applies to nuclear facilities that are designated by the CNSC. These are generally nuclear reactors, fuel fabrication facilities, or facilities for the long-term management of nuclear fuel waste. The NL Act also includes provisions for Canada to enter into reciprocity agreements with any country that provides satisfactory arrangements for compensation. Currently, the only such reciprocity arrangement is between the United States and Canada. Although the basic principles underlying the NL Act remain valid, the Act is almost thirty years old, and needs updating to address issues that have become evident over the years, and to keep pace with international trends.

In the previous Parliament, proposed legislation to update and modernize Canada's nuclear civil liability regime was introduced as Bill C-20 (Nuclear Liability and Compensation Act). It received Second Reading and was reported back to the House on December 10, 2009 after study by the Standing Committee on Natural Resources. However, it did not advance further and died with the cessation of Parliament on December 30, 2009. At this point in time, any decision to move forward on introducing a similar Bill rests with the Government.

The NFW Act requires nuclear utilities to form a waste management organization whose mandate is to propose to the Government of Canada approaches for the long-term management of nuclear fuel waste, and to implement the approach that is selected by the Government. The NFW Act also requires the utilities and AECL to establish trust funds to finance the implementation of the selected long-term nuclear fuel waste management approach. The NFW Act entered into force on November 15, 2002.

The CEA Act establishes in legislation the process and the obligations of federal departments and agencies for the conduct of environmental assessments of public or private projects involving the federal government. In 2000, a five-year review of the operation and provisions of the CEA Act was undertaken by the Minister of Environment. A multi-stakeholder consultation was held on a national scale to determine ways to improve the Act. A revised CEA Act, incorporating the results of the five-year review, came into force in October 2003.

Conventional occupational health and safety, labour relations and labour standards are governed by the Canada Labour Code. Provisions in the Code allow the federal government to incorporate by reference provincial statutes of general application as federal regulations, and to make arrangements with provincial governments for the administration of those regulations. This power has been exercised with respect to nuclear power facilities in Ontario, and for conventional occupational health and safety matters at Saskatchewan uranium mines and mills.

REFERENCES (FURTHER READING)

Natural Resources Canada, http://www.nrcan-rncan.gc.ca

Doern, B. and Morrisson, R. 2009. Canada's Nuclear Crossroads: Steps to a Viable Nuclear Energy Industry. C.D. Howe Institute. http://www.cdhowe.org/pdf/commentary_290.pdf.

Tammaermagi, H. and Jackson, D. 2009. Half Lives: A Guide to Nuclear Technology in Canada. Oxford University Press, Don Mills.

Tammaermagi, H. and Jackson, D. 2002. Unlocking the Atom. McMaster University Press, Hamilton.

Bratt, D. 2006. The Politics of CANDU Exports. University of Toronto Press, Toronto.

APPENDIX 1: INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS

Agreement with the Agency

• Amendments to articles VI and XIV of the Agency statute	Ratified	15 September 2000
• Agreement on privileges and immunities	Entry into force:	15 June 1966
• NPT related safeguards agreement INFCIRC/164	Entry into force:	21 February 1972
• IAEA Additional Protocol	Entry into force:	8 September 2000

Other Multilateral Safeguards Agreements

• India/Canada INFCIRC/211	Entry into force:	30 September 1971
• Japan/Canada INFCIRC/85	Entry into force:	20 June 1966
• Pakistan/Canada INFCRIC/135	Entry into force:	17 October 1969
• Spain/Canada INFCIRC/247	Entry into force:	10 February 1977

Main International Treaties

• NPT	Entry into force:	8 January 1969
• Convention on physical protection of nuclear material	Entry into force:	8 February 1987
• Convention on early notification of a nuclear accident	Entry into force:	8 February 1990
• Convention on assistance in the case of a nuclear accident or radiological emergency	Entry into force:	12 September 2002
• Vienna convention on civil liability for nuclear damage	N/A	
• Paris convention on third party liability in the field of nuclear energy	Not signed	
• Joint protocol relating to the application of Vienna and Paris conventions	Non Party	
• Protocol to amend the Vienna convention on civil liability for nuclear damage	N/A	
• Convention on supplementary compensation for nuclear damage	Not signed	

• Convention on nuclear safety	Entry into force:	24 October 1996
• Joint convention on the safety of spent fuel management and on the safety of radioactive waste management	Entry into force:	18 June 2001

Other relevant agreements:

• Improved procedures for designation of safeguards inspectors	Accepted:	8 June 1989
• ZANGGER Committee	Member	
• Acceptance of NUSS Codes	No reply	
• Nuclear Suppliers Group	Member	
• Nuclear Export Guidelines	Adopted	
• Agenda 21 of the UN conference on Environment and Development		1992
• Comprehensive Test Ban Treaty	Ratified	December 1998

Bilateral agreements

Canada has bilateral nuclear co-operation agreements with the following countries:

Argentina	Hungary	Slovenia
Australia	Indonesia	Slovakia
Brazil	Japan	Spain
China	Jordan	Sweden
Colombia	Kazakhstan	Switzerland
Czech Republic	Korea, Republic of	Turkey
Egypt	Mexico	Ukraine
Euratom	Philippines	United States of America
Finland	Romania	
Germany	Russian Federation	

APPENDIX 2: DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NULCEAR POWER RELATED ACTIVITIES

2.1 FEDERAL GOVERNMENT DEPARTMENTS AND AGENCIES

Nuclear Energy Division

Department of Natural Resources

580 Booth Street

Ottawa, Ontario K1A 0E4

Tel: (+1-613) 996-2090

Fax: (+1-613) 995-0087

http://www.nrcan.gc.ca/

Uranium and Radioactive Waste Division

Department of Natural Resources

580 Booth Street

Ottawa, Ontario, KIA 0E4

Tel: (+1-613) 996-2392

Fax: (+1-613) 947-4205

Atomic Energy of Canada Limited

2251 Speakman Drive
Mississauga, Ontario L5K 1B2
Phone: (+1-905) 823-9040

Fax: (+1-905) 403 7301

http://www.aecl.ca/

Canadian Nuclear Safety Commission

280 Slater Street, 4th Floor Reception

P.O. Box 1046, Station B

Ottawa, Ontario K1P 5S9

Tel: (+1-613) 995-5894 or 992-8828

Fax: (+1-613) 995-5086

http://www.nuclearsafety.gc.ca

Non-Proliferation and Disarmament Division

Department of Foreign Affairs and International Trade

125 Sussex Drive

Ottawa, Ontario K1A 0G2

Tel: (1+613) 992-3430

Fax: (1+613) 944-3105

http://www.international.gc.ca/arms-armes/

Nuclear Waste Management Organization
22 St. Clair Avenue East, Sixth Floor
Toronto, Ontario M4T 2S3
Tel: (1-416) 934-9814/(+1-866)249-6966
Fax: (1+416) 934-9526

http://www.nwmo.ca/

National Research Council

1200 Montreal Road, M-58
Ottawa, Ontario K1A 0R6

Tel: (+1-613) 993-9101

Fax: (+1-613) 952-9907

http://www.nrc-cnrc.gc.ca/

2.2 FIRMS INVOLVED IN THE FRONT END OF THE FUEL CYCLE

Cameco Corporation

2121 - 11th Street West

Saskatoon, Saskatchewan S7M 1J3

Tel: (+1-306) 956-6200

Fax: (+1-306) 956-6302

http://www.cameco.com/index.html

AREVA Resources Canada

817 - 825, 45th Street West, Box 9204

Saskatoon, Saskatchewan S7K 3X5

Tel: (+1-306) 343-4502

Fax: (+1-306) 653-3883

http://www.cogema.ca/

Denison Mines Limited

40 Dundas Street West, Suite 320

Toronto, Ontario M5G 2C2

Tel: (+1-416) 979-1991

Fax: (+1-416) 979-5893

2.3 RELEVANT ASSOCIATIONS

Canadian Nuclear Association

130 Albert Street, Suite 1610

Ottawa, Ontario K1P 5G4

Tel: (+1-613) 237-4262

Fax: (+1-613) 237-0989

http://www.cna.ca/

Canadian Nuclear Society

480 University Ave., Suite 200
Toronto, Ontario M5G 1V2

Tel: (+1-416) 977-7620
Fax: (+1-416) 977-8131

http://www.cns-snc.ca/

Uranium Saskatchewan Association Inc.

600 Spadina Crescent East

Saskatoon, Saskatchewan S7K 3G9

Tel: (+1-306) 242-8222

Fax: (+1-306) 244-4441

Canadian Electrical Association

1 Westmount Square, Suite 1600

Montréal, Québec H3Z 2P9

Tel: (+1-514) 937-6181

Fax: (+1-514) 937-6498

Electrical and Electronic Manufacturers Association

10 Carlson Court, Suite 210

Rexdale, Ontario M9W 6L2

Tel: (+1-416) 674-7410

Fax: (+1-416) 674-7412

2.4 RELEVANT POWER UTILITIES

Ontario Power Generation

700 University Avenue Toronto, OntarioM5G 1X6

Tel: (+1-416) 592-3453

http://www.opg.com/default2.asp

Bruce Power

P.O. Box 1540

Tiverton, Ontario, NOG 2T0

Tel. 519-361-3550

Fax: 519-361-3325

http://www.brucepower.com/

Hydro-Québec

75, boul. René Lévesque ouest

Montréal, Québec H2Z 1A4

Tel: (+1-514) 289-3811

Fax: (+1-514) 289-3342

http://www.hydro-quebec.com/en/

New Brunswick Power Corporation

515 King Street, P.O. Box 2000
Fredericton, New Brunswick E3B 4X1

Tel: (+1-506) 458-4342

Fax: (+1-506) 458-4390

http://www.nbpower.com/en/index.html

2.5 CANDU INDUSTRY

Monenco Agra Inc.

2010 Winston Park Drive, Suite 100
Oakville, Ontario L6H 6A3

Tel: (+1-905) 829-5399

Fax: (+1-905) 829-5401

Babcock and Wilcox Canada

P.O. Box 310

581 Coronation Boulevard

Cambridge, Ontario N1R 5V3

Tel: (+1-519) 621-2130

Fax: (+1-519) 621-5610

Canatom Inc.

2020 University, Suite 2200

Montréal, Québec H3A 2A5

Tel: (+1-514) 288-1990

Fax: (+1-514) 289-9813

CAE Electronics Ltd.

C.P. 1800

Saint-Laurent, Québec H4L 4X4

Tel: (+1-514) 341-6780

Fax: (+1-514) 341-7699

Dominion Bridge

500 Notre-Dame Street

Lachine, Québec H8S 2B2

Tel: (+1-514) 634-355l

Fax: (+1-514) 631-2668

GE Canada Inc.

Nuclear Products

107 Park Street North

Peterborough, Ontario K9J 7B5

Tel: (+1-705) 748-7509

Fax: (+1-705) 748-7338

SNC-Lavalin
455 René-Lévesque Blvd. W
Montreal, Quebec H2Z 1Z3
Tel: (+1-514) 393-1000
Fax: (+1-514) 866-0795

http://www.snclavalin.com/

AREVA Canada Incorporated
925 Brock Road
Pickering, ON L1W 2X9
Tel: 905-421-2600

http://www.arevacanada.ca/

CANDU Owner's Group

http://www.candu.org

2.6 RADIOISOTOPES

Nordion International Inc.

447 March Road

Kanata, Ontario K2K 1X8

Tel: (+1-613) 592 2790

Fax: (+1-613) 592 5302

2.7 HIGH ENERGY RESEARCH INSTITUTES

Canadian Institute for Synchrotron Radiation (CISR)
http://www.uwo.ca/cisr/index.html

TRIUMF (Canada)
http://www.triumf.ca/

Centre canadien de fusion magnétique (CCFM) http://www.ccfm.ireq.ca/

INRS - Energie et Matériaux
http://www.inrs-ener.uquebec.ca/

Plasma Physics Laboratory

at the University of Saskatchewan
http://physics.usask.ca/

Canadian Light Source at the University of Saskatchewan

http://www.lightsource.ca/

2.8 UNIVERSITIES

University Network of Excellence in Nuclear Engineering **(**UNENE**)**

http://www.unene.ca

Queen's University

http://www.queensu.ca

University of Alberta

http://www.ualberta.ca

McMaster University

http://www.mcmaster.ca

University of Guelph

http://www.uofguelph.ca

University of Toronto

http://www.utoronto.ca

University of Ontario Institute of Technology

http://www.uoit.ca

Royal Military College

http://www.rmc.ca

University of New Brunswick

http://www.unb.ca

University of Waterloo

http://www.uwaterloo.ca

Université de Montreal/Ecole Polytechnique http://www.polymtl.ca

University of Saskatchewan
http://www.usask.ca/

University of Western Ontario
http://www.uwo.ca/

Dalhousie University

http://www.dal.ca

2.9 OTHER ORGANIZATIONS

Atlantic Nuclear Services Ltd. (ANSL)
http://www.ansl.ca

Canadian Coalition for Nuclear Responsibility http://www.ccnr.org

Energy Council of Canada (ECC)

http://www.energy.ca

Report Coordinator, contact:

Sylvana Guindon

Natural Resources Canada

Tel: (+1-613)995-2870

Fax: (+1-613)995-0087

Sylvana.guindon@nrcan-rncan.gc.ca

Attachment 1: PREFIXES AND CONVERSION FACTORS

TABLE 1. PREFIXES

Symbol	**Name**	**Factor**
E	exa	10^{18}
P	peta	10^{15}
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
K	kilo	10^{3}
H	hecto	10^{2}
da	deca	10^{1}
D	deci	10^{-1}
C	centi	10^{-2}
M	mili	10^{-3}
µ	micro	10-6
η	nano	10^{-9}
P	pico	10^{-12}
F	femto	10^{-15}
A	atto	10^{-18}

TABLE 2. CONVERSION FACTORS FOR ENERGY

To:	**TJ**	**Gcal**	**Mtoe**	**MBtu**	**GWh**
From:	Multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	107	1	3.968×10^{7}	11630
Mbtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3412	1

TABLE 3. CONVERSION FACTORS FOR MASS

To:	**kg**	**T**	**lt**	**st**	**lb**
From:	Multiply by:				
kg (kilogram)	1	0.001	9.84×10^{-4}	1.102×10^{-3}	2.2046
T (tonne)	1000	1	0.984	1.1023	2204.6
Lt (long tonne)	1016	1.016	1	1.12	2240.0
st (short tonne)	907.2	0.9072	0.893	1	2000.0
lb (pound)	0.454	4.54×10^{-4}	4.46×10^{-4}	5.0×10^{-4}	1

TABLE 4. CONVERSION FACTORS FOR VOLUME

To:	**US gal**	**UK gal**	**bbl**	**ft^3**	**L**	**m^3**
From:	Multiply by:					
US gal (US gallon)	1	0.8327	0.02381	0.1337	3.785	0.0038
UK gal (UK gallon)	1.201	1	0.02859	0.1605	4.546	0.0045
bbl (barrel)	42.0	34.97	1	5.615	159.0	0.159
ft^3 (cubic foot)	7.48	6.229	0.1781	1	28.3	0.0283
l (litre)	0.2642	0.22	0.0063	0.0353	1	0.001
m^3 (cubic metre)	264.2	220.0	6.289	35.3147	1000	1