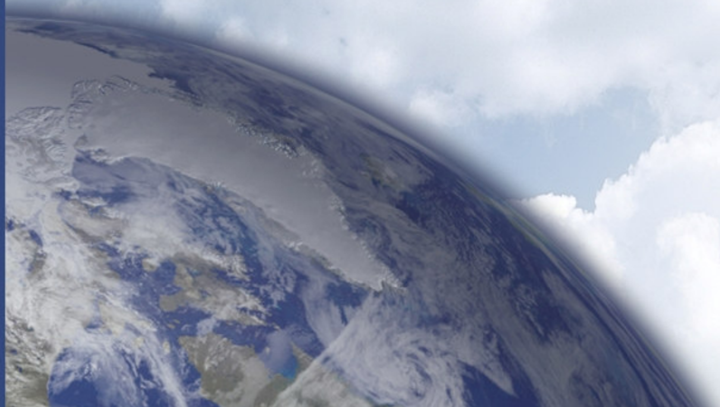
Government of Canada Gouvernement du Canada



Economic Scan of Canada's Energy Sector

Produced for the Energy Sector Sustainability Table

2008

Canada

INTRODUCTION

Sector Sustainability Tables

Sector Sustainability Tables (SSTs) are a multi-stakeholder mechanism created by the Government of Canada to provide advice on how best to attain the highest level of environmental quality, as a means to enhance the health and well-being of Canadians, preserve our natural environment, and advance our long-term competitiveness. Currently, SSTs have been established for the Energy, Mining, and Forests sectors.

The Energy Sector Sustainability Table (ESST) was established in 2005 with a mandate to advise the government on how to meet the energy needs of Canadians, to improve the environmental and economic sustainability of energy systems in Canada and to make recommendations on both short-term and long-term sustainable energy objectives. The table is co-chaired by senior representatives of government and industry and includes senior representatives from federal and provincial governments, industry, and civil society organizations.

ESST Membership (2007)

Co-chairs:

Michael Horgan, Deputy Minister, Environment Canada
Gerard Protti, Executive Vice-President, Corporate Relations, EnCana Corporation

Members:

Pierre Alvarez, Canadian Association of Petroleum Producers
Dane Baily, Canadian Petroleum Products Institute
Jan Carr, Chief Executive Officer, Ontario Power Authority
Mike Cleland, President and CEO, Canadian Gas Association
Cassie Doyle, Natural Resources Canada
Murray Elston, Canadian Nuclear Association
Joe Gargiso, Energy and Paperworkers Union of Canada
Michael Horgan, co-chair, Environment Canada
Robert Hornung, Canadian Wind Energy Association
Hans Konow, Canadian Electricity Association
Suzanne Leblanc, SNC-Lavalin
Liz Logan, Fort Nelson First Nation
Dave MacInnis, Canadian Energy Pipeline Association
Richard Nerysoo, Nihtat Gwich'in Council
Ken Ogilvie, Pollution Probe
André Plourde, University of Alberta
Gerard Protti, co-chair, EnCana Corporation
Louis Ranger, Transport Canada
Marlo Raynolds, Pembina Institute
Allison Scott, Nova Scotia Department of Energy
Nashina Shariff, Toxics Watch Society of Alberta
Vicky Sharpe, Sustainable Development Technology Canada
Peter Watson, Alberta Environment

About the Economic Scan

Discussions by the ESST to date have reflected on the view that Canadians should appreciate the significance of energy in the country's economy and environment. In light of this, the ESST tasked Environment Canada and Natural Resources Canada (NRCan) to develop two products: an environmental scan and an economic scan related to energy. The two products serve as companion reports providing detailed environmental and economic facts to inform decision making.

NRCan led the development of the economic scan, which provides the following:

- An overview of the contribution of the energy sector to Canada's economy, including such macroeconomic variables as value added, external trade, employment, expenditures and government revenues; and

- A better understanding of the magnitude and distribution of Canada's varied energy resources, together with baseline information on production and consumption.

Facts and statistics presented in this document reflect information available at the end of 2007.

Organization of the economic scan

The economic scan is organized as follows:

- Chapter 1. International context
- Chapter 2. Energy and the Canadian economy
- Chapter 3. Canada's primary energy resources
- Chapter 4. Electricity
- Chapter 5. Secondary energy use
- Chapter 6. Energy science and technology
- Annex 1. Provincial and territorial tables

The first chapter, "International context," provides an overview of global energy trends and underlines Canada's stature as a world leader in energy production and use.

The second chapter, "Energy and the Canadian economy," highlights the economic importance of Canada's energy sector by quantifying its contribution to key macroeconomic variables. It also discusses the importance of energy on other sectors of the economy.

The third chapter, "Canada's primary energy resources," shows the full scope of energy resources, from oil, natural gas and coal to uranium and renewable resources. For each primary resource, tables and graphs convey the level of resources, current production, external trade, domestic consumption and price.

Where appropriate, the processing and distribution system and the outlook for each energy resource are also provided. Most of the forward-looking information and analysis is derived from *Canada's Energy Outlook: The Reference Case 2006*, published by NRCan.

As well, regional differences within Canada for energy resources are assessed. Additional comparative information is found in Annex 1, "Provincial and territorial tables."

The fourth chapter, "Electricity," builds on the information in the third chapter, since electricity is an energy carrier, rather than an energy resource. This chapter covers the generation (broken down by source), trade, consumption, prices and reliability of electricity.

The fifth chapter, "Secondary energy use," is devoted to the sectors that use energy that is produced in or imported to Canada: the industrial, commercial, residential and transportation sectors. Trends in energy consumption and information on energy efficiency are presented for each sector.

The sixth chapter, "Energy science and technology," includes statistics on energy-related expenditures on research and development by the private and public sectors.

Finally, Annex 1 contains supplemental information, including disaggregated information for each province and territory.

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ABBREVIATIONS, PREFIXES AND SYMBOLS

Abbreviations

AB	Alberta
BC	British Columbia
BIPV	Building Integrated Photovoltaic
CAGR	compound annual growth rate
CANDU	CANada Deuterium Uranium
CANSIM	Canadian Socio-Economic Information Management System
CAPP	Canadian Association of Petroleum Producers
CBM	coal-bed methane
CCA	capital cost allowance
CFL	compact fluorescent lamp
CNSC	Canadian Nuclear Safety Commission
CO_2	carbon dioxide
CPI	consumer price index
EIA	Energy Information Administration (United States)
ESST	Energy Sector Sustainability Table
EUB	Alberta Energy and Utilities Board (now the Energy Resources Conservation Board and the Alberta Utilities Commission)
FSU	former Soviet Union
GDP	gross domestic product
GHG	greenhouse gas
IEA	International Energy Agency
IEUM	Industrial End-Use Model
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MB	Manitoba
NAICS	North American Industry Classification System
NB	New Brunswick
NEB	National Energy Board
NERC	North American Electric Reliability Corporation (now NERC Corporation)
NGL	natural gas liquids
NL	Newfoundland and Labrador
NO_x	nitrogen oxide
NRCan	Natural Resources Canada
NS	Nova Scotia
NT	Northwest Territories
NU	Nunavut
OECD	Organisation for Economic Co-operation and Development

ON	Ontario
OPEC	Organization of the Petroleum Exporting Countries
PE	Prince Edward Island
PERD	Program of Energy Research and Development
PV	photovoltaic
QC	Quebec
R&D	research and development
RESOP	Renewable Energy Standard Offer Program (Ontario)
REUM	Residential End-Use Model
RFO	residual fuel oil
RFP	request for proposal
RPS	renewable portfolio standard
S&T	science and technology
SEPH	Survey of Employment, Payrolls and Hours
SK	Saskatchewan
SO2	sulphur dioxide
SOC	standard offer contract
SSTs	Sector Sustainability Tables
SUV	sport utility vehicle
TEUM	Transportation Energy Use Model
TRAGS	Trade Retrieval and Aggregation System
U.K.	United Kingdom
U.S.	United States
WCSB	Western Canada Sedimentary Basin
WTI	West Texas Intermediate
yr	year
YT	Yukon Territory

Prefixes

Symbol	Prefix	Multiplying factor
k	kilo	10^3
M	mega	10^6
G	giga	10^9
T	tera	10^{12}
P	peta	10^{15}
E	exa	10^{18}

Symbols

Symbol	Definition	Symbol	Definition
MJ	megajoule = 10^6 joules (J)	m^2	square metre
GJ	gigajoule = 10^9 J	m^3	cubic metre
TJ	terajoule = 10^{12} J	km	kilometre
PJ	petajoule = 10^{15} J	L	litre
EJ	exajoule = 10^{18} J	kg	kilogram
kW	kilowatt = 10^3 watts (W)	t	tonne = 10^3 kg
kWh	kilowatt hour = 10^3 Wh	Mt	megatonne = 10^6 t
MW	megawatt = 10^3 kW	Btu	British thermal unit
MWh	megawatt hour = 10^3 kWh	Mcf	thousand cubic feet
GW	gigawatt = 10^6 kWh	Bcf	billion cubic feet
GWh	gigawatt hour = 10^6 kWh	Tcf	trillion cubic feet
TW	terawatt = 10^9 kW	Bbl	barrel
TWh	terawatt hour = 10^9 kWh	MB/D	thousand barrels per day
$	Dollar amounts are in Canadian dollars, unless otherwise indicated.	MMB/D	million barrels per day
US$	American dollars	mtoe	million tonnes of oil equivalent

CHAPTER 1: INTERNATIONAL CONTEXT

1.1. CHAPTER SUMMARY

- World energy demand has been growing and is expected to continue to grow at a sustained rate (1.6 percent annually to 2020). Most of the growth will come from emerging economies (e.g. China, India).

- As an industrialized country, Canada is expected to face growing energy demand, but at a slower pace (1.3 percent per year) than total world demand.

- Canada has a diversified and balanced portfolio of energy assets. It has great potential for supply development in key resources, including the following:

  - Growing crude oil production with a resource base second only to Saudi Arabia's in proven oil reserves, primarily in the form of oil sands
  - World's third largest producer and second largest exporter of natural gas, taking advantage of its proximity to the U.S. energy market
  - Largest producer of uranium in the world, with high-grade uranium reserves amounting to about one tenth of the world's proven reserves
  - Second largest producer of hydroelectricity, with more than 70 gigawatts (GW) of installed capacity, and significant undeveloped potential and a corresponding opportunity to further leverage the electricity storage potential of its hydroelectric system
  - Opportunities for significantly expanding the use of renewable energy resources, such as wind, bioenergy and ocean energy, provided by Canada's large land mass and long coastline

- As an energy consumer, Canada has a high level of energy intensity. This high level means Canada uses a large amount of energy per person and per unit of activity. The high level is due in large part to a cold climate, long distances, an energy-intensive industrial structure and a high standard of living.

1.2. Global Energy Context

With globalization, the world's economies are linked by energy infrastructure, including pipelines and electricity transmission grids; by physical flows of energy commodities, such as oil, gas, coal and uranium; by flows of investment in energy industries; and by financial flows that are the lifeblood of global markets for energy commodities and services. Hence, international energy developments affect Canada, and the development of Canada's energy sector affects the world.

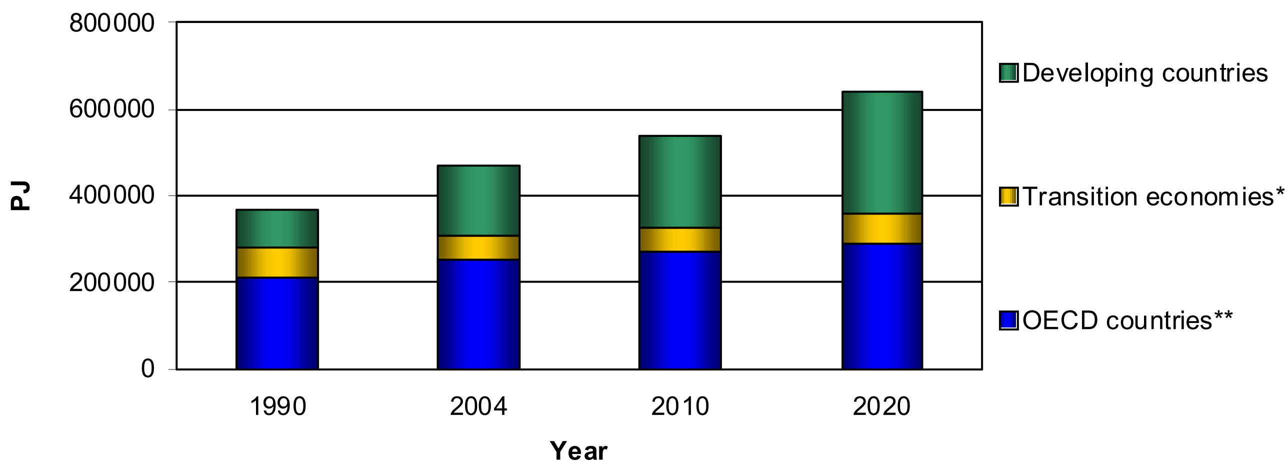
A major impact of integrated energy markets is that energy prices are increasingly affected not only by domestic resource and policy considerations but also by international supply and demand conditions and geopolitical considerations.

Many important distributional and equity issues surround access to energy, e.g. an estimated 1.6 billion people still lack access to electricity. However, global reserves of coal, oil and natural gas and other forms of energy are believed to be sufficient to meet rising demand in the foreseeable future.

As well, data on proven reserves substantially underestimate the amount of energy that could ultimately be recovered with the continued application of innovative technologies. For example, the world's proven oil reserves have more than doubled in the last 28 years, from 642 billion barrels in 1980 to 1332 billion barrels in 2008.[1]

According to *International Energy Outlook 2007*, prepared by the U.S. Energy Information Administration (EIA), world energy demand is projected to grow by 36 percent between 2004 and 2020, at an average annual rate of 1.6 percent (see Figure 1.1).[2] The most recent *World Energy Outlook*, prepared by the International Energy Agency (IEA), suggests a similar growth rate in world demand.

Figure 1.1: World Energy Demand Outlook



Source: EIA, *International Energy Outlook 2007*, Reference Case Projections, Table A1, www.eia.doe.gov/oiaf/ieo/pdf/ieorefcase.pdf .

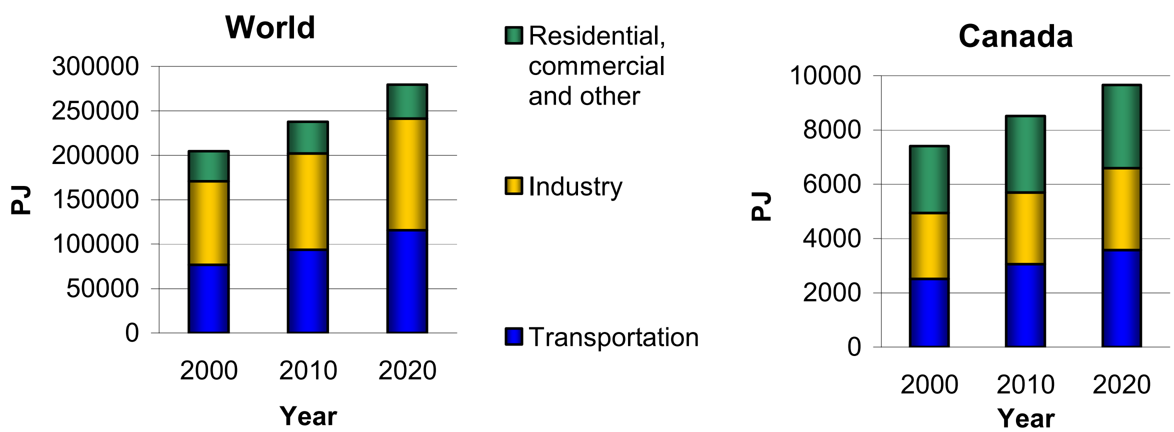
Note: Data in quadrillion British thermal units (Btu) were converted to petajoules (PJ) by multiplying by 1055.

*Transition economies are countries that are engaged in transition toward a market economy.
**OECD = Organisation for Economic Co-operation and Development.

According to the EIA, more than 77 percent of this world increase is expected to come from emerging economies, primarily China and India. The increased demand will be driven by economic and population growth, industrialization and urbanization. In comparison, Canada's energy demand is expected to grow by 1.3 percent per year until 2020.[3]

Transportation and industry are expected to drive the growth in world energy demand (see Figure 1.2). In comparison, energy demand in Canada is projected to be more evenly distributed among the residential, commercial, transportation and industry sectors.

FIGURE 1.2: ENERGY DEMAND BY SECTOR



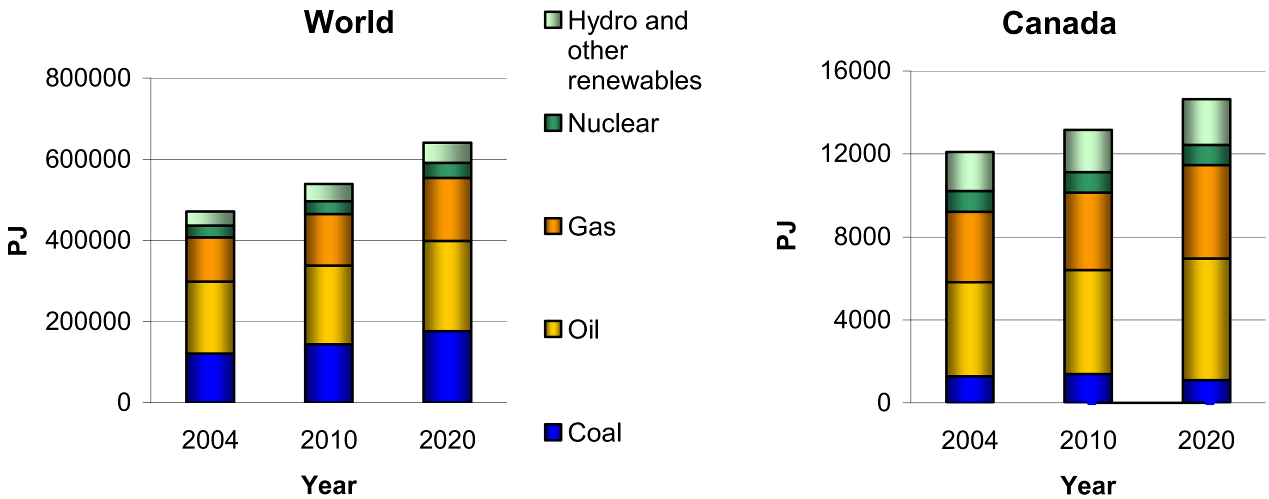
Sources:
EIA, *International Energy Outlook 2007*, Reference Case Projections, Table A2, http://www.eia.doe.gov/oiaf/ieo/pdf/ieorefcase.pdf .

Natural Resources Canada (NRCan), *Canada's Energy Outlook: The Reference Case 2006*, Table 12, p. 133.

In a business-as-usual scenario, the mix of energy types required to meet this increasing demand is projected to remain relatively unchanged. Fossil fuels (i.e. coal, oil and natural gas) will still be relied upon to provide most of the world's energy needs in the foreseeable future. In effect, as energy demand increases over the next two decades, fossil fuels are expected to supply about 90 percent of this growth (see Figure 1.3).

While all countries use energy, the distribution of energy resources is uneven around the world. According to the IEA, Canada is the sixth largest energy producer in the world, fifth when uranium is factored in (see Figure 1.4).

FIGURE 1.3: ENERGY DEMAND BY SOURCE

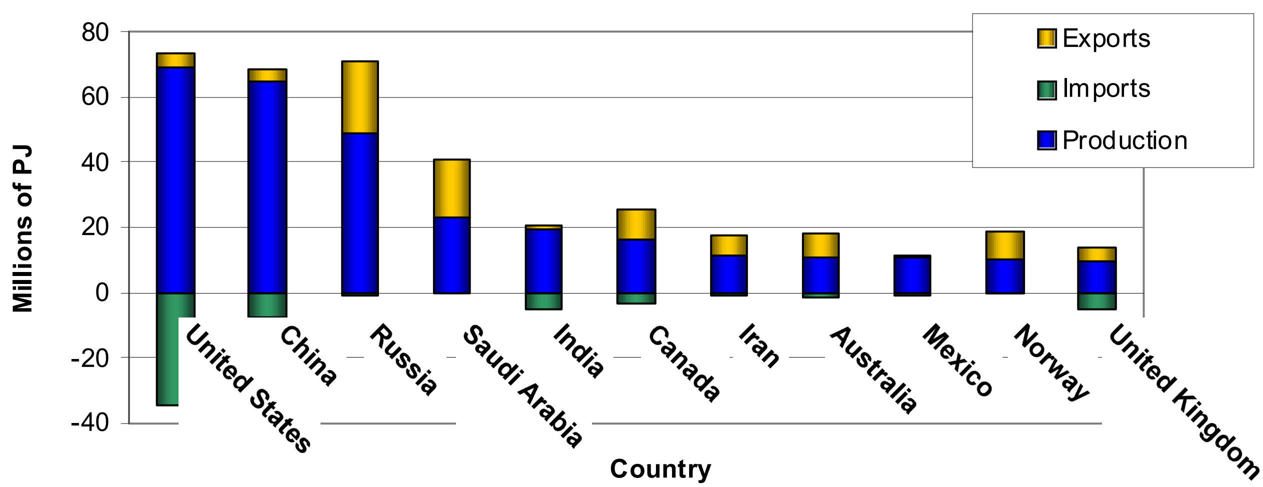


Sources:
EIA, *International Energy Outlook 2007*, Reference Case Projections, Table A2, www.eia.doe.gov/oiaf/ieo/pdf/ieorefcase.pdf .

NRCan, *Canada's Energy Outlook: The Reference Case 2006*, Table 15, p. 135.

Canada is also the sixth largest net exporter of energy.[4] Most of its exports are to the U.S. market because of geographical proximity and economic integration facilitated under the *North American Free Trade Agreement*. Under a business-as-usual scenario, Canada would remain the U.S.'s top foreign provider of gas and oil, accounting for 19 percent of American petroleum imports (up from today's 17 percent) and 33 percent of its natural gas imports (down from 88 percent).[5]

FIGURE 1.4: TOP PRODUCERS' ENERGY BALANCE, 2004



Source: IEA, 2007, http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Balances.

1.3. Primary Energy Resources

1.3.1. Oil

The world's proven reserves of oil are estimated at 1332 billion barrels. These reserves represent the equivalent of about 42 years of production at current rates. Oil reserves are unevenly distributed and increasingly concentrated in areas remote from the fastest-growing consuming centres – the Middle East alone holds 56 percent of the world's proven oil reserves.

With 178.6 billion barrels of oil, Canada has 13 percent of the world's proven oil reserves, second only to Saudi Arabia (see Table 1.1). About 97 percent of Canada's reserves are in the form of oil sands. Canada is the only country among the top seven reserve holders that is not a member of the Organization of the Petroleum Exporting Countries (OPEC).

Table 1.1: World's Top Proven Oil Reserves

Rank	Country	Barrels (in billions)	OPEC member
1	Saudi Arabia	266.8*	Yes
2	Canada	178.6	No
3	Iran	138.4	Yes
4	Iraq	115.0	Yes
5	Kuwait	104.0*	Yes
6	United Arab Emirates	97.8	Yes
7	Venezuela	87.0	Yes

Source: *Oil & Gas Journal*, vol. 105, issue 48 (December 24, 2007), pp. 24–25.

*Includes one half of the Saudi–Kuwaiti neutral zone, which has 5 billion barrels of reserves.

Oil is expected to continue to provide the largest share of the world's primary energy supply through to 2030.

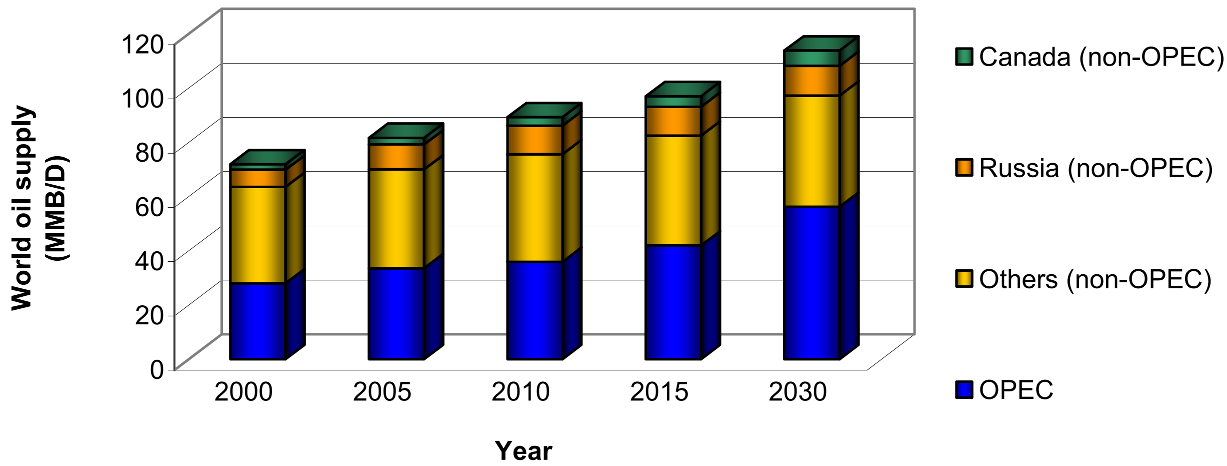
According to the IEA's *World Energy Outlook 2007*, oil demand is projected to grow slowly in OECD industrialized countries (0.5 percent demand growth expected through to 2030). The largest increase in oil demand is expected in developing economies, such as China and India, where demand will grow by an average of 2.6 percent through to 2030. Overall, world oil demand is expected to grow by 1.3 percent between 2005 and 2030.[6]

Oil production increases are expected in non-OECD regions, resulting in the growing influence of OPEC and former Soviet Union (FSU) countries over the markets. OPEC's share of world oil supply is expected to increase from 42 percent in 2006 to 52 percent by 2030 (see Figure 1.5). With its growing oil production and exports, Canada is an exception among OECD countries.

Between 2005 and 2030, Canada's oil sands production is projected to grow from 1 MMB/D to close to 5 MMB/D.[7] Producing about 5 percent of the world's oil supply by 2030, Canada is expected to remain a major net oil exporter. Canada is the world's seventh largest oil producer. According to the

National Energy Board, with growing oil sands production, Canada could become the world's fourth largest oil producer by 2015.

FIGURE 1.5: OPEC VERSUS NON-OPEC SHARE OF WORLD OIL SUPPLY



Sources:
IEA, *World Energy Outlook 2007*, Table 1.3, p. 82.

IEA, *World Energy Outlook 2006*, Table 3.2, pp. 92–93.

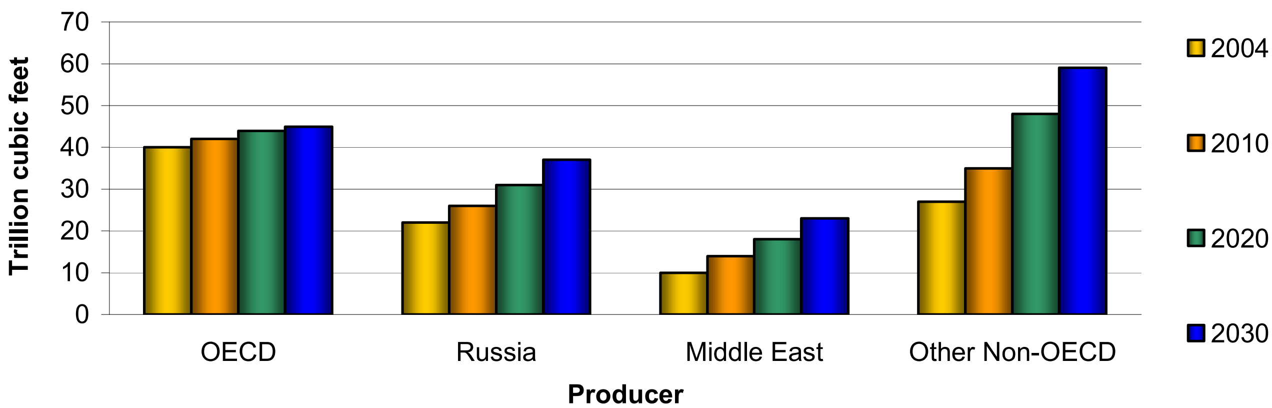
1.3.2. Natural gas

Natural gas reserves are plentiful in many areas of the world. But production has been limited, given the costs and physical constraints related to its transportation. Over the last decade, global demand for natural gas – cleaner than other hydrocarbons – has grown faster than for oil or coal. It is expected to grow more rapidly, reaching 26 percent of global energy demand by 2020 and 28 percent by 2030.[8]

Natural gas supply will not keep up with demand in OECD countries. The implication is that there will be a growing reliance on FSU and Middle East supplies, notably through the rapid development of a global liquefied natural gas (LNG) market (see Figure 1.6).

Canada's natural gas resources are much smaller than those of the FSU and Middle East countries. However, proximity to the U.S. energy market allowed a significant increase in production during the 1990s. Today Canada is the third largest producer and second largest exporter of natural gas in the world.

FIGURE 1.6: WORLD'S NATURAL GAS PRODUCTION



Source: Energy Information Agency (2007), *International Energy Outlook 2007*, http://www.eia.doe.gov/oiaf/ieo/excel/figure_45data.xls

1.3.3. Coal

Coal is the world's most abundant and widely distributed fossil fuel. It is second only to oil as an energy resource. And over the past few years, it has been the fastest growing fuel. The current proven world coal reserve is estimated at 1000 billion tonnes (t) spread over 70 countries.[9] Coal is expected to remain important despite its environmental shortcomings, particularly in such countries as China and India where oil reserves are inadequate to meet rapidly growing energy needs.

Canada has a large coal resource (see Table 1.2). A mid-sized producer, Canada has been an important supplier of metallurgical-grade coal to global markets.

TABLE 1.2: TOP 15 COAL-PRODUCING COUNTRIES, 2006

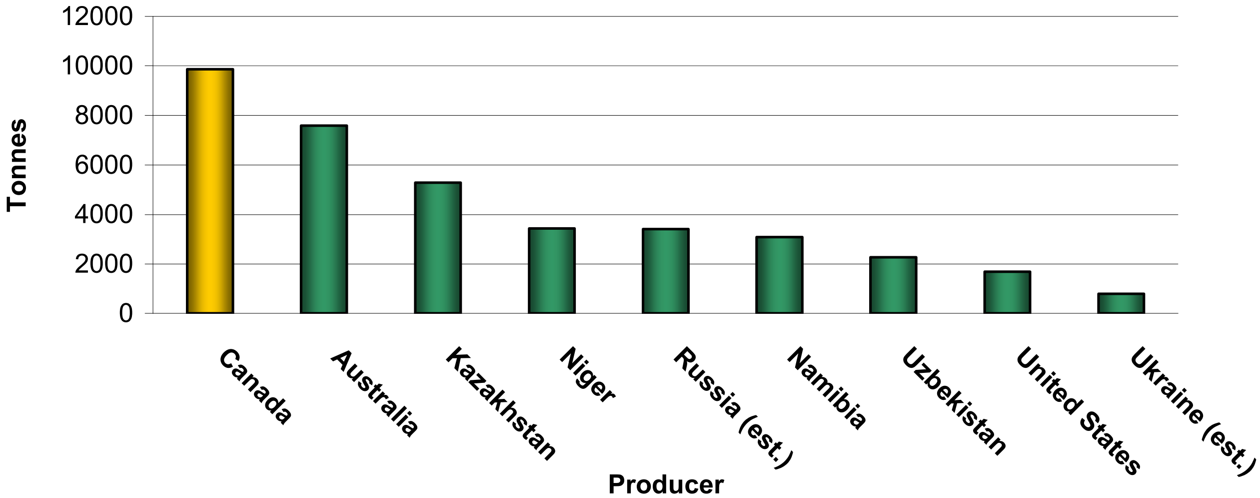
Country/area	Production (Mt)
China	2380
United States	1054
India	447
Australia	374
Russia	309
South Africa	257
Germany	197
Indonesia	195
Poland	156
Kazakhstan	96
Ukraine	81
Greece	71
Canada	**66**
Colombia	66
Turkey	63

Source: Natural Resources Canada (2007), Mineral and Metal Commodity Reviews, 2006 review of coal, page 20.1, available at http://www.nrcan-rncan.gc.ca/mms/cmy/com_e.html

1.3.4. Uranium

World production of uranium amounted to 39 655 t in 2006. Canada is the largest producer of uranium, providing one quarter of the world's production (see Figure 1.7). Its high-grade uranium reserves amount to 9 percent of the world's proven reserves.

FIGURE 1.7: URANIUM PRODUCTION, 2006



Source: World Nuclear Association, 2007, http://www.world-nuclear.org/info/inf23.html.

1.3.5. Nuclear energy

In 2005, nuclear power supplied 15 percent of the world's electricity.[10] The prospects for future nuclear development are more robust today than they have been for many years. According to recent international outlooks, the interest in building nuclear power reactors is increasing. For instance, the IEA forecasts a significant increase in the world's nuclear power capacity by 2030. Nuclear-generating capacity would increase from 368 GW in 2005 to between 416 and 519 GW in 2030. This increase would mean the construction of 50 to 150 new 1000-megawatt (MW) nuclear power reactors.

Higher fossil fuel prices, lower costs of new nuclear power reactors and concerns about energy supply security and greenhouse gas (GHG) emissions from fossil fuels are the main reasons for this renewed interest in nuclear energy.

Canada has developed the CANada Deuterium Uranium (CANDU) nuclear power generation technology. This technology uses heavy water as the moderator and coolant, and natural uranium as fuel. CANDU units have been constructed in North America, South America, Europe and Asia. There are 48 heavy water moderated reactors based on the CANDU design in operation, under construction or under refurbishment throughout the world.

1.3.6. Renewable energy

Worldwide, the energy supply from renewable sources (e.g. hydro, renewable combustibles and wastes, geothermal, wind, solar) is limited, compared with the supply from fossil fuels. Renewable energy represented 12.7 percent of total primary energy supply in the world in 2005. Most of this energy was in the form of combustible renewables and wastes.[11]

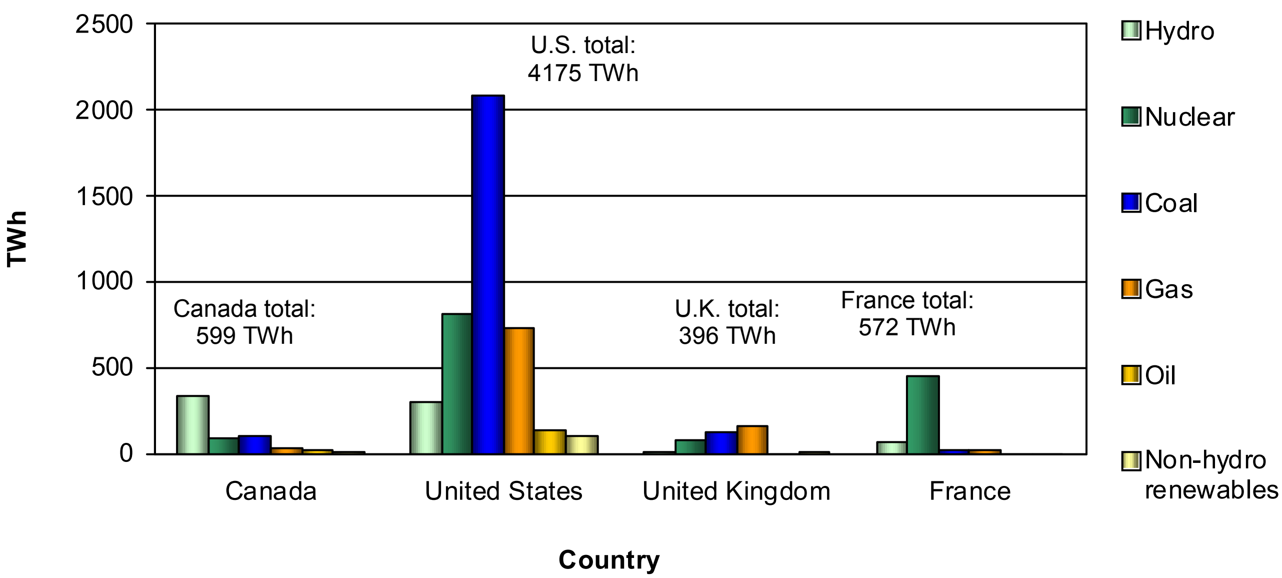
Canada is a leader in renewable energy, which represents 16.2 percent of its energy supply. Most of this renewable energy is produced in the form of hydroelectricity. Canada is the second largest producer of hydroelectricity worldwide, with more than 70 GW of installed capacity that accounts for 13 percent of the world's capacity.

Significant undeveloped potential remains in Canada. For example, four major hydro projects under consideration could amount to an additional 7.5 GW of capacity.[12] In addition, there is a corresponding opportunity to further leverage the economic potential of its hydroelectric storage. Due to its large land mass and lengthy coastline, Canada could significantly expand the use of some renewable energy resources, such as wind, bioenergy and ocean energy.

1.3.7. Electricity mix

The mix of energy resources that contributes to the electricity supply (the "electricity mix") varies from one country to another. This variation is based on resource availability and policy decisions. In Canada, hydroelectricity dominates the electricity mix, which also includes sizeable contributions from coal and nuclear (see Figure 1.8). In the United States, however, coal is the dominant resource; in France, nuclear dominates. In the United Kingdom, there is no dominant resource, as contributions are made from a variety of resources.

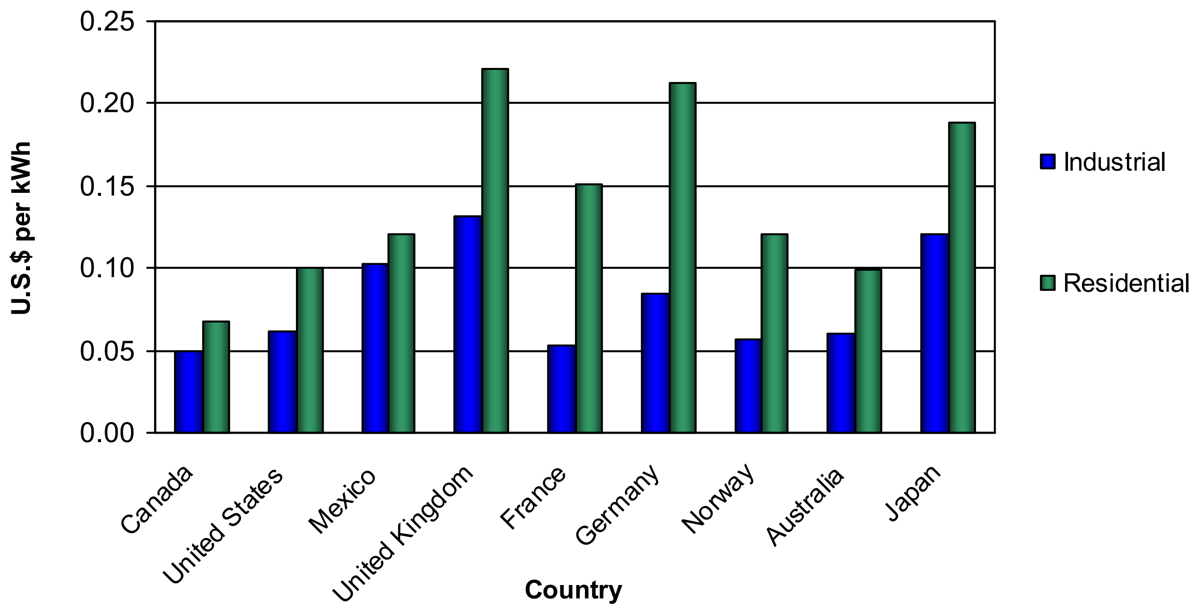
FIGURE 1.8: GROSS ELECTRICITY GENERATION BY SOURCE, SELECTED COUNTRIES, 2004



Source: IEA, 2007, http://www.iea.org/Textbase/stats/index.asp.

Electricity prices also vary substantially from country to country, again due to resource availability and policy decisions. Thanks to its extensive low-cost hydro resources, Canada has some of the lowest electricity rates in the developed world (see Figure 1.9).

FIGURE 1.9: ELECTRICITY RATES, COUNTRY COMPARISON, 2005

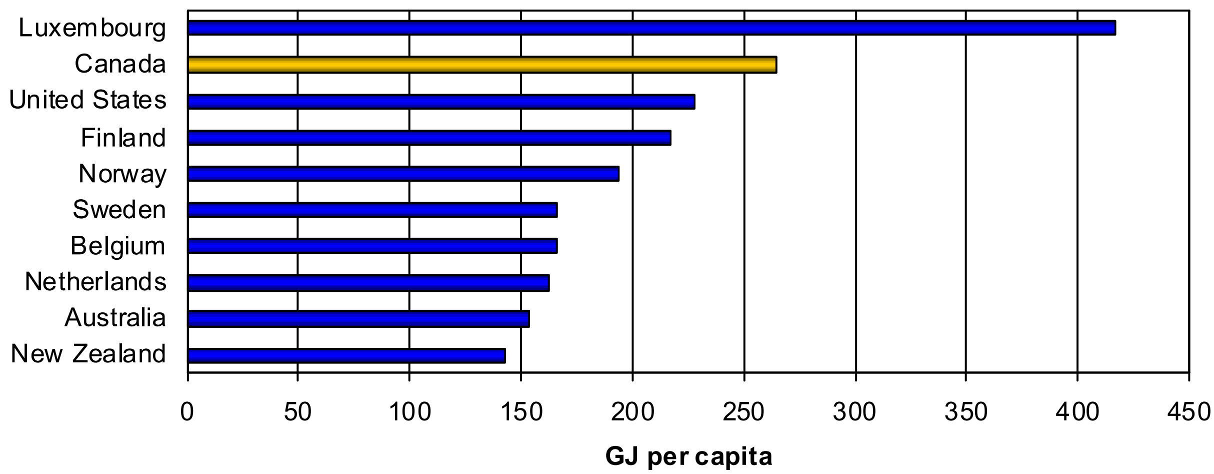


Source: IEA, Key World Energy Statistics 2007, pp. 42–43, available at: http://www.iea.org/textbase/nppdf/free/2007/key_stats_2007.pdf

1.4. SECONDARY ENERGY USE

In 2004, Canada used more energy per person than most IEA member countries. Second to Luxembourg's rate, Canada's 264-gigajoule (GJ) per capita rate was only slightly higher than that of the United States (see Figure 1.10).

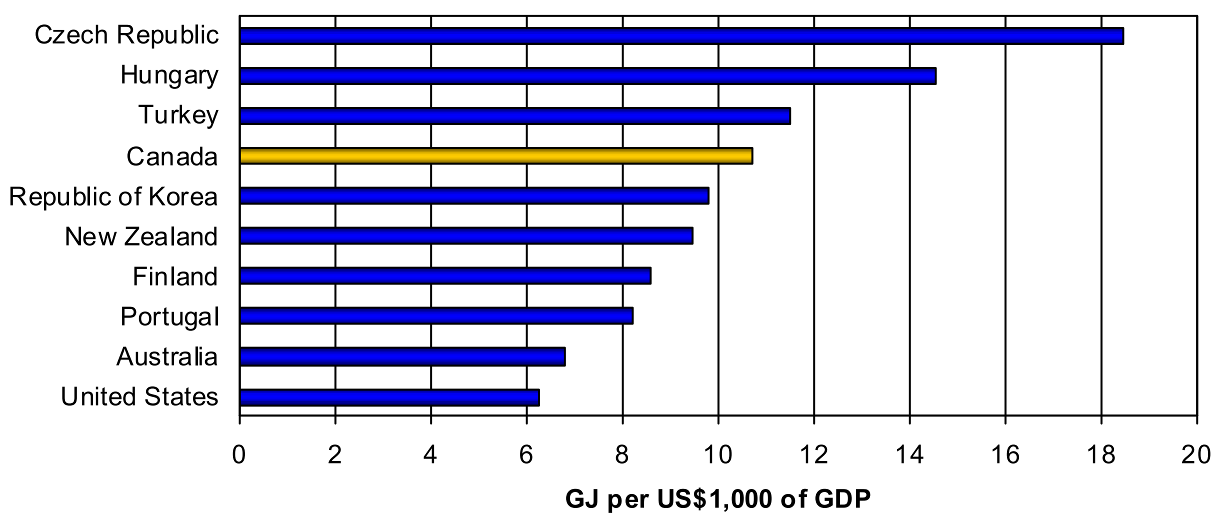
FIGURE 1.10: ENERGY INTENSITY FOR SELECTED IEA COUNTRIES, 2004



Source: IEA, Energy Balances of OECD Countries (2007), http://www.iea.org/Textbase/country/index.asp.

When energy intensity was calculated using gross domestic product (GDP) (in 2000 U.S. dollars), Canada had the fourth highest energy intensity among the IEA countries. Again, it had a higher energy intensity than the United States (see Figure 1.11).

FIGURE 1.11: ENERGY INTENSITY FOR SELECTED IEA COUNTRIES (IN 2000 U.S. DOLLARS)

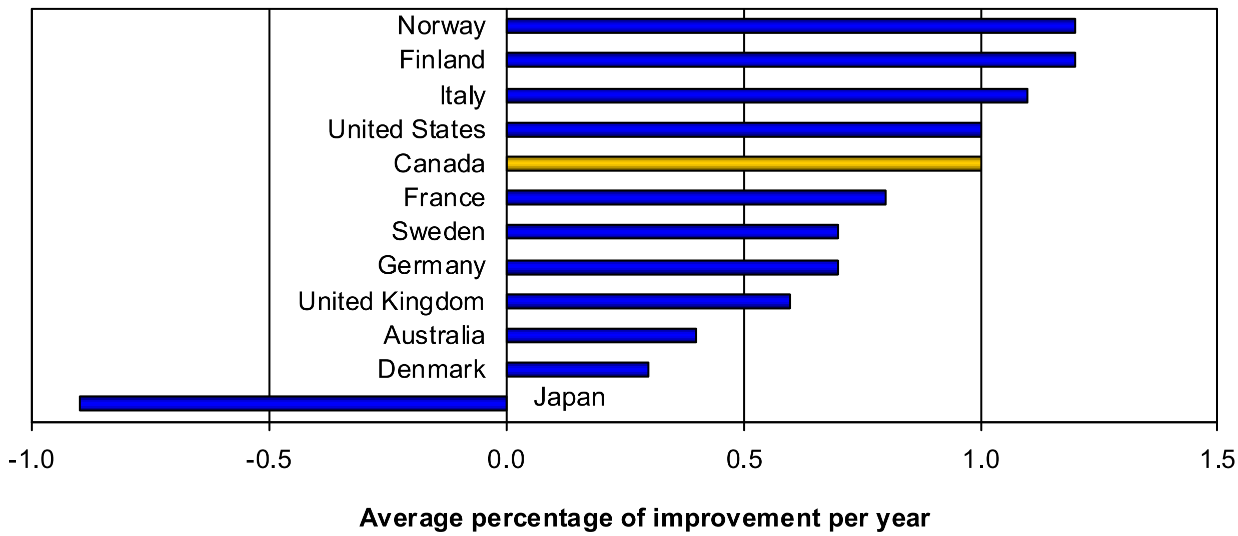


Source: IEA, Energy Balances of OECD Countries (2007), http://www.iea.org/Textbase/country/index.asp.

Canada’s high energy intensity is mainly due to national circumstances, such as a cold climate, long distances, an energy-intensive industrial structure and a high standard of living. When these circumstances are considered, Canada's energy intensity is comparable with that of other IEA countries, and Canada's improvements in energy intensity rank well.

Across all sectors of the economy, Canada’s energy intensity improved by an average of 1 percent per year between 1990 and 1998 (see Figure 1.12). When compared with IEA countries for which there are data, Canada’s rate of improvement came in fourth – behind Finland, Norway and Italy – matching rates of improvement in the United States.[13]

FIGURE 1.12: ENERGY INTENSITY IMPROVEMENTS FOR SELECTED IEA COUNTRIES, 1990–1998



Source: IEA, *Oil Crises & Climate Challenges: 30 Years of Energy Use in IEA Countries* (2004), Table A6, p. 210.

The commercial/institutional and residential sectors have made the largest improvements. Canada’s energy intensity has improved on average by 1.7 percent per year in the residential sector, ranking third out of 12 IEA countries. Canada ranks sixth in the commercial/institutional sector, with an average annual improvement of 1.4 percent.

The transportation sector is split into freight and passenger transportation. Improvements in freight transportation efficiency put Canada fifth, with an average annual rate of 1 percent. Passenger transportation has the smallest rate of improvement of all sectors. Canada ranks eighth among the IEA countries, with an average annual improvement of 0.2 percent.

Canada has an energy intensive industrial sector, yet energy intensity has been declining by approximately 0.8 percent per year. Among the IEA countries, Canada places fourth, behind Finland, Germany and Italy.

CHAPTER 2: ENERGY AND THE CANADIAN ECONOMY

2.1. CHAPTER SUMMARY

- Energy is an important sector of the Canadian economy. It accounted for 7.2 percent of total Canadian gross domestic product (GDP) in 2006.

- The energy sector is a source of well-paying jobs for Canadians.

  - It employed some 273 000 people in 2006, representing 1.9 percent of total Canadian employment.
  - In 2006, average wages and salaries in the energy sector were 73.1 percent higher than the national average.

- Energy products are key contributors to Canada's merchandise trade.

  - In 2006, Canada exported nearly $91 billion in energy products. Total energy exports now represent 20.7 percent of all Canadian merchandise exports.
  - Canada is a net exporter of energy products. The energy sector's $53.6-billion trade surplus in 2006 remains a key contributor to Canada's overall merchandise trade surplus.

- The energy sector is capital intensive, providing economic stimulation to other industries, such as construction and manufacturing. In 2005, it accounted for 20 percent of all capital investment and repair expenditures throughout Canada's economy.

- The cost of energy, which has been rising in recent years, affects other segments of the Canadian economy.

  - Energy costs as a percentage of total costs (excluding capital costs) are just under the 4 percent mark for the manufacturing sector. For energy-intensive industries, however, the share is much higher.
  - In 2006, the average Canadian household spent 9.6 percent of its disposable income on energy, compared with 8.8 percent in 1997.

- Governments receive significant revenues from energy. For instance, revenues from federal, provincial and territorial income tax on the energy sector amounted to $7.25 billion in 2005. That amount represented more than 15 percent of income tax paid by all corporations that year.

2.2. Introduction

Energy has a profound impact on the performance of the Canadian economy. This impact arises from direct economic contribution (by the energy sector), indirect contribution (by industries that serve the energy sector) or tertiary contributions (by industries that are not related to the energy sector but are intensive users of energy in their production processes).

The energy sector is important to the Canadian economy as a source of employment, wealth creation and government revenues; as a destination for investment; and for its contribution to a positive net trade balance.

The energy sector is typically defined as the collection of the following industries as classified by the North American Industry Classification System (NAICS) 2007:[14]

- Oil and gas extraction (NAICS 211)
- Coal mining (NAICS 2121)
- Other metal ore mining (NAICS 21229)
- Support activities for mining and oil and gas extraction (NAICS 213)
- Electric power generation, transmission and distribution (NAICS 2211)
- Natural gas distribution (NAICS 2212)
- Petroleum refineries (NAICS 32411)
- Other petroleum and coal product manufacturing (NAICS 32419)
- Pipeline transportation (NAICS 486)

For this analysis, unless otherwise noted, “energy sector” refers to a slightly modified version of the “typical” definition due to data limitations.[15]

As well, the energy sector requires specialized machinery, equipment, steel pipes, and other goods and services that are unique to the energy sector and are provided by other sectors. The economic contribution of these industries on the Canadian economy (e.g. in terms of GDP, employment) is not captured in this definition of energy sector. Instead, much of this economic activity is captured in other sectors of the economy, such as construction, manufacturing and transportation.[16]

2.3. ENERGY SECTOR'S CONTRIBUTION TO THE CANADIAN ECONOMY

2.3.1. Gross domestic product

GDP (measured in 2002 constant prices)[17] in the energy sector has been growing at an annual rate of 1.1 percent per year since 1997. It reached $86.4 billion (in 2002 dollars) in 2006 (see Table 2.1). The oil and gas extraction ($41.8 billion) and the electric power generation, transmission and distribution ($25.1 billion) industries were the largest contributors to output in this sector. Despite this modest growth, the energy sector's share of Canadian economic output has slipped slightly. It accounted for 7.2 percent of Canadian GDP in 2006.

2.3.2. Employment

Canada's energy sector employed some 273 000 people in 2006, representing 1.9 percent of Canadian employment.[18] Growth in employment in the sector averaged 3.2 percent per annum over 1997–2006 compared with 2.1 percent employment growth across the Canadian economy.

With more than 94 000 employees in 2006, the electric power generation, transmission and distribution industry led all energy sector industries in total employment. Employment in the support activities for mining and oil and gas extraction industry reached 82 150 in 2006 – more than double its employment level of nearly 40 200 in 1997. This translates into a compound annual growth rate (CAGR) of 13.6 percent over 1997–2006.

TABLE 2.1: ENERGY SECTOR GDP AND EMPLOYMENT BY INDUSTRY, CANADA, 2006

NAICS code	Industry	GDP (in millions of 2002 dollars)	Employment
211	Oil and gas extraction	41,832	49 670
2121	Coal mining	891	5 458
213	Support activities for mining and oil and gas extraction	6,397	82 159
2211	Electric power generation, transmission and distribution	25,126	94 062
2212	Natural gas distribution	3,120	14 497
324	Petroleum and coal product manufacturing	3,450	22 608
486	Pipeline transportation	5,617	4 661
	Total energy sector	**86,433**	**273 115**
	All industries	1,195,470	14 041 306
	Energy-sector share	7.2%	1.9%

Source: Statistics Canada, Canadian Socio-Economic Information Management System (CANSIM) database (2007), Table 281-0024 and Table 281-0027.

2.3.3. Wages and salaries

The energy sector is a source of highly paid jobs. In 2006, average wages and salaries in Canada's energy sector were 73.1 percent higher than the national average.[19,20] Moreover, wages and salaries in the sector have been growing at a faster rate than those in the economy as a whole. Since 1997, average wages and salaries in the energy sector have grown at a CAGR of 2.6 percent, compared with 2.0 percent growth for the entire economy over the same period. In 2006, wages and salaries in the energy sector grew by 3.3 percent, compared with a growth of 3.0 percent across all industries.

Historically (since 1997) workers in the oil and gas extraction industry were, on average, the best paid among energy sector workers. This was still the case in 2006 where, on average, these workers earned 25 percent more than the average worker in the energy sector and nearly 2.2 times more than the average Canadian worker.

2.3.4. Trade in energy products

Exports

In 2006, Canada exported more than $91 billion in energy products – a decrease of 0.9 percent from the previous year (see Table 2.2).[21] Total energy exports now represent 20.9 percent of Canadian merchandise exports. Exports of crude oil and natural gas account for 71.7 percent of all energy exports. Each of these products experienced double-digit annual growth rates (14.3 percent and 17.2 percent respectively) over 1997–2006.

Imports

Total imports of energy products reached $37.2 billion in 2006 – a 4.1 percent increase from 2005. In 2006, imports of crude oil represented 62.6 percent of total imports of energy products and 5.9 percent of total Canadian merchandise imports.

Trade balance

Canada is a net exporter of energy products. Since 1997, it has consistently been running a positive trade surplus in total energy products. Despite a 4.1 percent decline from 2005, the energy sector's $54.5-billion trade surplus in 2006 remained a key contributor to Canada's merchandise trade surplus. In absolute terms, natural gas recorded the largest surplus, at $25.5 billion, whereas Canada's trade surplus in crude oil witnessed the energy sector's largest year-over-year growth (up 83.1 percent from 2005).

TABLE 2.2: TRADE IN ENERGY PRODUCTS, CANADA, 2006

Product	Exports (in millions of dollars)	Imports (in millions of dollars)	Balance (in millions of dollars)
Coal	3,321	1,290	2,031
Coal products	357	116	241
Refined petroleum products	14,688	8,204	6,484
Crude oil	37,955	23,316	14,639
Electricity	2,493	1,177	1,316
Uranium	2,170	440	1,730
Liquid petroleum gases	2,973	339	2,634
Natural gas	27,798	2,351	25,447
Total energy products	**91,755**	**37,233**	**54,622**
Total merchandise	439,545	396,443	43,102
Energy products' share of merchandise	20.9%	9.4%	126.7%

Source: Natural Resources Canada (NRCan), Trade Retrieval and Aggregation System (TRAGS) (2007), based on Statistics Canada, *Canadian International Merchandise Trade*, Cat. No. 65-001-XIB.

2.3.5. Capital and repair expenditures

Canada's energy sector is capital intensive, providing economic stimulation to other industries, such as construction and manufacturing. [22] In 2005, the sector spent $65.6 billion in total capital and repair expenditures – a 24.6 percent increase from 2004 (see Table 2.3). By contrast, total capital and repair expenditures for the Canadian economy increased by 8.7 percent from 2004. In 2005, Canada's energy sector accounted for 20 percent of all such expenditures throughout the entire economy. Capital and repair expenditures in the sector increased at a CAGR of 9.5 percent between 1997 and 2005, compared with 5.9 percent for the economy as a whole.

The oil and gas extraction industry was responsible for two thirds of all capital and repair expenditures in the energy sector in 2005. At the same time, the electric power generation, transmission and distribution industry accounted for another 19 percent of the sector's expenditures. Within the oil and gas extraction industry, more than one third of the capital expenditures was directed toward conventional developmental drilling in 2005. For oil sands activities (non-conventional extraction), expenditures on in-situ capital more than doubled between 2004 and 2005. They accounted for nearly 10 percent of all capital expenditures within this industry.

Capital construction accounts for the largest share (68.5 percent) of all capital and repair expenditures in the energy sector. In 2005, the sector invested $45 billion in capital construction, a 27.5 percent increase from the previous year.

TABLE 2.3: CAPITAL AND REPAIR EXPENDITURES BY THE ENERGY SECTOR, CANADA, 2005

NAICS code	Industry	Capital expenditures (in millions of dollars)	Repair expenditures (in millions of dollars)	Total capital and repair expenditures (in millions of dollars)
211	Oil and gas extraction	42,047.9	1,807.5	43,855.5
2121	Coal mining	605.9	n/a	n/a
213	Support activities for mining and oil and gas extraction	2,681.8	666.8	3,348.6
2211	Electric power generation, transmission and distribution	9,814.1	2,629.8	12,443.9
2212	Natural gas distribution	1,158.2	134.8	1,293.0
324	Petroleum and coal product manufacturing	2,759.3	663.9	3,423.2
486	Pipeline transportation	838.5	443.2	1,281.7
	Total energy	**59,905.7**	**6,346.0**	**65,645.9**
	All industries	273,225.3	54,306.0	327,531.3
	Energy-sector share	21.9%	11.7%	20.0%

Source: Statistics Canada, CANSIM database (2007), Table 029-0007.

2.4. Role of Energy in the Rest of the Economy

The recent rise in commodity prices has clearly been beneficial to oil and gas producers. But it has had a negative effect on other segments of the economy. Certain energy-intensive industries have been particularly affected by the recent increases in fuel costs. These industries include the following:

- Pulp, paper and paperboard mills (NAICS 3221)
- Iron and steel mills and ferro-alloy manufacturing (NAICS 3311)
- Alumina and aluminum production and processing + Non-ferrous metal (except aluminum) production and processing (NAICS 3313+ 3314)
- Chemical manufacturing (NAICS 325)

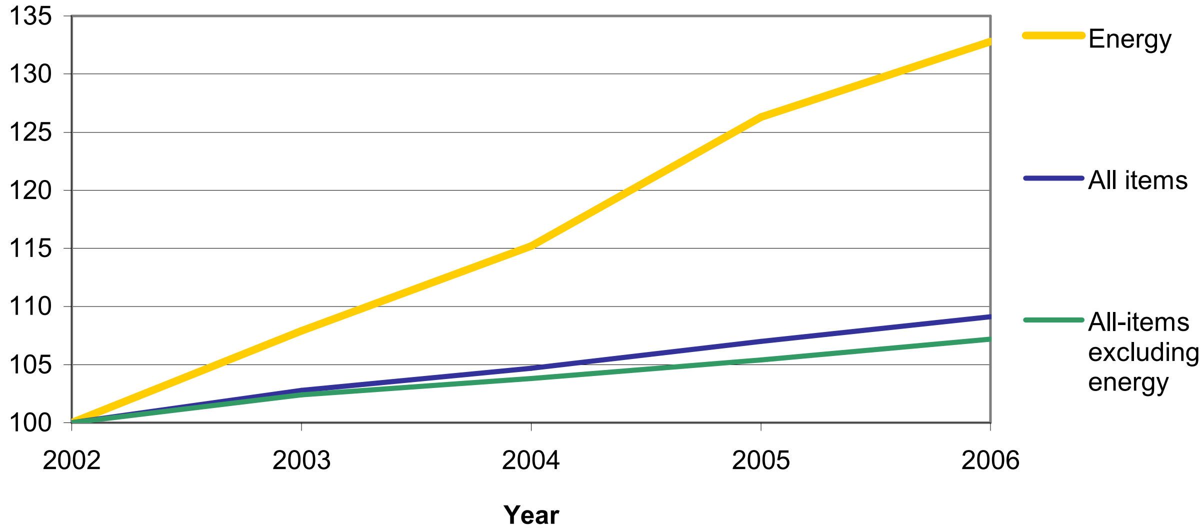
Between 1997 and 2003, energy costs as a percentage of total costs (excluding capital costs) hovered at 3 percent for the manufacturing sector. Between 2003 and 2005, energy costs as a percentage of total costs increased, approaching 4 percent in 2005. For the energy-intensive industries (listed above), energy costs as a share of total costs for manufacturing activities are higher. In general, over 1997–2003, energy costs grew. For example, in 2003, this share was 17.6 percent in the pulp, paper and paperboard mills industry and 12.6 percent in the iron and steel and ferro-alloy manufacturing industry.[23]

Between 2003 and 2005, energy costs as a percentage of total costs for these energy-intensive industries increased at a faster rate than those for the manufacturing sector. With the exception of the iron and steel and ferro-alloy manufacturing industry, the share of energy costs increased by roughly 1.5 percentage points for all other energy-intensive industries in this period.

Recent increases in energy costs are also having an impact on consumers. Between 2002 and 2006, the energy price index increased by nearly 33 percent (see Figure 2.1). Although energy carries a weight of roughly 9 percent of the total consumer price index (CPI), its strong growth over 2002–2006 resulted in a total CPI that is nearly 2 percentage points higher than the CPI that excludes energy.[24]

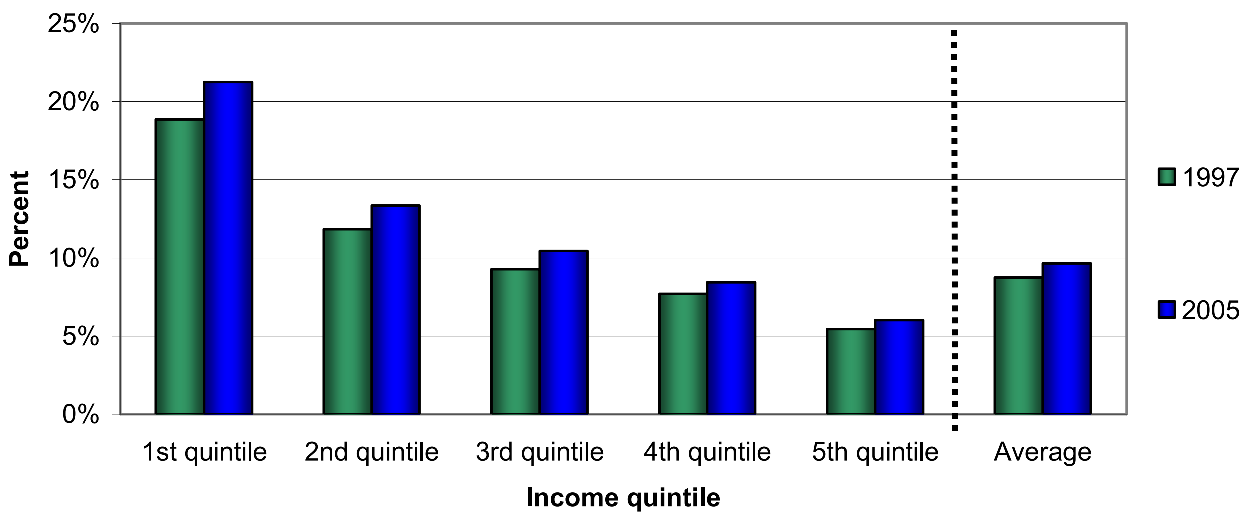
In 2005, the bottom 20 percent (i.e. the first quintile) of Canadian households (in terms of total household income) spent more than 21.3 percent of their disposable income on heating and lighting their homes and on fuels for transportation (up from 18.9 percent in 1997) (see Figure 2.2).[25] The average household spent 9.6 percent of its disposable income on energy, compared with 8.8 percent in 1997. Higher prices for energy products reduce the purchasing power for consumers, thus reducing growth in real consumer spending.

FIGURE 2.1: GROWTH OF THE CONSUMER PRICE INDEX
(2002 = 100)



Source: Statistics Canada, CANSIM database (2007), Table 326-0021.

FIGURE 2.2: PERCENTAGE OF DISPOSABLE INCOME SPENT ON ENERGY



Source: Statistics Canada, Detailed Average Household Expenditure by Household Income Quintile for Canada and Provinces, (Cat. No. 62F0032XDB).

2.4.1. Government revenues and expenditures

Government revenues from federal, provincial and territorial income tax on the energy sector were $7.25 billion in 2005 (see Table 2.4). That amount represented more than 15 percent of federal, provincial and territorial income tax paid by all corporations that year. In 2001, federal, provincial and territorial income tax receipts from the energy sector were $4 billion, representing 11 percent of total corporate income taxes paid. Between 2001 and 2005, the $3-billion increase in corporate income taxes paid by the energy sector accounted for about 30 percent of the increase in total corporate taxes.

TABLE 2.4: ENERGY SECTOR: FEDERAL, PROVINCIAL AND TERRITORIAL CORPORATE INCOME TAXES, ROYALTIES AND LAND SALES

Industry	2001	2002	2003	2004	2005
	millions of dollars				
Oil and gas extraction and support activities					
Federal income tax	967	1,055	1,180	2,504	2,598
Provincial/territorial income tax	441	488	444	1,034	1,151
Total income tax	1,408	1,542	1,625	3,538	3,749
Royalties and land sales	14,485	9,435	12,994	14,246	19,894
Total income tax and royalties	15,893	10,997	14,619	17,884	23,643
Petroleum and coal products manufacturing					
Federal income tax	1,347	1,244	724	1,179	1,596
Provincial/territorial income tax	676	532	329	463	724
Total income tax	2,023	1,777	1,053	1,642	2,321
Utilities					
Federal income tax	214	568	554	451	350
Provincial/territorial income tax	96	238	205	227	173
Total income tax	311	807	758	678	522
Pipelines					
Federal income tax	194	298	316	356	431
Provincial/territorial income tax	88	134	127	196	227
Total income tax	283	431	444	553	658
Total energy sector					
Federal income tax	2,722	3,165	2,774	4,490	4,975
Provincial/territorial income tax	1,301	1,392	1,105	1,920	2,275
Total income tax	**4,023**	**4,557**	**3,880**	**6,411**	**7,250**
Royalties and land sales	14,485	9,435	12,994	14,246	19,894
Total corporate taxes, royalties and land sales	**18,510**	**13,992**	**16,874**	**20,757**	**27,144**
Total all industries					
Federal income tax	24,174	24,091	28,000	31,433	31,489
Provincial/territorial income tax	11,469	11,060	11,703	14,288	15,003
Total income tax	**35,643**	**35,151**	**39,703**	**45,722**	**46,492**

Sources:
Statistics Canada, *Oil & Gas Extraction* (2006), (Cat. No. 26-213), for royalties and crown land sales data.

Statistics Canada, *Financial and Taxation Statistics for Enterprises 2005* (2007), (Cat. No. 61-219), for federal, provincial and territorial income tax data.

Income taxes are profit based. Rising corporate income taxes paid by the energy sector reflect growing profits in the sector. The energy sector's operating profits rose from $39 billion in 2001 to $59 billion in 2005. In 2005, of the top five industries ranked by operating profits, energy industries accounted for three of them – oil and gas extraction and support activities, utilities, and petroleum and coal products manufacturing.

Royalties and land sales are an important source of revenue for governments. In 2005, the oil and gas industry paid nearly $20 billion in royalties and land sales. Royalty payments are subject to large swings, e.g. in 2002, the oil and gas industry paid $9.4 billion in royalties – a 30 percent drop from the previous year.

Governments also receive energy-related revenues through other means, including dividends from Crown-owned electric utilities, and sales and excise taxes.

Governments also incur expenditures that benefit the energy sector. These expenditures include direct spending on government programs and energy-related tax incentives and spending on broad areas of government activities, such as public infrastructure, human resources development, education, health care and international relations.

Following is an overview of the federal corporate income tax system, including special features that apply to energy.

2.4.2. Federal corporate income tax for energy

Federal corporate income taxes are determined by applying the applicable tax rate to taxable income calculated according to the *Income Tax Act.* Income tax rules broadly follow generally accepted accounting principles. Assets are placed in specific capital cost allowance (CCA) classes. These classes specify the rate at which the asset may be deducted. In general, CCA rates reflect the economic life of the assets in that CCA class.

Some features of the tax system promote certain types of activity. The Scientific Research and Experimental Development Tax Incentive Program provides a tax credit for qualifying research and development (R&D) spending, and a number of energy industries are important users of this program. And the Atlantic investment tax credit promotes investment in Atlantic Canada. Several energy production activities qualify for this credit, although oil-and-gas exploration and development and pipeline expenses do not.

Specific features

A number of specific income tax measures apply to energy industries.

The oil and gas sector has specific provisions (reflecting the special characteristics of the industry). It can deduct exploration, development and oil-and-gas property expenses. Oil and gas exploration and development expenses are also eligible for flow-through share treatment, whereby a corporation can flow out the eligible deductions to an investor. This tax treatment is designed to help small exploration companies raise capital.

In recent years, the tax treatment of the oil and gas sector has been undergoing fundamental reforms. Royalties are now fully deductible, and the resource allowance, a special deduction permitted in lieu of royalty deductibility, has been phased out. As well, corporate tax rates for the oil and gas sector, which had been higher than those for other industries, have been brought into line with the general corporate rate. Finally, the accelerated CCA for oil sands mining and in situ projects, which permitted companies a fast write-off of certain kinds of assets, will be phased out, as announced in Budget 2007.

The tax treatment of electricity-generating equipment has also undergone important changes. CCA rates have been increased to better reflect the economic life of the different assets. Also, a range of renewable energy and energy conservation equipment has been given an accelerated deduction – to encourage clean energy production and to contribute to the government's economic and environmental objectives.

Moreover, a new category of expense was introduced in the 1996 budget to make the tax treatment of certain types of renewable and conservation expenses more consistent with oil-and-gas exploration expenses. Included in this category are intangible expenses associated with developing such projects as wind farms, small-scale hydroelectric installations and co-generation systems (e.g. for process engineering, right of access to the project site, test wind turbines). These expenses are immediately deductible and are also eligible for flow-through shares.

2.4.3. Federal energy programming

Following is an overview of energy-related federal programming.

The Government of Canada is responsible for the interprovincial/inter-territorial and international movements of energy and energy goods, resource management on frontier lands, and uranium and nuclear power. It is also concerned with energy matters on policies of national interest, such as economic development and security. The government has actively promoted energy efficiency and alternative energy since the energy crises of the 1970s. Over time, the policy rationale for federal involvement in these areas has expanded to include trans-boundary environmental concerns, principally climate change.

To address its responsibilities, the Government of Canada has used legislative and regulatory instruments. For instance, it set up regulatory boards (e.g. the National Energy Board, the Canadian Nuclear Safety Commission), created Atomic Energy Canada Limited and enacted the *Energy Efficiency Act*. The Act allows the government to regulate the efficiency of energy-using equipment and appliances. More recently, the Government of Canada announced its intention to regulate greenhouse gas (GHG) emissions and air pollutants from large industrial emitters, including the energy sector.

The Government of Canada also invested in various targeted energy programs. For instance, the long-standing Program of Energy Research and Development (PERD) provides funding for R&D aimed at ensuring a sustainable energy future for Canada. Through PERD, funds are allocated to 13 federal departments and agencies. In turn, these organizations support energy R&D activities in federal laboratories, the private sector, associations, universities and provincial and territorial research organizations. And Natural Resources Canada's CANMET Energy Technology Centre is a major R&D performer. It develops and delivers knowledge and technology-based programs for sustainable energy production and use through its facilities in Varennes, Qc.; Ottawa, On.; and Devon, Ab.

The Government of Canada is pursuing an integrated strategy to address climate change and air pollution through its Clean Air Agenda. The centrepiece of this approach is mandatory national regulation of greenhouse gas (GHG) and air pollutant emissions from major sources – industry, transportation, and consumer and commercial products. To complement its regulatory framework, the government has also introduced a series of measures to help Canadians use energy more efficiently, boost renewable energy supplies, and develop cleaner technologies. A number of these programs are being delivered by Natural Resources Canada under the ecoENERGY banner.

The ecoENERGY Efficiency Initiative promotes smarter energy use. It supports energy efficiency improvements in homes, small buildings and industry. It includes three program components:

- ecoENERGY for Buildings and Houses encourages the construction, operation and retrofit of more energy-efficient houses and buildings through a range of complementary activities, such as rating, labelling and training.

- ecoENERGY Retrofit provides direct incentives to homeowners and small and medium-sized businesses to invest in energy efficiency retrofits.

- ecoENERGY for Industry encourages the accelerated uptake of energy-saving investments by Canadian industry. It promotes the transfer of knowledge, new technologies and best practices.

The ecoENERGY Technology Initiative funds research, development and demonstration of next-generation clean energy technologies. These technologies are needed to reduce the emissions from energy production and use.

The ecoENERGY Renewable Initiative supports electricity and heat production from renewable sources through two program components:

- ecoENERGY for Renewable Power offers an incentive on the production of electricity from renewable sources to stimulate up to 4000 megawatts of renewable power. Eligible sources include wind, solar and biomass power.

- ecoENERGY for Renewable Heat supports the increased use of renewable energy technologies in space heating and cooling and water heating in residential and commercial buildings.

In addition, the government is delivering the ecoTRANSPORT Strategy which includes a series of initiatives designed to reduce the environmental impacts of transportation and secure Canada's future prosperity and competitiveness, by making the transportation system more sustainable, both economically and environmentally.

- ecoENERGY for Personal Vehicles gives consumers information on fuel consumption and decision-making tools, such as vehicle labels, guides and information, to encourage more fuel-efficient buying, driving and maintenance practices.

- ecoENERGY for Fleets introduces fleets to energy-efficient practices that can reduce fuel consumption and emissions.

- ecoAUTO Rebate Program gives Canadians rebates on the purchase of more fuel-efficient vehicles (available on 2006, 2007 and 2008 model year vehicles bought by December 31, 2008). The ecoAUTO Rebate Program is part of the Vehicle Efficiency Incentive (VEI).The VEI includes a performance-based fee on the most fuel-inefficient vehicles available in Canada.

For 2011 model-year vehicles, the government is developing fuel consumption regulations that are benchmarked against a stringent, dominant North American standard. The federal commitment is to develop made-in-Canada standards that will achieve, at a minimum, the U.S. goal of 35 miles per gallon – or 6.7 litres per 100 kilometres – for the average fuel economy of vehicles sold in 2020.

As well, the Government of Canada announced a $2-billion Renewable Fuels Strategy. Regulations will require a 5 percent renewable fuel content based on the gasoline pool by 2010 and a 2 percent renewable fuel content in diesel fuel and heating oil by 2012. The strategy also includes three program components:

- ecoENERGY for Biofuels offers an incentive for producing renewable alternatives to gasoline and diesel.
- ecoAGRICULTURE Biofuels Capital (ecoABC) provides a capital incentive for renewable fuels' facilities owned by farmers.
- Sustainable Development Technology Canada is receiving funding for the NextGen Biofuels Fund. This fund supports the large-scale demonstration of production facilities for next-generation renewable fuels.

A $1.5 billion clean air and climate change trust fund supports provincial and territorial projects for reducing GHG and CAC emissions, including projects directly related to energy efficiency and the development and deployment of clean energy technologies.

In Budget 2008, the Government of Canada announced additional energy investments, including $250 million for carbon capture and storage in the coal-fired electricity sector and $300 million for nuclear energy.

CHAPTER 3: CANADA'S PRIMARY ENERGY RESOURCES

Canada's primary energy resources are well studied, and information is readily available. Below is quantitative information on such aspects as reserves, production, exports, imports, consumption, prices and outlook for each resource.[26] There is also information on emerging sources, such as solar, geothermal and wind energy. Bioenergy is considered in its various forms (e.g. round wood, agricultural commodities) and as by-products from non-energy activities (e.g. wood waste, pulping liquor and municipal solid waste). However, information on emerging sources and biomass is less readily available than that for primary sources. (For resources supporting electricity generation, additional information can be found in Chapter 4, "Electricity.")

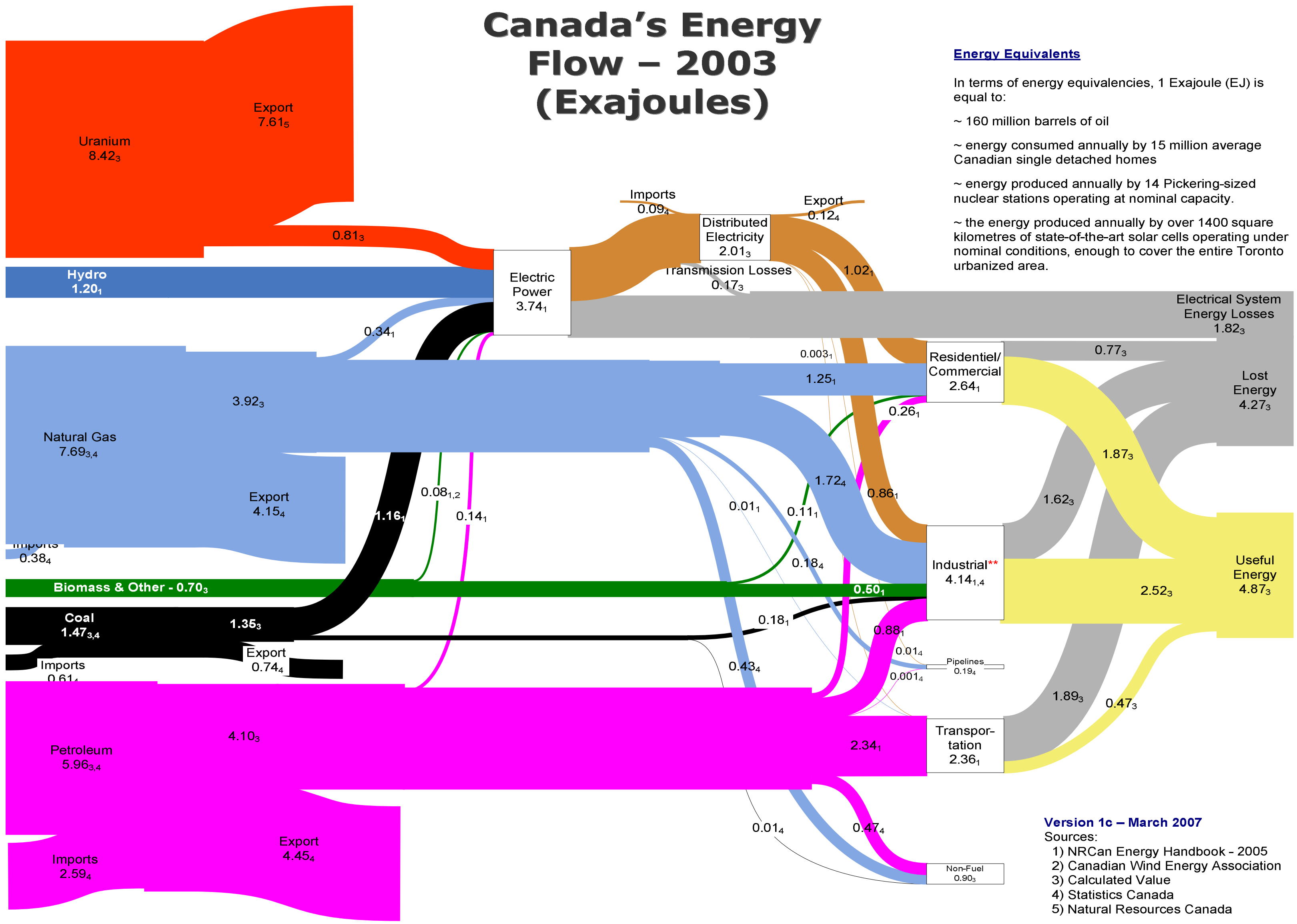
3.1. ENERGY FLOW

The flow of energy in the Canadian economy is the result of a complex system that includes interactions within the energy sector and with end-users (see Figure 3.1). "Primary" energy products are extracted from non-renewable resources – crude oil, natural gas, coal and uranium – and renewable resources – particularly hydro and biomass. They are also extracted from emerging resources, such as the wind and sun.

Some of these primary energy products are consumed as such by end-users. However, the greater part of the volumes of these products are processed and transformed into "secondary" energy products to meet the needs of end-users. For instance, crude oil is refined to produce a family of refined petroleum products that includes gasoline, diesel and fuel oil. And coal, uranium, natural gas and fuel oil are used to generate electricity.

Adding to the complexity, energy products can be exported or imported at both primary and secondary stages. For instance, a Canadian oil refinery can import crude oil and export part of its production of refined products to nearby markets in the United States. The energy sector uses a significant amount of energy for extraction, processing and transportation. During energy transformation, the sector also has energy efficiency losses. More energy is lost through the inefficiencies of energy-using equipment (cars, appliances, heaters, etc.). Some of the energy produced in Canada may also be used for non-energy purposes. Examples are the use of natural gas liquids to produce basic plastics, and the production of lubricants and asphalt from the heavier elements obtained during the refining of crude oil

FIGURE 3.1:



Energy Equivalents

In terms of energy equivalencies, 1 Exajoule (EJ) is equal to:

~ 160 million barrels of oil

~ energy consumed annually by 15 million average Canadian single detached homes

~ energy produced annually by 14 Pickering-sized nuclear stations operating at nominal capacity.

~ the energy produced annually by over 1400 square kilometres of state-of-the-art solar cells operating under nominal conditions, enough to cover the entire Toronto urbanized area.

Version 1c – March 2007

Sources:
1) NRCan Energy Handbook - 2005
2) Canadian Wind Energy Association
3) Calculated Value
4) Statistics Canada
5) Natural Resources Canada

**Upstream petroleum refining is included in the *Industrial* end-use sector

3.2. OIL

3.2.1. Key descriptors

- Canada has a substantial oil resource with 178.6 billion barrels of oil in proven reserves, of which 173.2 billion barrels are in the form of oil sands.
- Crude oil production reached an historical peak in 2006, totalling 2.7 million barrels per day (MMB/D). While conventional resources continued to provide more than half of the crude oil production, most of the production growth in recent years came from oil sands.
- Driven by high commodity prices, the Canadian upstream oil and gas industry was active in 2006. Well completions have more than doubled since the late 1990s. At the same time, capital investments have more than tripled, reaching $52.9 billion in 2006.
- The Canadian oil industry works in a dual market: domestic oil is exported from the western provinces, while international oil is imported to the East Coast. In 2006, crude oil exports reached 1.8 MMB/D – about two thirds of domestic production – while imports amounted to 0.85 MMB/D.
- Canada has an extensive network of pipelines carrying crude oil to domestic refineries. The three main refining centres are in Edmonton, Ab.; Sarnia, On.; and Montréal, Qc. With refinery utilization rates approaching 100 percent, very small disruptions in supply can affect the price and availability of petroleum products.
- More than two thirds of the refined petroleum products sold in Canada – gasoline, low-sulphur diesel and aviation fuels – are used for transportation.
- Within the last few years, oil prices have significantly increased. This increase is due to renewed geopolitical concerns in the Middle East, the lower spare oil capacity, production cuts by the Organization of the Petroleum Exporting Countries (OPEC), the devaluation of the U.S. dollar and the significant growth in speculative trading in oil futures.
- In the coming years, the oil sands will dominate the Canadian oil sector. Oil sands production is expected to triple by 2020, representing 80 percent of Canadian oil production. New pipeline infrastructure will be required to accommodate the increase in supply and market requirements. Several companies are evaluating the possibility of constructing new refineries or expanding existing operations in Canada.

3.2.2. Reserves

Canada's oil reserves at 178.6 billion barrels as of December 31, 2006, are sufficient to meet demand for the next 200 years at current rates of production.[27,28] Oil reserves are defined as the amount of oil that can be recovered from known reservoirs under current technology and present economic conditions. Oil reserves are specifically proven by drilling, testing or production. Undiscovered oil, which is thought to exist based on geological information but has yet to be found, is excluded from the reserves definition.

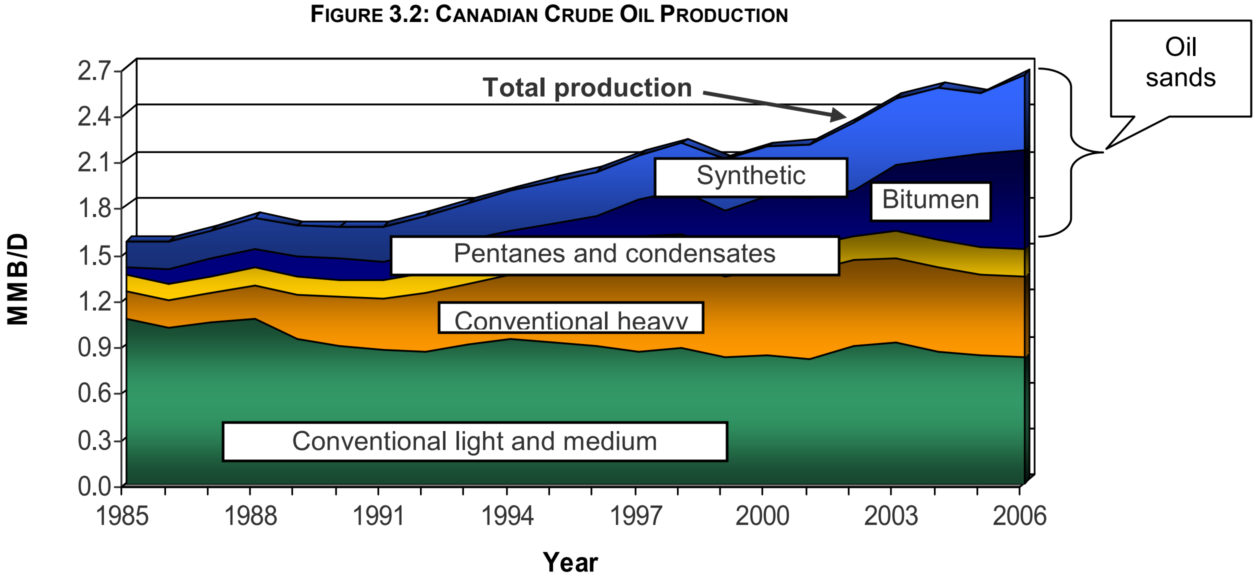
Canada's oil reserves consist of 173.2 billion barrels of oil contained in the oil sands deposits of Alberta (established reserves) and 5.4 billion barrels of conventional oil reserves. Most of Canada's oil reserves are found in the Western Canada Sedimentary Basin, which underlie Alberta, Saskatchewan and part of the Northwest Territories.

Within the last two years, East Coast offshore crude oil reserves have been adjusted upward, from 873 million to 1651 million barrels, in all three producing areas (Hibernia, Terra Nova and White Rose) in offshore Newfoundland and Labrador. East Coast offshore conventional crude oil reserves are close to the size of Alberta's conventional crude oil reserves (1997 million barrels).

3.2.3 Production

Total Canadian crude oil production rose from 1.6 MMB/D in 1985 to an historical peak of close to 2.7 MMB/D in 2006 (see Figure 3.2). While conventional sources continued to provide more than half of all crude oil production, they experienced limited growth during that period.

FIGURE 3.2: CANADIAN CRUDE OIL PRODUCTION



Source: Statistics Canada, *Energy Statistics Handbook, April to June 2007*, Cat. No. 57-601-XIE, tables 3.2-1, 3.2-2 and 3.2-3.

Between 1985 and 2006, Canadian oil sands production (shown as bitumen and synthetic crude oil in Figure 3.2) rose from 0.2 MMB/D to more than 1.1 MMB/D. This increase was mainly in response to higher crude oil prices and profits that encouraged investment in the oil sands industry.

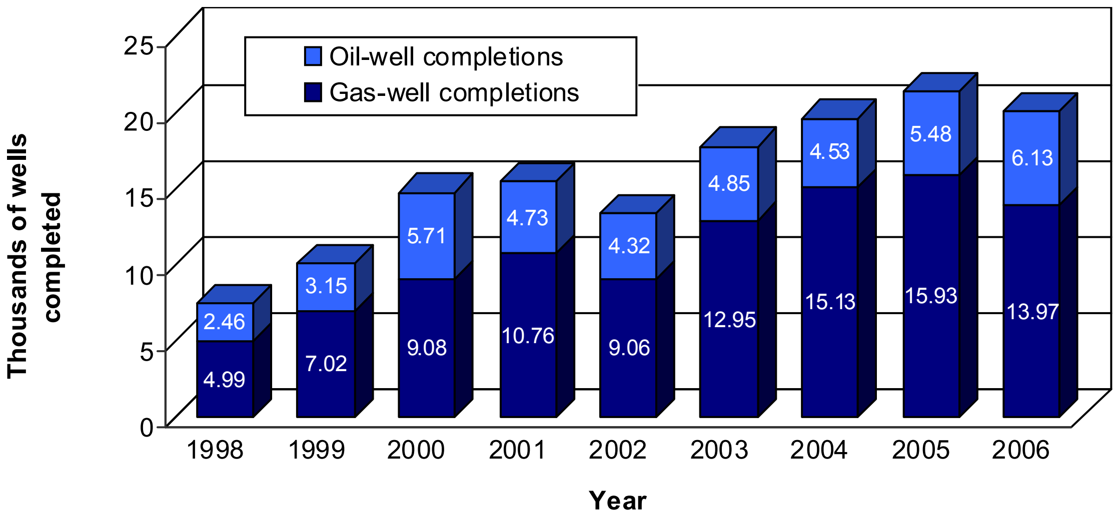
Factors affecting the pace of oil sands development include skilled labour shortages and the rising cost of labour, water availability, environmental regulations, constraints of refining/upgrading and pipeline capacity, and natural gas shortages. Oil sands growth will also be affected by the challenge of building community infrastructure in Fort McMurray, Alta., and surrounding communities, where the oil sands' workers live.

Most of Canada's crude oil comes from the western provinces: Alberta (68.8 percent), Saskatchewan (16.1 percent), British Columbia (1.5 percent) and Manitoba (0.8 percent). In 2006, eastern Canada's production was 316 thousand barrels per day (MB/D), or 11.9 percent of Canada's overall production. Newfoundland and Labrador accounted for the largest component (11.4 percent).

3.2.4. Oil and gas wells drilled

Most Canadian petroleum companies drill both oil and gas wells. Showing the total of oil and gas well completions indicates the health of the Canadian upstream oil and gas industry. From 1998 to 2006, the number of oil and gas well completions in Canada increased 170 percent, from 7 450 in 1998 to 20 099 in 2006 (see Figure 3.3).

FIGURE 3.3: CANADIAN OIL AND GAS WELL COMPLETIONS

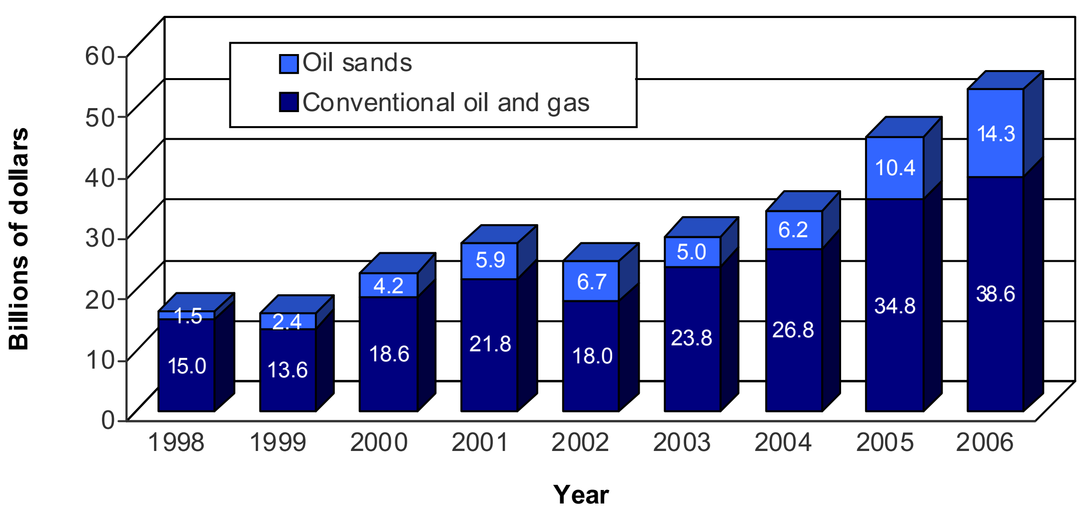


Source: Canadian Association of Petroleum Producers (CAPP), *Statistical Handbook for Canada's Upstream Petroleum Industry* (September 2007), tables 1.5A and 1.6A.

3.2.5. Investment

Between 1998 and 2006, investment in the Canadian upstream oil and gas industry tripled, from $16.5 billion in 1998 to $52.9 billion in 2006 (see Figure 3.4). Of this amount, the investment in oil sands increased tenfold, from $1.5 billion in 1998 to $14.3 billion in 2006.[29]

FIGURE 3.4: CAPITAL INVESTMENT IN THE CANADIAN UPSTREAM OIL-AND-GAS INDUSTRY

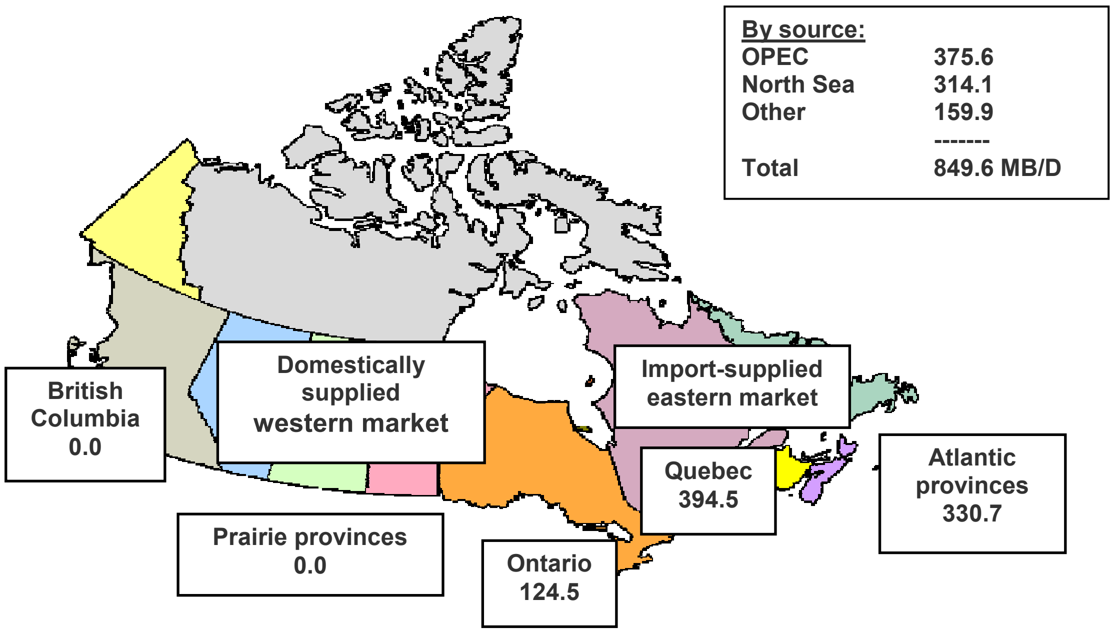


Source: CAPP, *Statistical Handbook for Canada's Upstream Petroleum Industry* (September 2007), tables 4.2B and 4.16A.

3.2.6. Exports and imports

Due to logistics and transportation costs, crude oil imports satisfy about half of the domestic refinery demand (see Figure 3-5). Refineries in western Canada run domestically produced crude oil, while refineries in Quebec and the Atlantic provinces run primarily imported crude oil. Refineries in Ontario run a mix of imported and domestically produced crude oil.

FIGURE 3.5: CRUDE OIL IMPORTS, 2006
(MB/D)

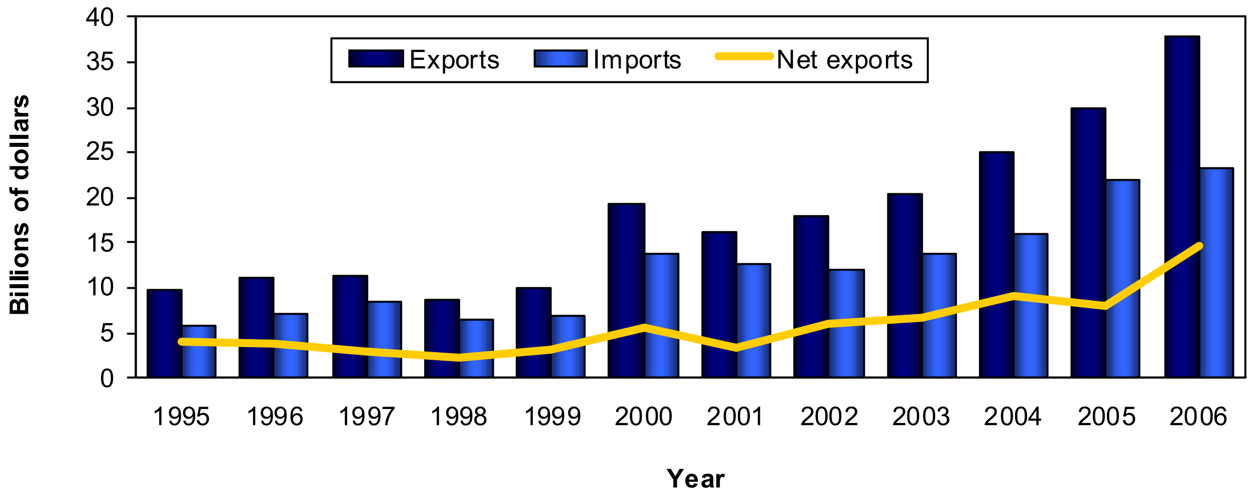


Source: Statistics Canada, *Energy Statistics Handbook, April to June 2007*, Cat. No. 57-601-XIE, tables 4.5-1 and 4.5-2, pp. 54–56.

In 2006, exports of Canadian crude oil reached nearly 1.8 MMB/D. Of these exports, more than 99 percent was bound for the United States.[30] In fact, Canada is the largest exporter of crude oil to the United States. Higher oil prices and growing exports raised the value of net Canadian crude oil exports from $4.0 billion in 1995 to $14.6 billion in 2006 (see Figure 3.6).

Crude oil imports amounted to 0.85 MMB/D in 2006, reaching a value of $23.3 billion. International trade in oil has a significant impact on Canada's trade balance. For 2006, net oil exports represented 38.6 percent of Canada's net exports.

FIGURE 3.6: VALUE OF CANADIAN CRUDE OIL IMPORTS AND EXPORTS



Source: Statistics Canada, *Energy Statistics Handbook, April to June 2007*, Cat. No. 57-601-XIB, tables 3.1 and 3.2, pp. 39–40.

3.2.7. Pipeline capacity

Efficient and inexpensive transportation of energy is crucial for Canada's energy sector. Pipelines provide the most reliable and efficient way to transport large amounts of crude oil.

About 23 000 kilometres (km) of main trunk lines transport crude oil from the Western Canada Sedimentary Basin to Canadian refineries and international border crossing points, and from the United States to Canadian refineries. Also, more than 12 000 km of gathering lines transport crude oil from producers' fields to the main trunk lines. And more than 5 000 km of pipeline transport refined petroleum products.[31]

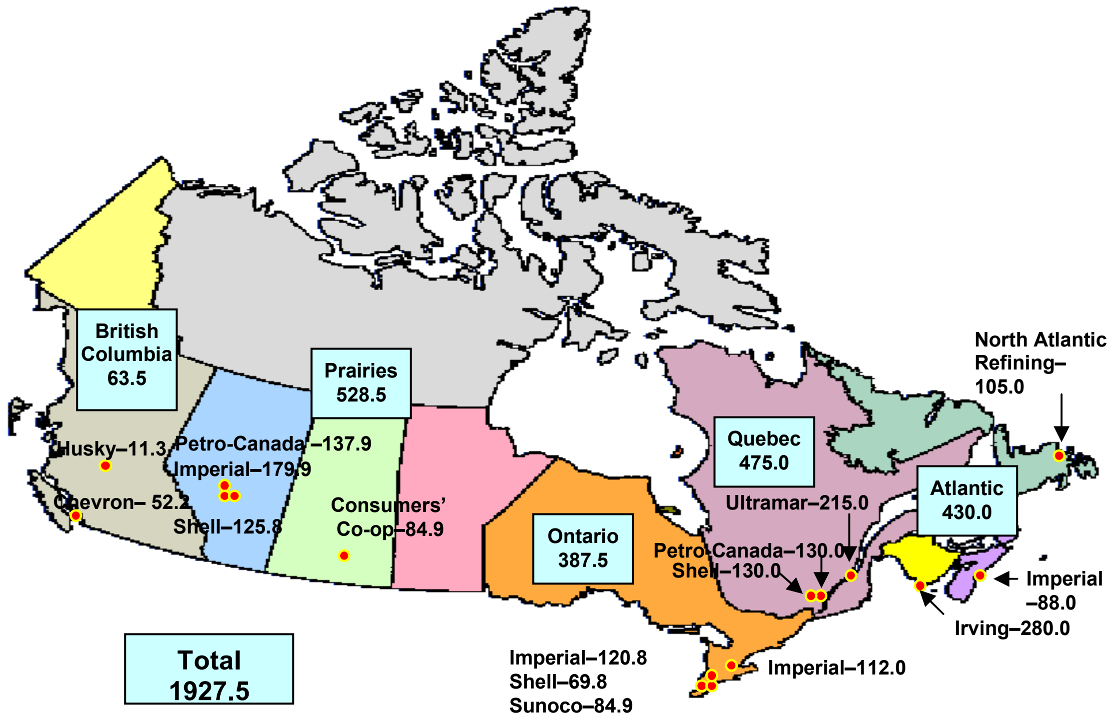
3.2.8. Refining capacity

There are three main refining centres in Canada: in Edmonton, Ab.; Sarnia, On.; and Montréal, Qc. (see Figure 3.7). There are no refineries in Manitoba, Prince Edward Island or the territories.

Refinery utilization rates of close to 100 percent, and growth in demand for petroleum products, have created a need for significant additions to refinery capacity in Canada. Without investment in new refining capacity, supply interruptions could become more frequent and increasingly difficult to manage.

Due to the high demand for petroleum products in the northeastern United States, refiners in Atlantic Canada export considerable volumes of petroleum products there.

FIGURE 3.7: CAPACITY OF REFINERIES IN CANADA, 2006 (MB/D)



Source: Natural Resources Canada, Oil Division, annual survey of refiners.

3.2.9. Consumption

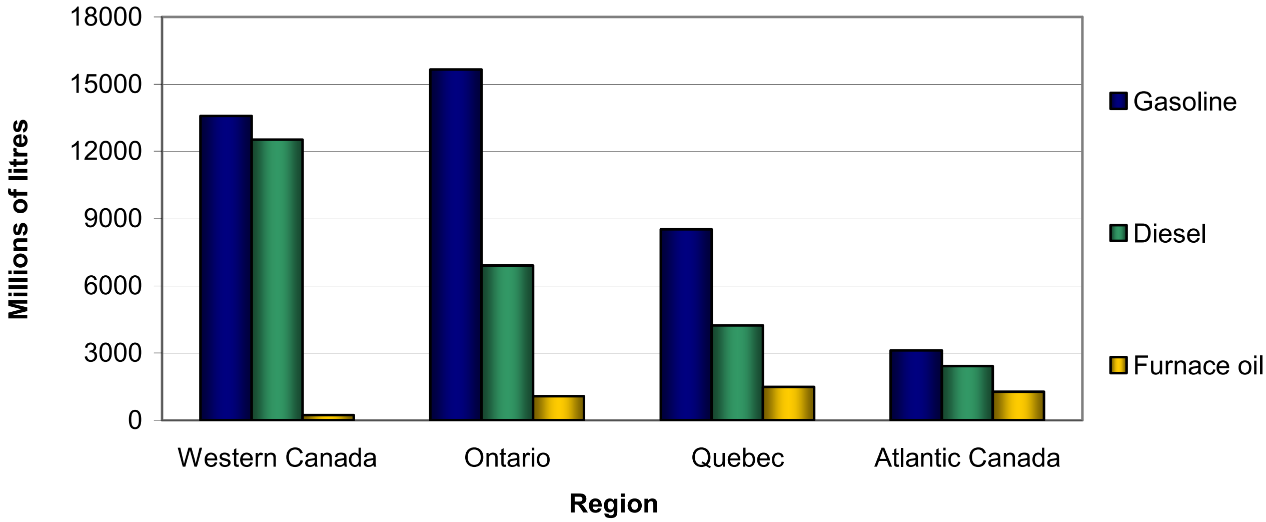
Sales of refined petroleum products in Canada totalled 100.0 billion litres in 2006. [32] More than two thirds of these sales were products used for transportation: 40.9 billion litres of gasoline, 20.7 billion litres of low-sulphur diesel fuel and 6.8 billion litres of aviation fuels.

Other refined products sold in Canada are used for energy purposes (e.g. furnace oil, high sulphur diesel, heavy fuel oil) and non-energy purposes (e.g. asphalt, lubricants).

Ontario and Quebec accounted for 59 percent of the gasoline consumed in Canada (see Figure 3.8). The western provinces accounted fr 33 percent of Canada's gasoline consumption, while the remaining 8 percent of gasoline was consumed in the Atlantic Provinces and the territories.

In 2005, Ontario and Quebec accounted for 43 percent of the diesel fuel consumed in Canada, while the western provinces accounted for 46 percent. The relatively greater dependence on diesel in western Canada reflects regional differences in fleet composition and the comparatively greater need to truck most manufactured goods to the West from outside the region.

FIGURE 3.8: DOMESTIC SALES OF PETROLEUM PRODUCTS BY REGION, 2006



Source: Statistics Canada, *The Supply and Disposition of Refined Petroleum Products in Canada* (February 2007), (Cat. No. 45-004-XIE), Table 1.

Due to the abundant supply of natural gas in western Canada, relatively little furnace oil is consumed in this region. The western provinces (British Columbia, Alberta, Manitoba and Saskatchewan) account for only 6 percent of the furnace oil consumption in Canada.

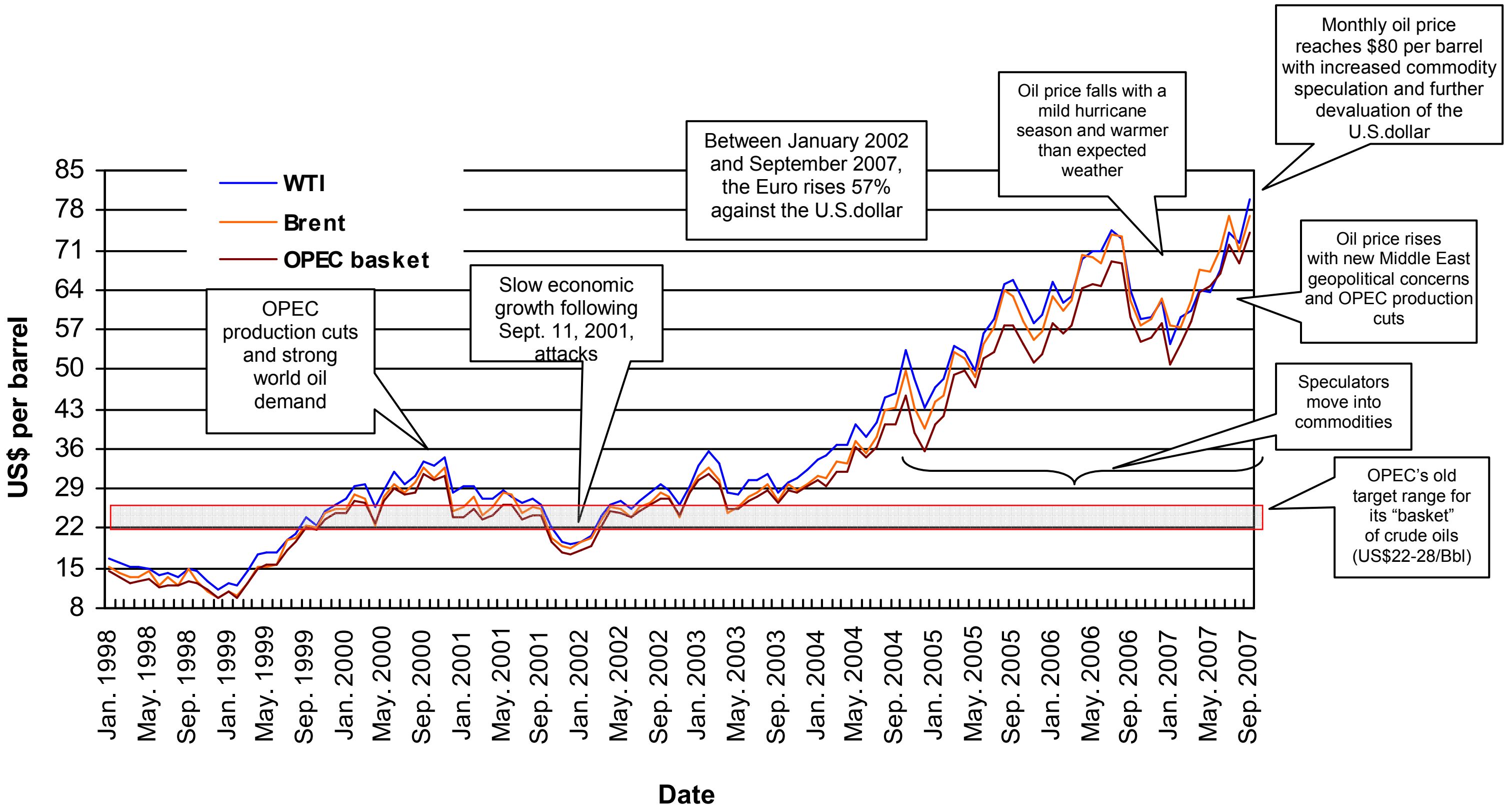
In contrast, natural gas is not an option in many markets in Atlantic Canada. This region accounts for more than 30 percent of Canada's furnace oil consumption despite representing only 7 percent of the country's population. Although Atlantic Canada consumes the most furnace oil on a per capita basis, Ontario and Quebec account for the majority (63 percent) of Canadian consumption measured in absolute terms.

3.2.10. Prices

In the late 1990s, oil prices were low due to a relatively stable world oil market, with high production by the Organization of the Petroleum Exporting Countries (OPEC) and weak oil demand.

Within the last few years, however, oil prices have significantly increased (see Figure 3.9). This increase is due to renewed geopolitical concerns in the Middle East, a lower spare-oil capacity, OPEC production cuts, the devaluation of the U.S. dollar and significant growth in speculative trading in the oil futures.

FIGURE 3.9: NOMINAL CRUDE OIL PRICES



Sources:
Energy Information Administration (EIA) Web site, West Texas Intermediate (WTI) and Brent prices, http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm.

OPEC Web site, OPEC Basket prices, www.opec.org/home/basket.aspx.

Regardless of the source of crude oil, the price that Canadian refineries pay for crude oil is determined by the world oil market. Both imported and domestic crude oil are bought and sold in relation to global prices. In this respect, Canadian refiners are "price takers" and have little influence on the price they pay for crude oil. However, Canadian oil producers have obtained higher prices for their crude oil on the world market.

Recently, crude oil and product supply disruptions have had a greater impact on the prices of refined petroleum products than in the past. This impact is due to minimal excess refining capacity and lower excess crude-oil production capacity coupled with increased international demand.

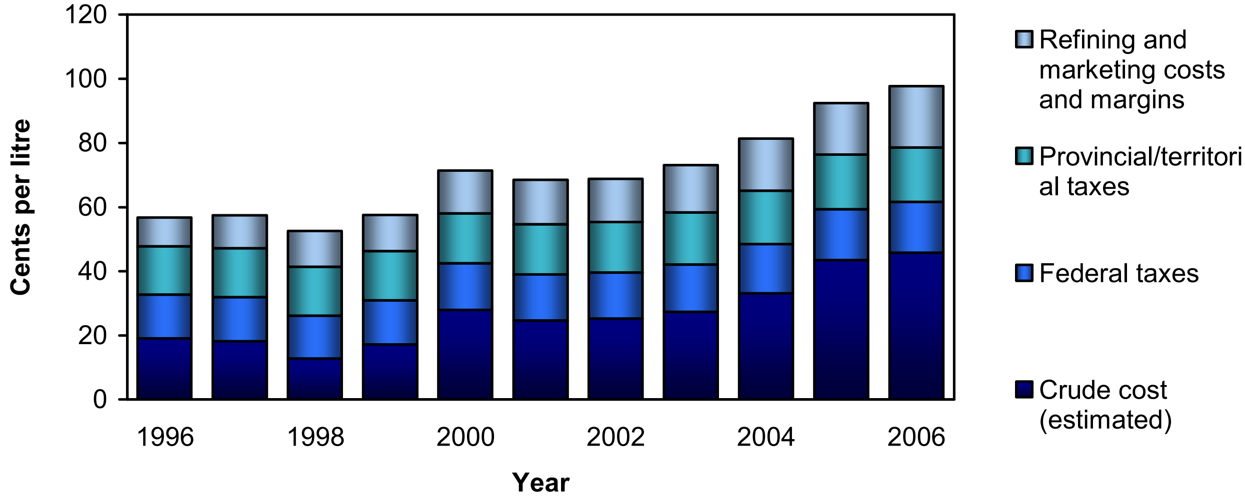
The downstream petroleum sector is complex and highly competitive. Each petroleum product in each regional market reacts to a different set of supply/demand and transportation pressures, with resulting variation in product prices. Increasingly stringent fuel specifications and the need for new refining capacity have increased capital spending by North American refiners. These increased costs have been passed on to the consumer in the form of higher prices.

Recently, there has been a significant increase in the nominal price of crude oil and petroleum products such as gasoline. However, in constant dollar terms, the "real" prices are actually lower than they were in the early 1980s.

A number of factors contribute to the final pump price, the smallest of which is retail profit. As the raw material for gasoline, the most important component is the price of crude oil (see Figure 3.10).

Although low in international terms, taxes follow as the second major component of the price of gasoline in Canada.

FIGURE 3.10: REGULAR GASOLINE PUMP-PRICE COMPONENTS, CANADA, AVERAGE

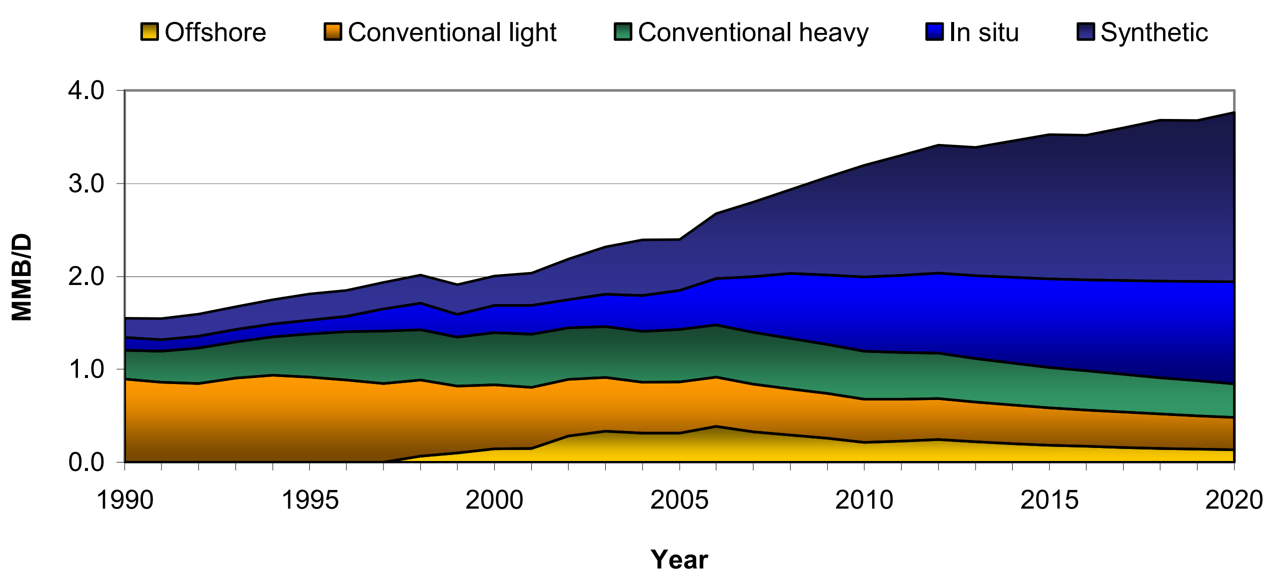


Source: Natural Resources Canada, Oil Division, weekly and monthly surveys, http://fuelfocus.nrcan.gc.ca/petrolium_prices_e.cfm

3.2.11. Outlook

Over the next 15 years, the Canadian oil sector will be dominated by the pace of development of the oil sands. Current in situ and synthetic bitumen production (from oil sands) of just more than 1 MMB/D is expected to grow to as much as 3 MMB/D by 2020 (see Figure 3.11).[33] The Canadian oil panorama will decidedly shift to a greater focus on heavier crude and opportunities for its upgrading and further refining. By 2020, 80 percent of production is forecast to come from the oil sands. While output from the oil sands is projected to triple, production from conventional sources is expected to decline.

FIGURE 3.11: CRUDE OIL PRODUCTION



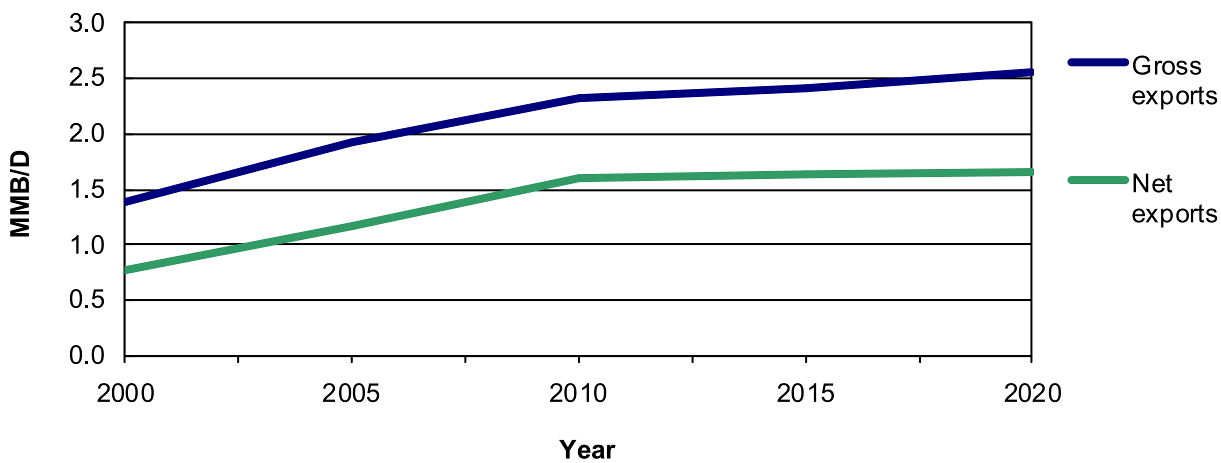
Source: Natural Resources Canada, *Canada's Energy Outlook: The Reference Case 2006*, Appendix IV, Table 16B, p. 137.

The extent of this development and the evolution of the industry over the next 15 years will depend on the interplay of international oil prices, environmental considerations, the pace of technology development, and the availability of investment and its flows.

Supply projections are based on a conservative assumption of international oil prices of US$45 per barrel from 2010 to 2020 (in constant 2003 dollars).[34] At these price levels, oil sands production would be profitable and attractive to investors. If higher prices prevail, production would be higher.

Crude oil gross exports are projected to continue to increase, although at a slower pace after 2010. Exports are projected to reach about 2.6 MMB/D by 2020 (see Figure 3.12).

FIGURE 3.12: CRUDE OIL EXPORTS



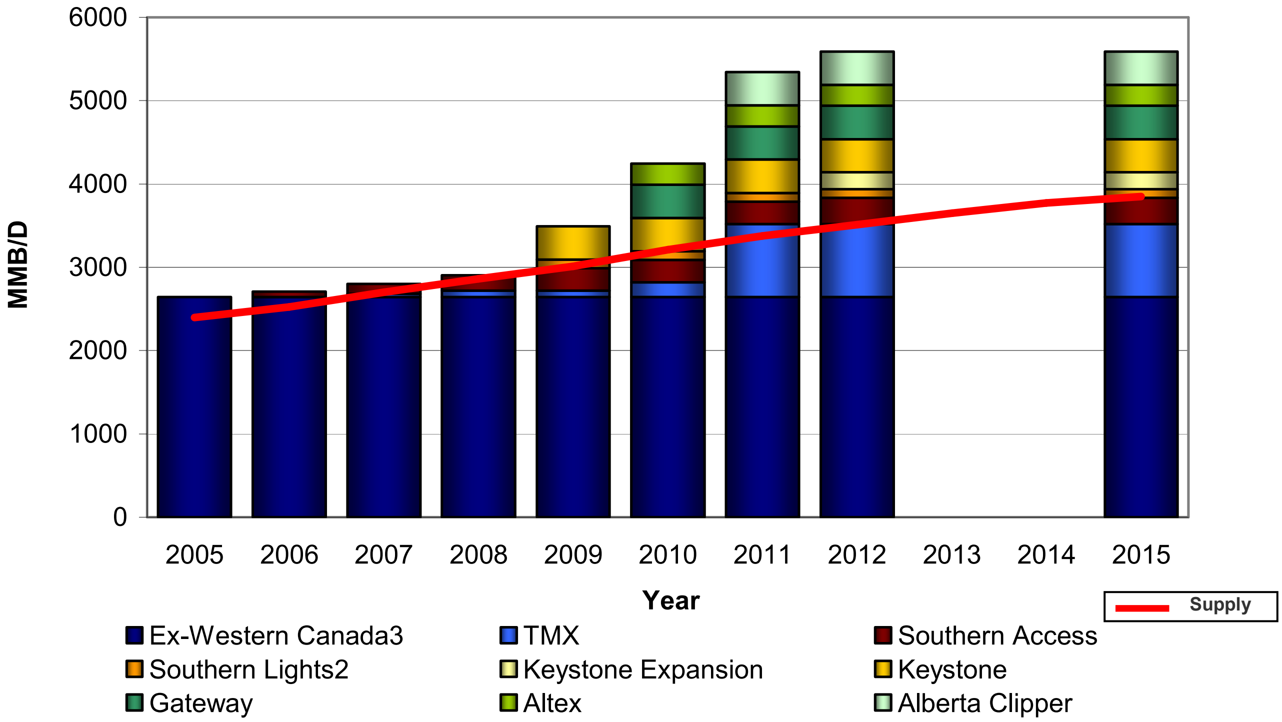
Source: Natural Resources Canada, *Canada's Energy Outlook: The Reference Case 2006*, Appendix IV, Table 16B, p. 137.

Today pipeline capacity in Canada is adequate, although it is expected to be tight in 2007 and 2008. The gap between supply and existing pipeline capacity begins to widen after 2008 (see Figure 3.13). Due to the rapid expansion of Canada's oil sands over the next decade, pipeline infrastructure must be built to accommodate the increase in supply and market requirements.

Several pipeline projects have been proposed to bridge the projected gap between future supply and existing pipeline capacity. However, all of these projects are not expected to be realized. Any prolonged lack of investment in this area could hinder Canada's ability to expand the production of its petroleum resources.

The tight refining capacity in North America has created a need for further investment in the refining industry. Because the demand for petroleum products is projected to increase, capacity expansion will become increasingly important to satisfy North American demand.

FIGURE 3.13: SUPPLY FORECAST AND PROPOSED CRUDE-OIL PIPELINE PROJECTS



Source: National Energy Board (NEB), *Canada's Oil Sands Opportunities and Challenges to 2015: An Update*, Cat. No. NE23-116/2006E, Figure 5.2, p. 33.

Several refining companies are evaluating the possibility of constructing refineries or expanding existing operations in Canada. While the primary market for their products would likely be the United States, this additional refining capacity would help ease the tight market for petroleum products throughout North America. As is the case with crude oil production, the extent of capital investment will depend on environmental considerations and the economic viability of construction or expansion.

Finally, fuel ethanol is expected to play an increasing role in the gasoline market, as a result of renewable fuel mandates emerging at the provincial level. These mandates may create logistical supply issues within the downstream distribution system, which spans a number of provinces.

3.3. NATURAL GAS

3.3.1. Key descriptors

- The Canadian natural gas industry operates in an integrated marketplace with the United States. The two markets are connected by a series of pipelines, and prices in the two countries influence one another. More than half (55 percent in 2006) of Canadian natural gas production is exported to the United States.
- Most of Canada's recoverable natural gas reserves are in the western provinces of British Columbia, Alberta and Saskatchewan. In addition, smaller reserves are in northern Canada and Atlantic Canada.
- In 2006, natural gas prices at AECO averaged $6.79 per gigajoule (GJ), 17 percent lower than the record level set in 2005. Over the medium term, natural gas prices are expected to remain in the $6/GJ–$8/GJ range due to the tight balance between supply and demand.
- The combination of lower natural gas prices and lower exports in 2006 resulted in a 15 percent decline in export revenues, from $32.0 billion in 2005 to $27.3 billion in 2006.
- North American producers drilled a record number of natural gas wells in 2006, 11 percent more than in 2005. However, production increased a marginal 2 percent (3 percent in the United States, 1 percent in Canada). This increase illustrates how pools found are becoming smaller and less productive due to basin maturity.
- Finding and development costs for natural gas have escalated due to this maturity effect. In addition, producers must now target non-conventional sources of natural gas, such as coal-bed methane. Also, numerous terminals for receiving liquefied natural gas (LNG) are proposed for Canada, the United States and Mexico.
- The Mackenzie Valley and Alaska pipelines offer the potential to provide significant quantities of natural gas to the North American market, although their year of completion remains uncertain.
- Increasingly, the North American market is affected by factors in other markets. For example, LNG is expected to become the next major incremental continental supply source. However, U.S. LNG imports declined 7 percent in 2006. This decline was due to tight global supply and the diversion of spot cargos (LNG sales done under short-term agreements rather than long-term contracts) to European markets, where more attractive prices prevailed.

3.3.2. Reserves

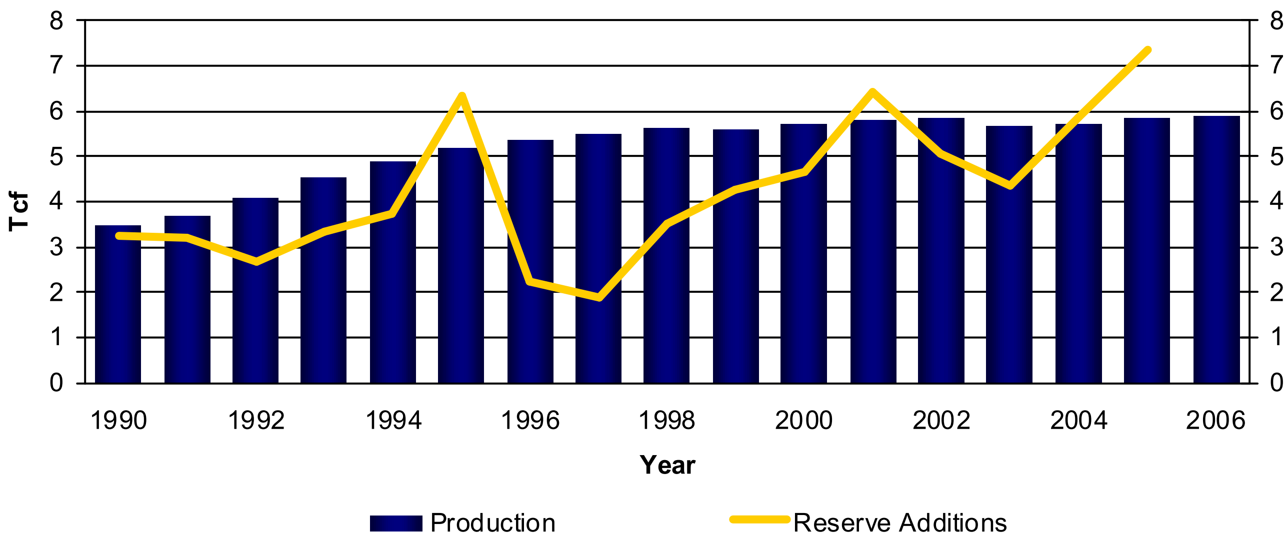
As of January 1, 2006, Canada and the United States had combined proved natural gas reserves[35] of 262.0 trillion cubic feet (Tcf), with 56.5 Tcf in Canada.[36] At present, 98 percent of Canadian proved reserves of natural are from the Western Canada Sedimentary Basin (WCSB). In addition, offshore Nova Scotia had estimated proved reserves of 500 billion cubic feet (Bcf).

The WCSB extends from the foothills of the Rocky Mountains in northeastern British Columbia and Alberta, across Saskatchewan and into the southwestern plains of Manitoba. This basin produces about 24 percent of U.S. and Canadian production and contains 21 percent of proved natural gas reserves.

Proved reserves change every year because gas is withdrawn and new reserves are discovered through exploration by producers. In Canada, reserves have been relatively flat since about 1999, meaning reserve additions from new drilling have about equalled the amount produced (see Figure 3.14). Proved reserves remain just below 60 Tcf. However, recently, maintaining reserve levels has required ever-increasing drilling levels. If drilling and/or reserve additions falter, production will soon follow downward.

In addition to proven reserves, Canada has an estimated 204 Tcf of undiscovered “conventional” natural gas resources. It also has an estimated 80 Tcf of undiscovered “unconventional” resources in the WCSB. These undiscovered resources include natural gas from coal, tight gas and shale gas.[37] Undiscovered resources are estimates of economically recoverable natural gas volumes that have not yet been found but are expected to be found eventually by drilling, based on current geological information.

FIGURE 3.14: WESTERN CANADA PRODUCTION VERSUS RESERVE ADDITIONS



Source: Statistics Canada, *Energy Statistics Handbook (*2006), Table 6.4, "Natural gas – deliveries of marketable gas by province," and Table 6.9, "Natural gas – marketable natural gas, remaining established reserves in Canada.”

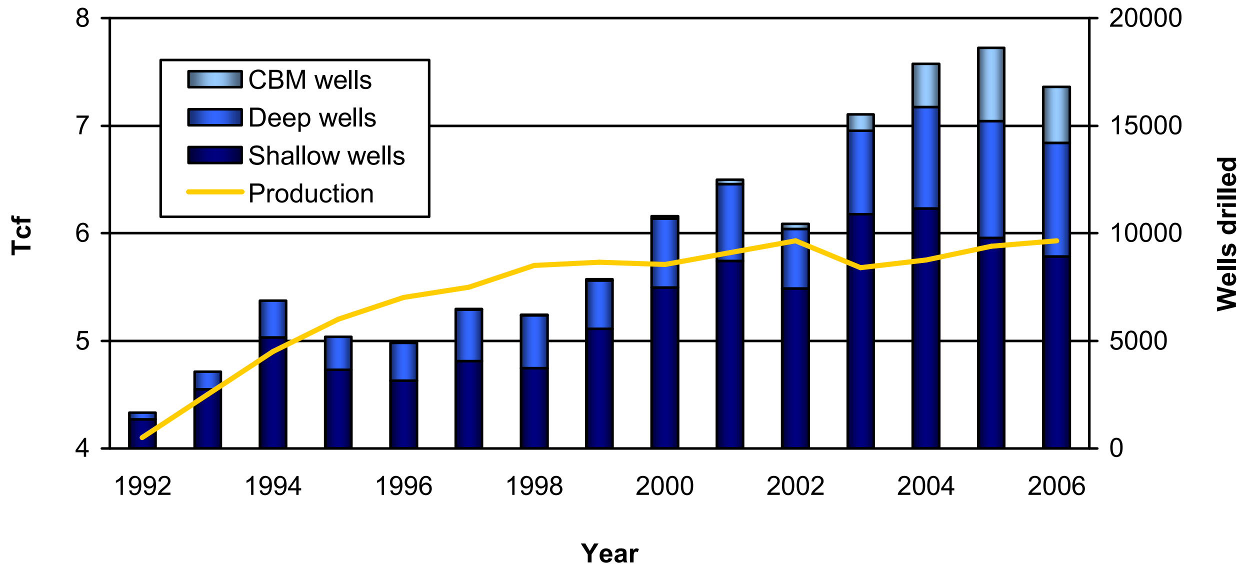
3.3.3. Production

Canadian natural gas production increased substantially from around 4 Tcf in 1992 to 6 Tcf in 2002 (see Figure 3.15). Canada is now the world’s third largest producer of natural gas. However, production has flattened since 2002 because the most accessible conventional pools have been depleted. In 2006, marketable production of natural gas in Canada was about 6.0 Tcf, 1 percent higher than in 2005. The vast majority (98 percent) of Canadian natural gas production comes from western Canada. Much of the remaining 2 percent comes from Sable Island, Nova Scotia.

In addition to flat production, more wells are required just to maintain production or increase it marginally. For example, in 2006, nearly 14 500 wells were drilled, and production increased by less than 0.1 Bcf/d. In the early 1990s, though, less than 5000 wells would garner a large year-over-year production gain.

Growth in conventional natural gas production in the WCSB has levelled off over the last few years. However, this is not a signal that production from this basin will soon end. Rather, producers are responding to price signals by exploiting deeper, more prolific and higher-cost reserves in the remoter areas of the basin and by developing the large unconventional resource base that exists.

FIGURE 3.15: CANADIAN PRODUCTION VERSUS GAS WELLS DRILLED

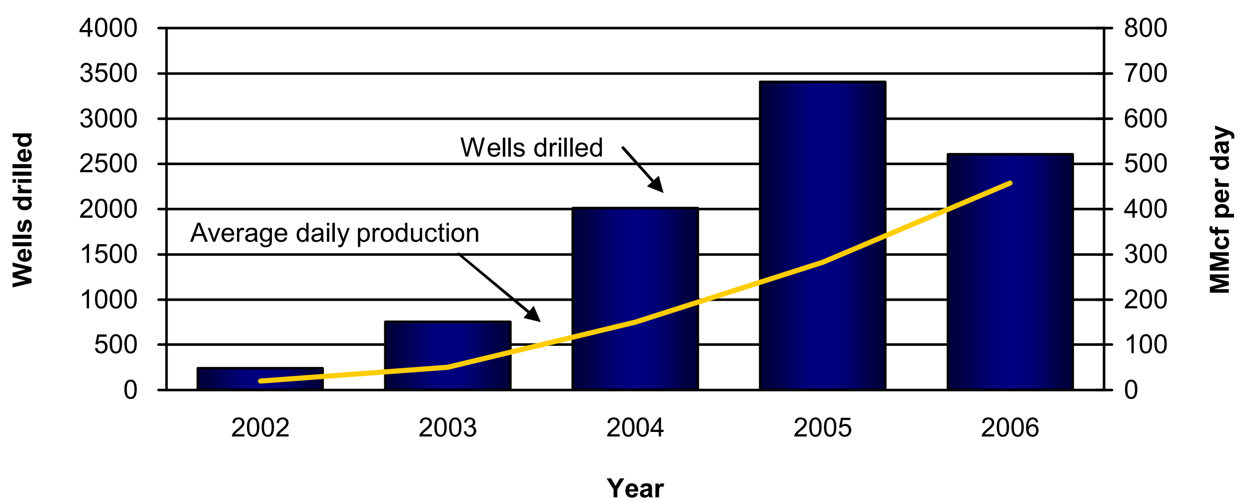


Sources:
Statistics Canada, *Energy Statistics Handbook* (2006), (Cat. No. 57-601-X), pp. 95–96.

Drilling data are from the National Energy Board.

Unconventional natural gas, such as coal-bed methane (CBM), is a growing part of the Canadian natural gas supply mix. CBM development in Alberta is increasing rapidly as more wells are drilled (see Figure 3.16). In 2006, CBM accounted for approximately 3 percent of total Canadian natural gas production. It is expected to increase to 15 percent by 2020.

FIGURE 3.16: ALBERTA COAL-BED METHANE PRODUCTION AND WELLS DRILLED



Sources:
Drilling data are from NEB internal database using geoSCOUT mapping data.

Production data are from EUB, *Alberta's Energy Reserves 2006 and Supply/Demand Outlook 2007–2016* (2007), Section 4.2.

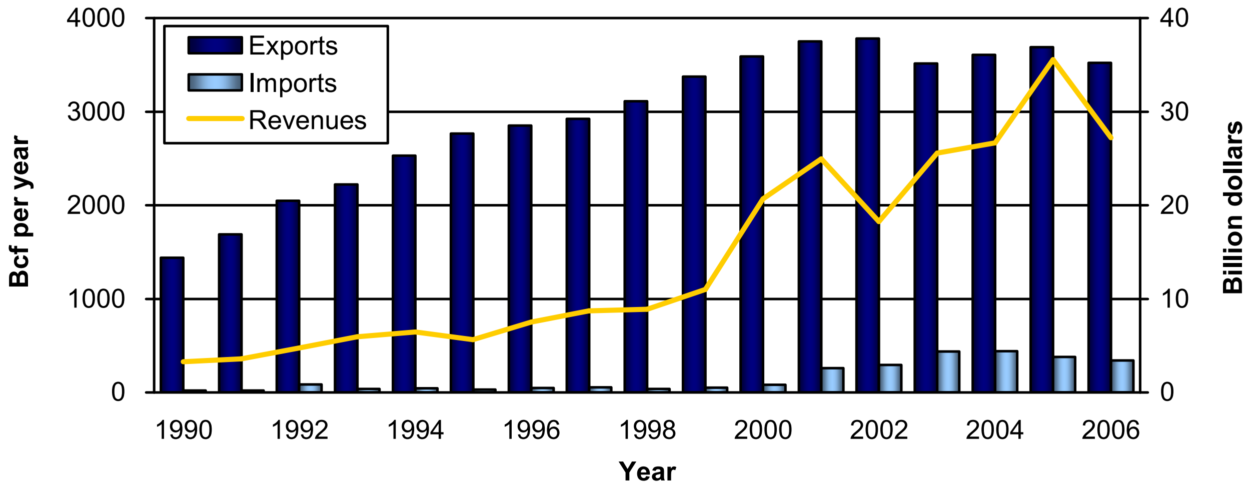
3.3.4. Exports and imports

Since the 1980s, Canada has grown to become the world's second largest exporter of natural gas. All exports of natural gas are to the United States. Canada also imports gas from the United States, primarily into Ontario. Net exports are calculated by deducting imports from gross exports.

Gross natural gas exports grew substantially during the 1990s and peaked at 3.8 Tcf in 2002 (see Figure 3.17). However, gross exports have declined from their peak, and in 2006, gross exports amounted to 3.5 Tcf. The combination of lower natural gas prices and fewer exports led to gross export revenues of $27.3 billion in 2006, down from the record of $32.0 billion in 2005.

Canadian imports of natural gas have increased in recent years, from 39 Bcf in 1999 to 300–350 Bcf since 2003. Much of the natural gas imported by Ontario from the U.S. midwest is produced in western Canada and transported through U.S. pipelines to Ontario.

FIGURE 3.17: CANADIAN NATURAL GAS EXPORTS, IMPORTS AND REVENUES



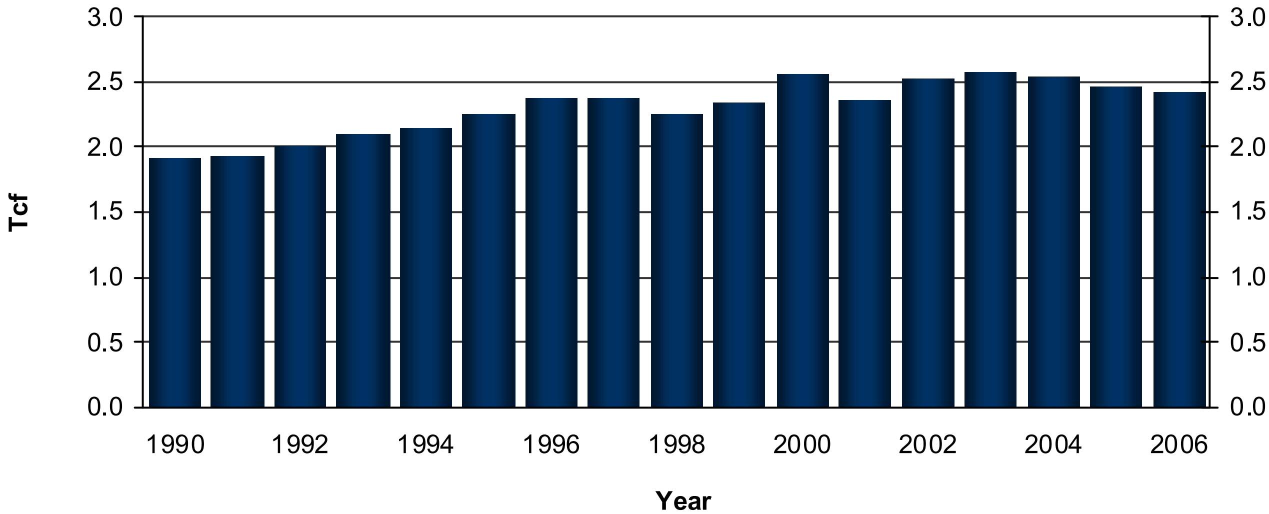
Source: NEB, http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/sttstc/sttstc-eng.html.

3.3.5. Consumption

Since 1999, Canadian natural gas consumption has increased (see Figure 3.18). However, in recent years, consumption has flattened in response to marginal supply gains, high prices and some industrial demand losses. In 2006, natural gas consumption in Canada amounted to 2.4 Tcf.

Canadian consumption is divided almost evenly between eastern and western Canada. The two largest consumers are Ontario and Alberta. Ontario's consumption profile is characterized by a large residential and commercial sector. Meanwhile, Alberta's demand is dominated by its large industrial/energy sector, in particular the oil sands.

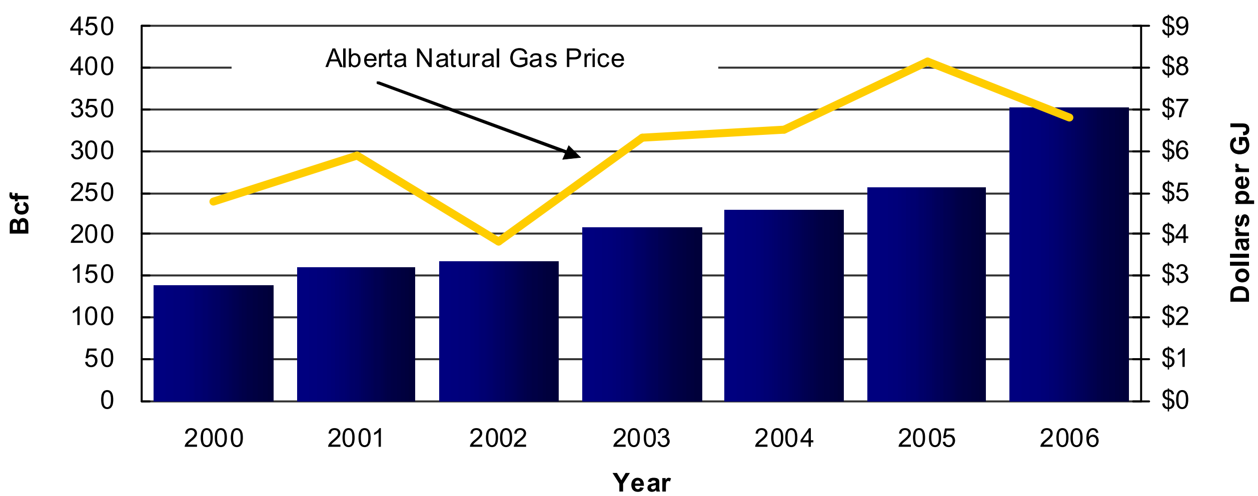
FIGURE 3.18: CANADIAN NATURAL GAS DEMAND



Source: Statistics Canada, *The Daily* (1990–2006), Crude oil and natural gas production, 1990–2008, http://www.statcan.ca/english/dai-quo.

Oil sands operations use significant amounts of natural gas (see Figure 3.19). Since 2000, the consumption of natural gas at oil sands operations has more than doubled. It reached 350 Bcf in 2006 – greater than the natural gas consumption of Saskatchewan and Manitoba combined. Unlike many industrial operations, the oil sands' demand for natural gas continues to increase despite higher natural gas prices. However, these prices are encouraging oil sands operators to use natural gas more efficiently and to look for alternative fuels for use in their operations.

FIGURE 3.19: PURCHASED NATURAL GAS DEMAND BY OIL SANDS' OPERATIONS



Sources:
EUB, Alberta's Energy Reserves 2006 and Supply Demand 2007–2016 (2007), Figure 5.33.

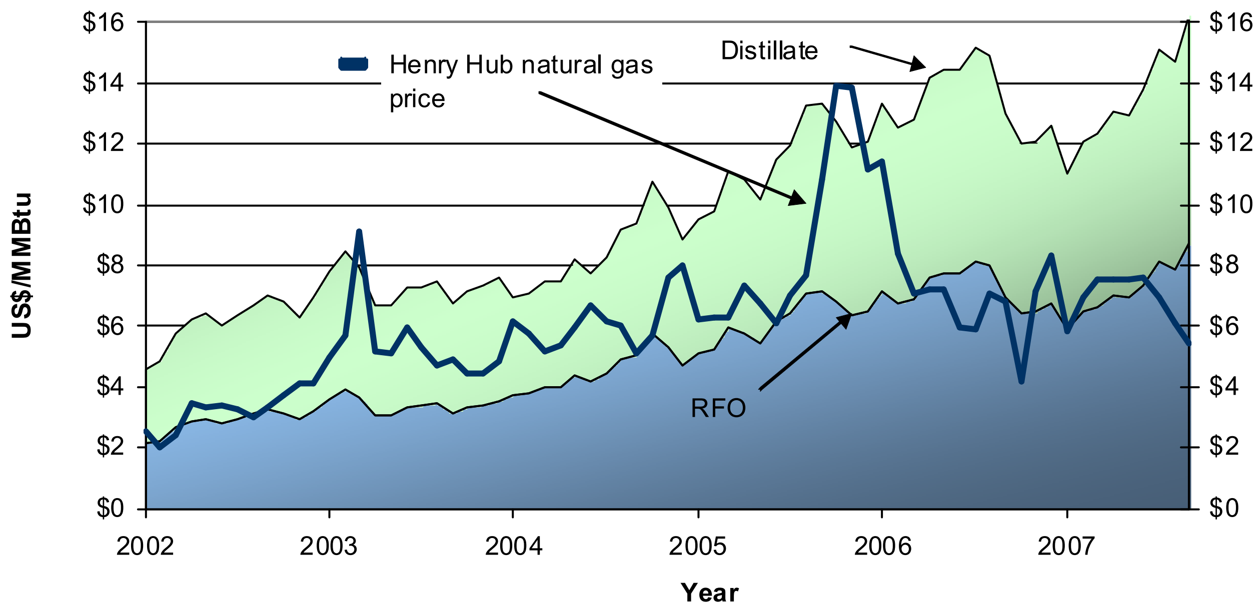
GLJ Energy Publications, Canadian Natural Gas Focus (September 2007), p. 5.

3.3.6. Prices

Natural gas tends to be priced within the band set by residual fuel oil (RFO) and distillate, which are common substitutes for natural gas (see Figure 3.20). While natural gas prices have escalated in recent years, gas prices have remained mostly at the lower end of the band. At times, natural gas prices were higher than those in the band, such as after the Gulf Coast hurricanes in 2005. Market forces tend to restore the relationship quickly, because industrial users with fuel-switching capability will go to the lower-priced fuel in response to a change in prices.

More recently, natural gas prices have been lower than oil prices. This difference is due mainly to high gas-storage levels at the same time as rising oil prices.

FIGURE 3.20: OIL VERSUS NATURAL GAS PRICE RELATIONSHIP



Source: GLJ Energy Publications, *Canadian Natural Gas Focus* (September 2007), p. 26.

Note: Distillate and RFO prices are derived by formula from the U.S. WTI oil price.

After record levels in 2005, North American natural gas prices fell in 2006. This drop ranged from 14 to 19 percent in various markets. Mainly, this reflects the 2006 return of most of the Gulf Coast natural gas supply that had been temporarily lost in late 2005, due to Hurricane Katrina. This return of supply, combined with a 2 percent drop in demand, led to the lower 2006 gas prices.

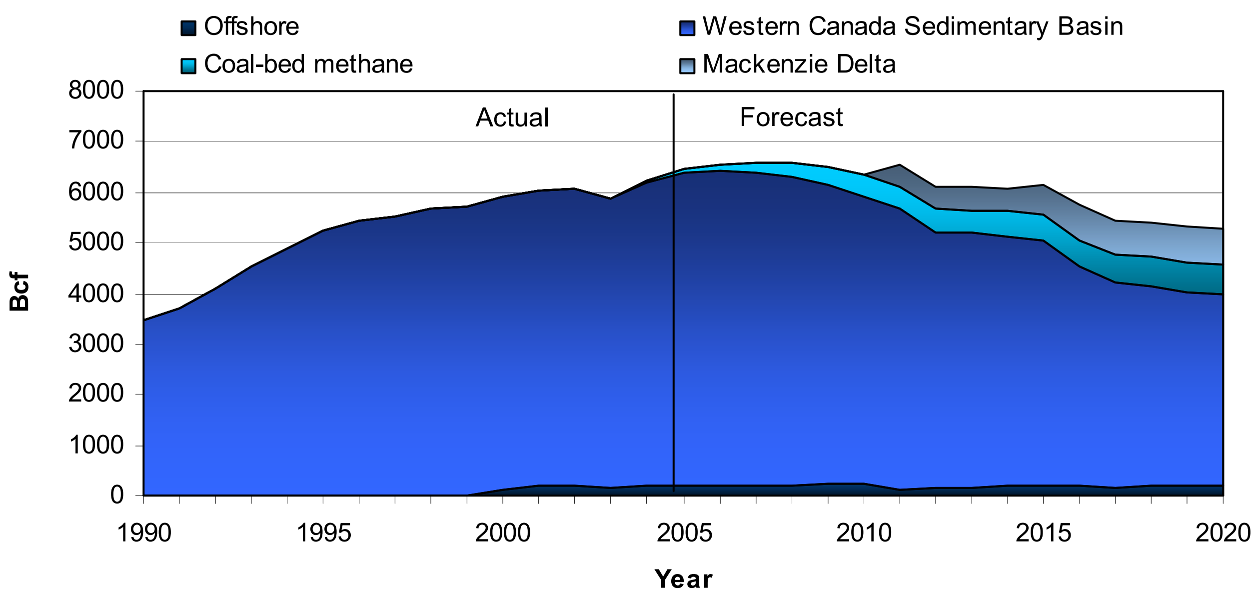
3.3.7. Outlook

The 2020 North American natural gas supply portfolio will look quite different from the current situation (see Figure 3.21).[38] Declines in conventional natural gas production are forecast. These declines are partly offset by expected growth in western Canadian unconventional natural gas production; growth in natural gas production in the Mackenzie Delta (Canada) and Alaska (United States); and the importation of LNG to North America, including Canada. As well, CBM production is expected to increase by 7 percent per year between now and 2020.

Canadian natural gas supply, including LNG imports, may be lower in 2020 than it is now. A lower supply of natural gas and the outlook for higher Canadian natural gas demand would lead to a drop in

Canadian natural gas exports to the United States. Canadian net exports are forecast to remain relatively flat over 2006–2020, hovering between 2.6 and 3.3 Tcf per year.

FIGURE 3.21: NATURAL GAS PRODUCTION



Source: NRCan, *Canada's Energy Outlook: The Reference Case 2006*, Figure US2, p. 37.

In terms of demand, U.S. natural gas demand is expected to reach about 27 Tcf in 2020, for a Canada–U.S. total of 31 Tcf. This is an increase of 5 Tcf, or 19 percent, above actual 2005 demand levels. It represents an average increase of about 1.2 percent per year. As U.S. dependence on LNG imports increases, and LNG expands to meet incremental demand, the continental gas market may integrate with global natural gas markets to some degree.

If this happens, the prices that Canadian gas producers and consumers pay for natural gas will be increasingly influenced by world prices for natural gas. Consumers could expect to benefit from a growth in LNG imports, since the increase in supply will help moderate prices.

In 2020, LNG imports are expected to account for approximately 17 percent of total North American gas supply. Today, LNG imports represent 3 percent of total North American supply. In Canada, nine LNG terminals have been proposed in Atlantic Canada, Quebec and British Columbia. The Canaport LNG terminal in Saint John, New Brunswick, is the most advanced of these projects. It is expected to begin accepting LNG imports in November 2008. Other terminals are possible, but not until 2010–2012.

3.4. COAL

3.4.1. Key descriptors

- Coal is Canada's most abundant fossil-fuel resource.
- Canada is a mid-sized coal producer. More than half of its production is used in Canada for electricity generation and for metallurgical applications. The remaining production is exported.
- Canada also imports coal, primarily for electricity generation.

3.4.2. Reserves

Canada has a large coal endowment. It holds 8.7 billion tonnes (t) of coal classified as "proved amount in place," of which 6.6 billion t are deemed "proved recoverable reserves". [39] [40] At today's production rate, these recoverable resources will last about 100 years.

The geological resource is far larger, however. An estimated 190 billion t of coal are considered to be additional to the "proved" amounts.[41] As a share of total hydrocarbon reserves, coal far exceeds oil, oil sands and natural gas (excluding gas hydrates). Canada-wide, almost 85 percent of recoverable hydrocarbon resources are coal.

Coal is found in regions across Canada and in different forms, from those with the most carbon to those with the least carbon. Anthracite and bituminous coals are high-rank coals and have higher carbon content. Both can be consumed for metallurgical and thermal purposes. Sub-bituminous and light coals are low-rank coals and have lower carbon content. They are consumed only for the generation of electricity. Higher-carbon coal holds more energy content, leading to more market interest. But such factors as availability of the resource and proximity to markets also allow for the exploitation of lower-carbon coal.

British Columbia, Alberta and Saskatchewan have the largest known reserves and resources in Canada, and coal mining is active. Coal is also found and mined in Nova Scotia and New Brunswick. Coal reserves and resources have been identified in Yukon Territory, Ontario, Newfoundland and Labrador, the Northwest Territories, and Nunavut, but there are no mining activities at present.

3.4.3. Production

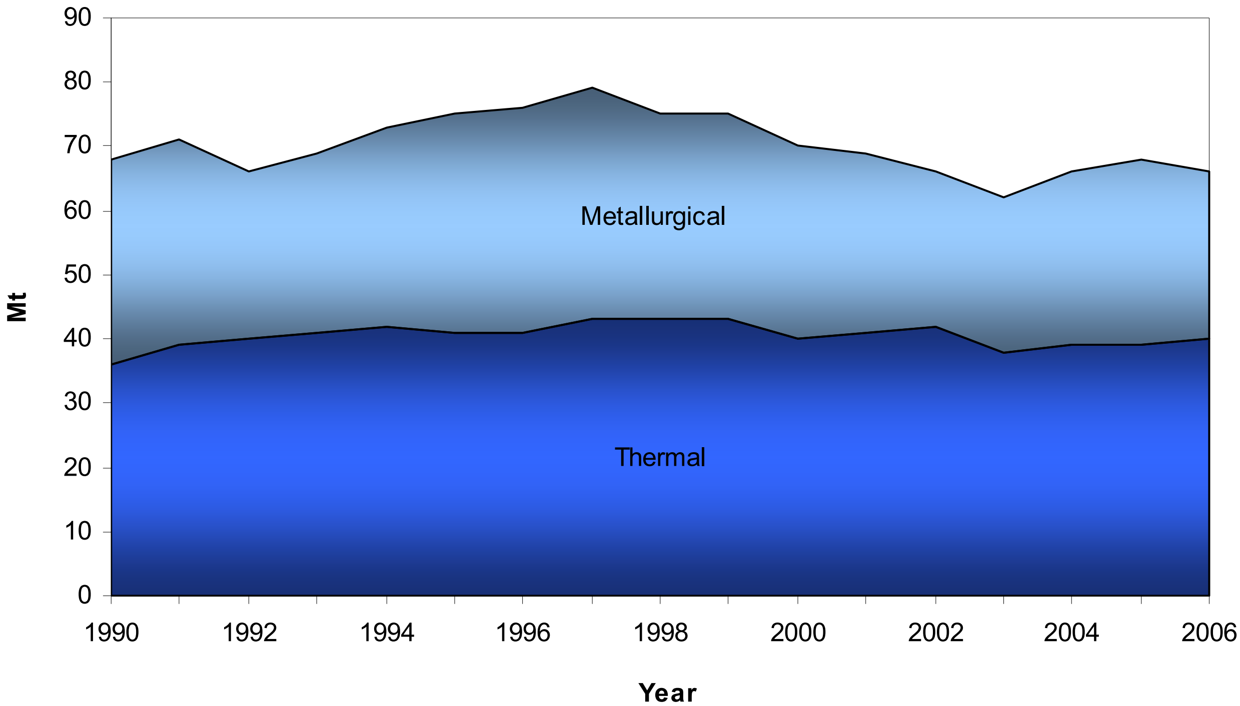
Coal production has remained relatively steady over the past decade. In 2006, Canada produced 66 megatonnes (Mt) of coal, a decline of 3.4 percent from 68.3 Mt in 2005 (see Figure 3.22).[42]

About 25 coal mines were operating in Canada at the end of 2006. British Columbia had 10 coal mines in operation; Alberta, 9; Saskatchewan, 3; and New Brunswick, 1. Nova Scotia had several small-scale mines without significant output. Canada's coal production in 2006 was mainly from Alberta and British Columbia, the two largest-producing provinces. They produced 32.0 Mt and 23.4 Mt of coal respectively.

Essentially all of Canada's metallurgical (or coking) coal – i.e. all of the production from British Columbia and part of Alberta's – was exported. Metallurgical coal is high-carbon coal that is transformed into coke and fed with iron ore into blast furnaces for primary steel production.

Almost all the thermal coal – i.e. all of the coal from Saskatchewan, New Brunswick and Nova Scotia and most of the coal from Alberta – was consumed domestically for coal-fired power generation.

FIGURE 3.22: CANADIAN COAL PRODUCTION

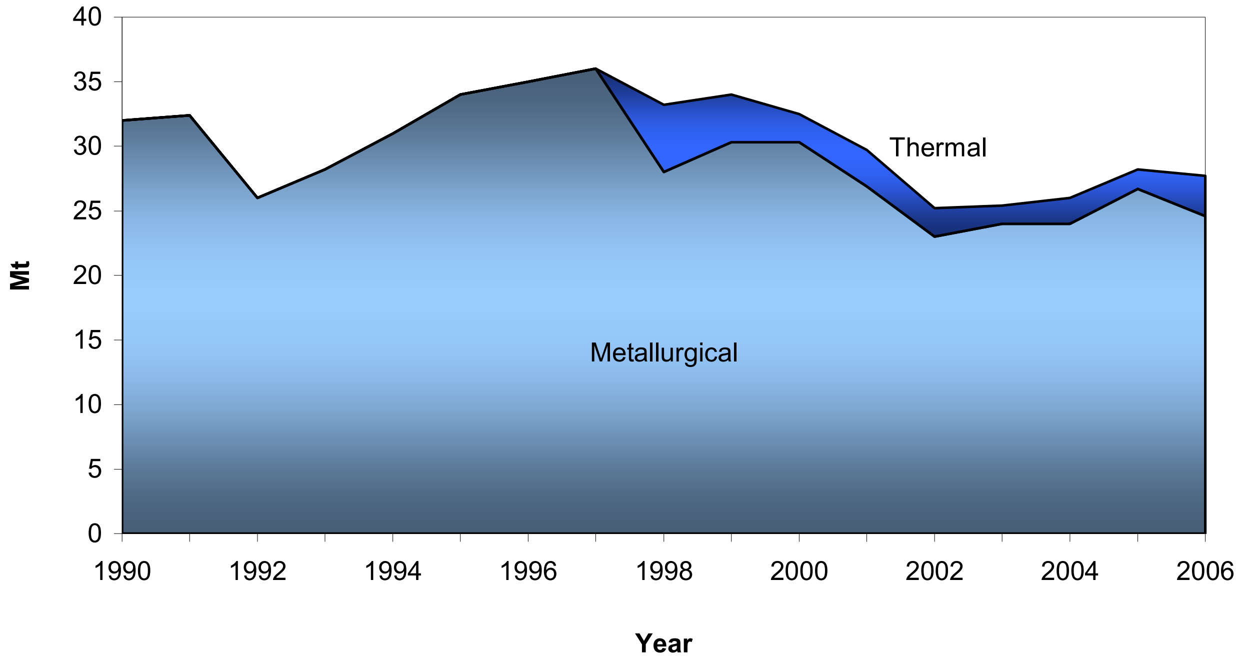


Source: NRCan, *Mineral and Metal Commodity Reviews* (2007), 2006 review of coal, p. 20.3.

3.4.4. Exports and imports

Coal exports are vital to the Canadian coal industry. [43] More than 40 percent of total production is exported. In 2006, Canada exported 27.7 Mt of coal, a decline of 2 percent compared with 2005. The value of these exports was $3.2 billion. While Canada is a mid-sized coal producer, it is a significant exporter of metallurgical coal (see Figure 3.23). In 2006, Canada exported 24.6 Mt of metallurgical coal.

FIGURE 3.23: CANADIAN COAL EXPORTS



Source: NRCan, *Mineral and Metal Commodity Reviews* (2007), 2006 review of coal, p. 20.4.

Asia is Canada's largest export *region,* accounting for more than half of total exports (see Table 3.1). Exports to this region increased by 3 percent in 2006 compared with 2005. Japan was the largest export *country*. Canada has significant exports to some European countries, too. Due to weaker demand in 2006, however, Canada's exports to Europe declined about 10 percent from 2005. Canada exports to several other countries, including the United States and Mexico and other countries in Latin America.

Canadian coal exports are mainly from Elk Valley Coal Corporation's five coal mines in British Columbia, with additional exports from Alberta. About 90 percent of exports were shipped through coal terminals in Vancouver. The rest was shipped through terminals in Prince Rupert in northern British Columbia.

TABLE 3.1: CANADA'S COAL EXPORTS, 2006

Destination	Exports (Mt)	Share (%)
Asia	15.2	55
Japan	8.7	31
South Korea	5.0	18
Europe	7.9	29
Latin America	2.4	9
United States and Mexico	2.0	7
Other	0.2	1
Total	**27.7**	**100**

Source: NRCan, *Mineral and Metal Commodity Reviews* (2007), 2006 review of coal, Table 1, "Canada, coal, production and trade, 2004–06," pp. 20.8–20.9.

While Canada is a net exporter of coal, it also imports coal to central and eastern Canada. This is due mainly to geography, since it is cheaper to obtain coal from the eastern and central regions of the United States than from Canada's western provinces. Canada imported 20.8 Mt of coal in 2006, similar to the volume imported in 2005. Of the total imports, 16.5 Mt was thermal coal, mainly for coal-fired electricity generation in Ontario, Nova Scotia and New Brunswick. Meanwhile, metallurgical coal imports were 4.2 Mt, consumed by Canada's primary steel industry in Ontario. Of the total coal imports, the United States supplied 17.9 Mt; the combined supply of Colombia, Venezuela and Russia was close to 3 Mt.

3.4.5. Consumption

Canada's coal consumption in 2006 was estimated to be 58 Mt.[44] Electricity generation consumed about 51 Mt, of which 37 Mt was supplied domestically and 15 Mt was imported. The ready availability and low cost of this resource makes coal the main fuel for electricity production in many provinces. Coal was used to produce about 74 percent of electricity in Alberta, 63 percent in Saskatchewan, 60 percent in Nova Scotia and 18 percent in Ontario (see Table 3.2). Canada's steel and cement and other industries consumed more than 4 Mt of coal.

TABLE 3.2: PROVINCIAL CONSUMPTION OF COAL, 2006

Province	Consumption (Mt)	Share (%)
Alberta	26.0	45
Ontario	16.0	28
Saskatchewan	11.0	19
Nova Scotia	2.4	4
New Brunswick	1.0	2
Quebec	0.8	1
Other	0.8	1
Total	**58.0**	**100**

Source: NRCan, *Mineral and Metal Commodity Reviews* (2007), 2006 review of coal, pp. 20.4–20.5.

3.4.6. Prices

Canadian coal exporters enjoyed near-record coal prices, averaging US$113/t for metallurgical coal during the 2006 coal year. [45, 46] This was the result of continuing demand increases and the tight supply on global coal markets. Canadian exporters settled various metallurgical coal contracts for the 2007 coal year at US$94–$97 per tonne.

3.4.7. Outlook

Canada is the world's second largest metallurgical coal supplier. Its metallurgical coal production and exports will benefit from the growing global demand for metallurgical coal in the short- to mid-term, because the forecast indicates that global demand will exceed supply. The long-term growth will depend on the global economy and the development of the steel industry because Canada's metallurgical coal is export oriented. Thermal coal production is expected to be stable.

Canada's coal consumption could eventually decline as a result of measures to reduce greenhouse gas (GHG) emissions, such as the closure or retrofit of coal-fired generation facilities. However, the development and implementation of technologies, such as carbon capture and storage and clean coal, could help sustain the use of coal for electricity generation in a carbon-constrained future.

3.5. URANIUM

3.5.1. Key descriptors

- The Canadian nuclear industry covers the entire nuclear-energy fuel cycle, from uranium mining, refining, conversion and fuel fabrication to nuclear reactor design, nuclear plant construction, maintenance, waste management and decommissioning.
- Canada has the world's largest reserves of high-grade, low-cost uranium, mostly in northern Saskatchewan. Canada is also the world's largest producer of uranium.
- Nearly 85 percent of Canada's uranium production is exported, and the rest fuels CANada Deuterium Uranium (CANDU) reactors in Canada.
- After many years of relatively low prices, uranium prices have increased dramatically since 2002. This has led to a frantic pace of exploration activity in Canada and around the world.
- With its resource base and current output, Canada is well positioned to maintain leadership in uranium production into the future.

3.5.2. Reserves

Canada has the third largest uranium reserves in the world, behind Australia and Kazakhstan.[47, 48] As of January 1, 2007, Canada's uranium reserves, recoverable from known mineral deposits at $100 per kilogram (kg) of uranium, amounted to 423 400 t, or 9 percent of the world's total.

The energy in 1 t of uranium is equivalent to 95 000 barrels of oil or 18 500 t of coal.[49] Canada's reserves are therefore equivalent to 42 billion barrels of oil or 8 billion tonnes of coal.

At current production rates, these known reserves will last more than 40 years. In addition, significant undiscovered resources are thought to exist, on the basis of geological evidence.

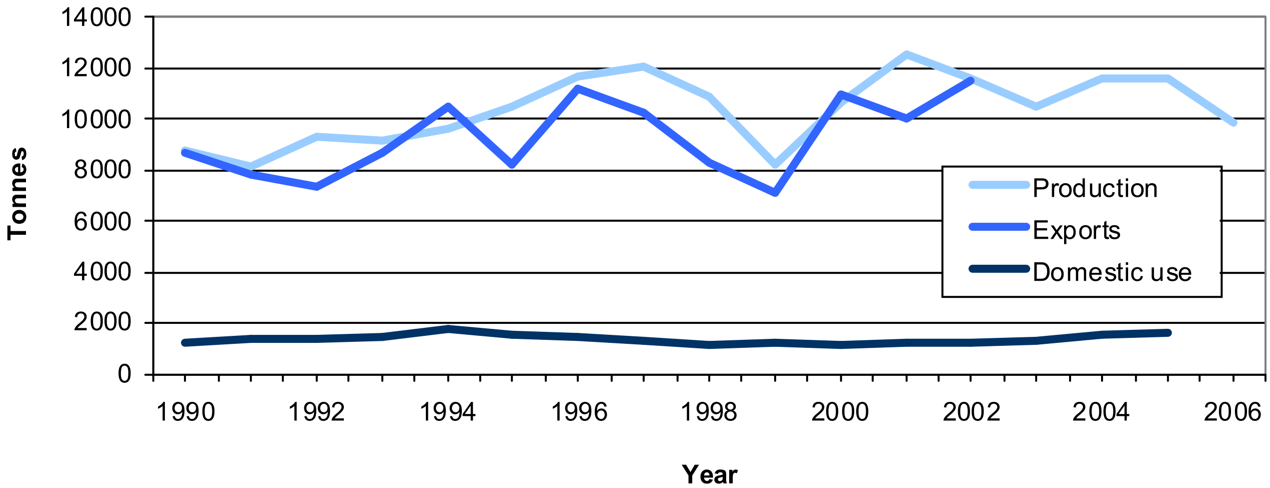
Most of Canada's reserves are in northern Saskatchewan, which hosts the world's largest high-grade deposits. For example, the grades average 22 percent uranium at the McArthur River mine, the highest-grade uranium mine in the world and Canada's largest producer. These average grades are from 10 to 100 times the average grades of deposits mined elsewhere in the world.

3.5.3. Production

Canada is the world's largest producer of uranium with 25 percent of the world's total. In 2006, Canada produced of 9862 t of uranium, valued at more than $615 million (see Figure 3.24).

Current production is from the McClean Lake, McArthur River and Rabbit Lake (Eagle Point) mines in northern Saskatchewan (see Figure 3.25). Two additional mines (Cigar Lake and Midwest) are scheduled to begin operations soon. Once the Cigar Lake mine begins operation in 2011, production capacity should increase to about 16 000 t of uranium per year. There is excellent potential to discover additional reserves in Canada and increase production further.

FIGURE 3.24: CANADIAN URANIUM PRODUCTION, EXPORTS AND DOMESTIC USE*



Sources:
Data on production and exports are from NRCan, Uranium and Radioactive Waste Division. (The division's publication of annual uranium exports ended in 2003.).

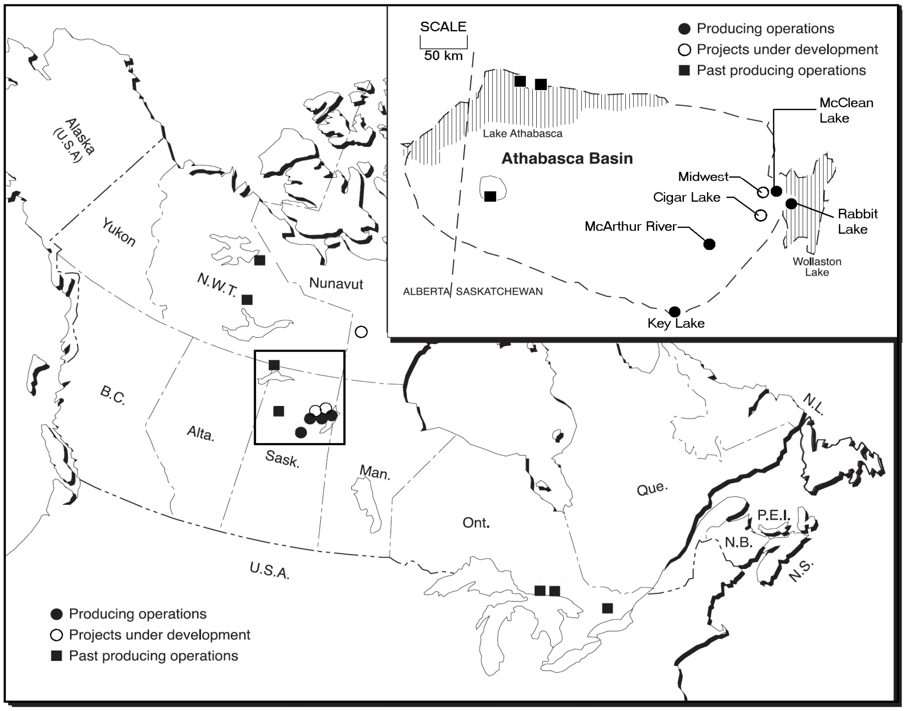
Data on domestic use are from Statistics Canada, *Electric Power Generation, Transmission and Distribution* (2006), Cat. No. 57-202-XIB, Table 6.

*Production may not equal the sum of exports and domestic use because of changes in the amount of stock.

3.5.4. Processing

The world's largest – and Canada's only – uranium refinery is at Blind River, Ontario. Uranium mine concentrates from Canada and abroad are refined to produce uranium trioxide. The product is shipped to a conversion facility in Port Hope, Ontario. The facility produces one quarter of the world's supply of uranium hexafluoride and the only supply of fuel-grade natural uranium dioxide. Uranium hexafluoride is exported to the United States and elsewhere around the world to produce enriched uranium fuel for light-water reactors. Uranium dioxide is shipped to fuel fabrication facilities in Port Hope and Peterborough, Ontario, to produce natural uranium fuel for CANDU reactors in Canada and abroad.

FIGURE 3.25: URANIUM MINING IN CANADA, 2006

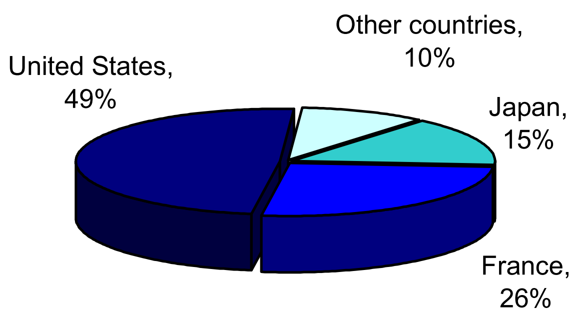


Source: NRCan, *Canadian Minerals Yearbook* (2006), Mineral and Metal Commodity Reviews, "Uranium," Figure 2, p. 59.3.

3.5.5. Exports and domestic consumption

Nearly 85 percent of Canadian uranium production is exported (see Figure 3.26). In recent years, about half of the exports went to the United States; one quarter, to France; and one eighth, to Japan. The rest of the uranium fuels domestic CANDU reactors. The domestic use of uranium decreased slightly in the late 1990s, while generation at some nuclear units was suspended.

FIGURE 3.26: CANADIAN URANIUM EXPORTS, COUNTRY OF FINAL DESTINATION, 1998–2002



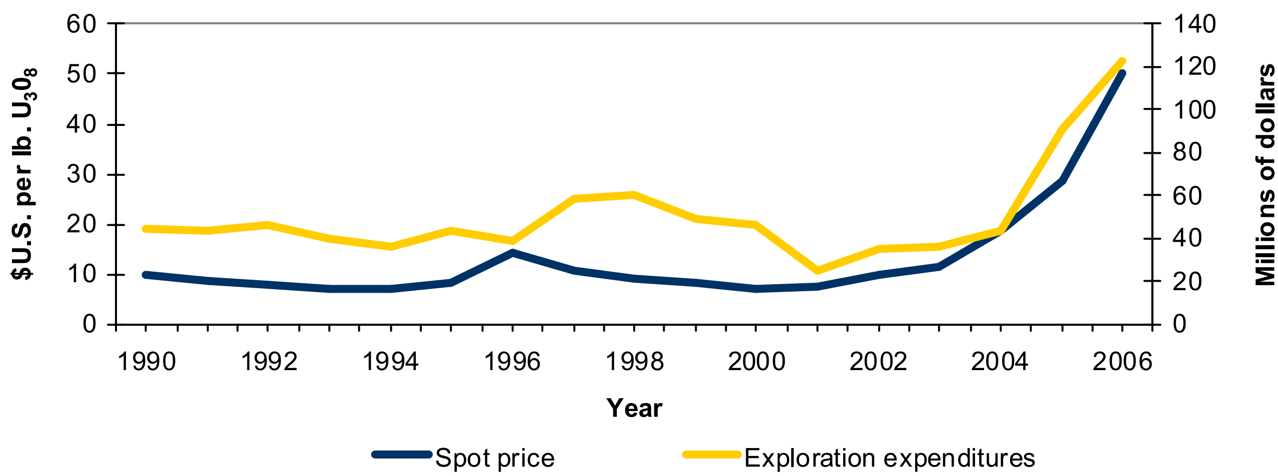
Source: NRCan, *Canadian Minerals Yearbook* (2003), Mineral and Metal Commodity Reviews, "Uranium," Figure 6, p. 58.9.

3.5.6. Prices

Overproduction in the 1970s and early 1980s and subsequent inventory liquidation, including that of former military inventories, kept uranium prices depressed in the 1990s. In fact, global uranium production has been running at less than 60 percent of consumption since the fall of the former Soviet Union at the end of 1991. However, these inventories are nearing exhaustion.

After many years of relatively low prices, uranium spot prices (i.e. prices for transactions that are based on the short term) have increased tenfold since 2003. They reached US$135 per pound (lb.) of uranium oxide concentrate (U_3O_8) at the end of June 2007. Prices are expected to remain high because supply continues to struggle to meet demand. This trend will likely continue until additional production capacity is developed in Canada and in the rest of the world.

FIGURE 3.27: URANIUM SPOT PRICES AND EXPLORATION EXPENDITURES



Sources:
TradeTech, www.uranium.info.

NRCan, *Survey of Mineral Exploration, Deposit Appraisal and Mine Complex Development Expenditures* (2006).

Spot prices for uranium affect expenditures on exploration activities (see Figure 3.27). Such expenditures are expected to lead to increased production.

3.5.7. Outlook

The dramatic increase in uranium spot prices has fuelled a tremendous increase in exploration activity. More than 200 junior mining companies are involved, many for the first time. Exploration expenditures, including underground exploration at existing mines, increased from $36 million in 2003 to $213 million in 2006.[50] In addition to the Athabasca basin in Saskatchewan, active uranium exploration programs are under way in Nunavut, the Northwest Territories, the Yukon Territory, Newfoundland and Labrador, Quebec, Ontario, Manitoba, and Alberta.

There have already been early indications of success, but it will take several years for the uranium industry to fully respond to the current supply/demand imbalance. Stringent regulations mean that average mine development ranges from 10 to 15 years.

Continued improvement in the political climate for nuclear energy, including rapid nuclear development in China and India, suggests that the demand for uranium will increase. Significant quantities of Canadian uranium will need to be produced to meet global demand, well into the foreseeable future. With a large, high-grade, low-cost uranium resource base and current output, Canada is well positioned to maintain leadership in uranium production.

3.6. RENEWABLE ENERGY

3.6.1. Key descriptors

- Canada, with its large land mass and diversified geography, has substantial renewable energy resources, including bioenergy and hydro, wind, geothermal, solar and ocean energy.
- Renewable energy resources contribute about 16 percent to Canada's primary energy supply:
  - Hydroelectricity is the most important product of renewable energy resources produced in Canada, providing more than half of the country's electricity.
  - Various types of biomass also contribute significantly to Canada's energy supply.
  - Several emerging sources, such as wind and solar energy, are experiencing high growth rates.
  - Production of biofuels, such as ethanol, is increasing in Canada as production facilities are built. Biofuels are expected to account for 2 percent of the energy use for on-road transportation by 2008.

3.6.2. Renewable energy resources

Renewable energy resources are characterized by their ability to provide a sustainable source of energy. Some resources, such as wind, solar and tidal energy, are not at risk of depletion. Others, such as bioenergy, continue to be renewable only if the rate of consumption is equal to or below the rate of regeneration.

With its large land mass and diversified geography, Canada has an abundance of renewable energy resources. These resources include hydro, wind, geothermal, solar and ocean energy and bioenergy. The availability and quality of renewable resources varies from region to region across Canada.

Renewable energy resources already play a role in Canada's energy mix. They provided 16.2 percent of the primary energy supply in 2005 (see Table 3.3). These resources are used to produce electricity, thermal energy and transportation fuels. Hydroelectricity is by far the most important product of renewable energy resources produced in Canada. Several emerging resources, such as wind and solar power, are making much smaller contributions but are experiencing high growth rates.

TABLE 3.3: PRIMARY ENERGY SUPPLY FROM RENEWABLE RESOURCES, 2005

Renewable resource	Total primary supply (percent)
Hydro	11.5
Wind	<1.0
Solar/tide	<1.0
Geothermal	n/a
Combustible renewables and waste*	4.6
Total renewable energy supply	**16.2**

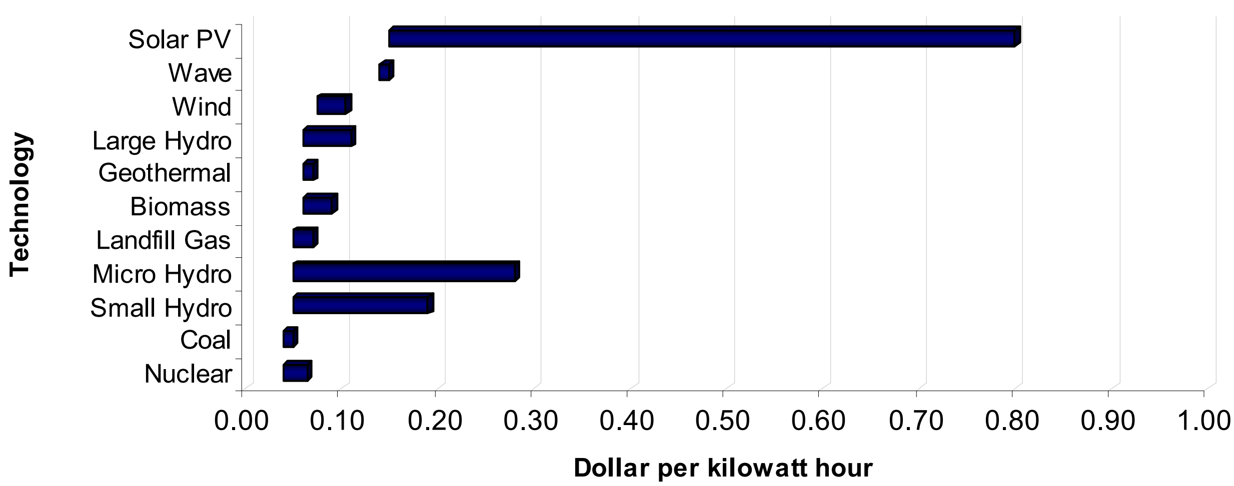
Source: International Energy Agency, *Renewables Information 2007*, pp. 19 and 109.

*Combustible renewables and waste include solid biomass, liquid biomass, renewable municipal waste and biogas.

The contribution of renewable energy resources other than hydro is relatively small. This is due in part to their relatively high cost of production. For example, electricity generation technologies have a range and magnitude of costs of production (see Figure 3.28).

Several key benefits can be claimed from the use of renewable energy resources. Most noted is the potential contribution to reductions in GHG and air pollutant emissions. Other benefits, such as energy diversification, are possible.

FIGURE 3.28: RELATIVE COSTS OF ELECTRICITY GENERATION TECHNOLOGIES, 2003



Source: Canadian Energy Research Institute, *Relative Costs of Electricity Generation Technologies* (2006), p. 3, www.ceri.ca/documents/CERIComparativeCostsSept2006.pdf.

In recognition of these benefits, the federal and many provincial and territorial governments encourage the incremental use of renewable energy through various mechanisms. These mechanisms include tax incentives, production incentives, requests for proposals[51] (RFPs), renewable portfolio standards[52] (RPSs) and standard offer contracts[53] (SOCs). They are helping to increase the market penetration of renewable energy technologies, such as wind, biomass, small hydro and solar photovoltaics.

In Canada, electricity is by far the most common product of the use of renewable energy resources (other products include thermal and mechanical energy). As such, most of the information available on the use and potential of renewable energy resources is on electricity generation. Moreover, information on renewable energy resources is less well documented than that for conventional non-renewable sources. For these reasons, this section will provide a cursory review of most of the renewable energy resources in Canada. Information on their use for electricity generation is provided in Chapter 4, “Electricity.” Biofuels, however, will be discussed in greater detail in this section.

3.6.3. Hydro energy

The natural flow of water can be used as a source of energy. Canada is characterized by a large number of rivers flowing from mountainous areas (e.g. the Canadian Shield, Rocky Mountains) toward its three bordering oceans. Before the invention of electricity, the flow of rivers provided mechanical power for transformation activities, such as milling and sawing.

Today conventional hydroelectricity – i.e. electricity produced from turbines turning from the flow of rivers – is the most important renewable energy resource in Canada. It provides almost 60 percent of electricity production. By the end of 2005, Canada had an installed hydro capacity of 71 978 megawatts (MW).[54]

It is thought that significant hydro resources that may be economically and environmentally acceptable remain in many provinces and territories. But no comprehensive estimates of this potential exist.

Notable large-scale hydro projects are under consideration, however. They include the Conawapa generating station (1250 MW) in northern Manitoba, the Lower Churchill Project (2824 MW) in Newfoundland and Labrador, and the Romaine River project (1550 MW) in Quebec. TransCanada Corporation and ATCO Power are studying the feasibility of building a large hydro dam at Slave River in northeast Alberta, which could represent an installed capacity of 2000 MW.

In addition to projects involving large dams or reservoirs, there is potential for small- and medium-scale run-of-the-river hydro developments, particularly in British Columbia, Ontario and Quebec.

3.6.4. Ocean energy

Bordering only the United States to the south, much of Canada is surrounded by ocean. It provides access to the energy that can be harnessed from its natural movement, including that of tidal currents and ocean waves.

Canada has a total installed capacity for ocean energy of 20 MW, in a tidal barrage, or dam, in Annapolis Royal, Nova Scotia, in operation since 1984. Recently, a technology demonstration project using a Canadian-designed tidal current turbine with a 0.065-MW installed capacity was located at Race Rocks, British Columbia. In addition, four tidal-current demonstration projects are proposed for the Bay of Fundy, between New Brunswick and Nova Scotia.

Ocean energy is still an emerging sector with a range of technologies under development. The degree of development of ocean energy technologies varies across several countries. The most advanced activities are in the United Kingdom and the United States.[55] The waters off Canada’s coasts offer significant theoretical potential for wave and tidal-current energy. Preliminary studies estimate a total gross resource potential of 225 000 megawatts (MW).[56] However, assessment of the economic potential for ocean energy is still under development. The relative cost of generating electricity from ocean energy, e.g. wave power (see Figure 3.28), is estimated to be quite high compared with some other emerging renewable technologies.

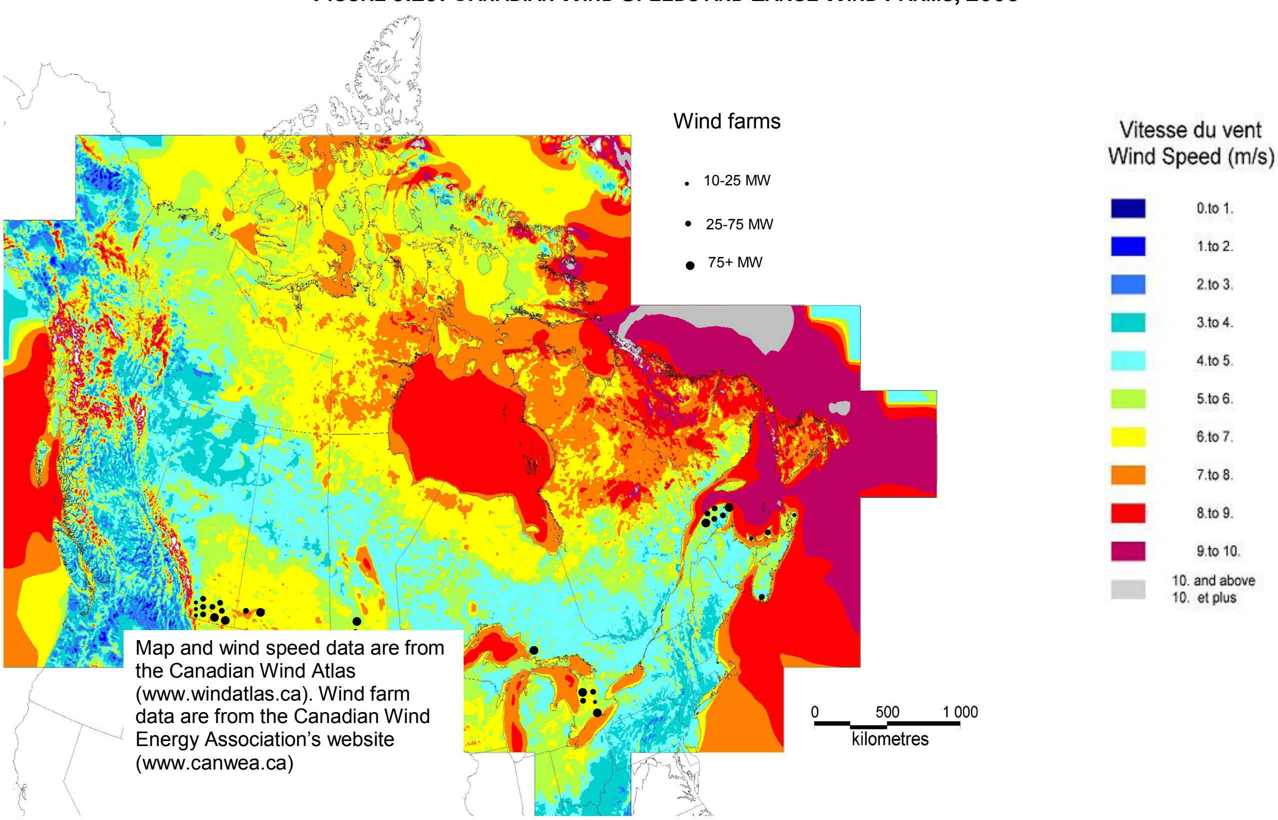
3.6.5. Wind energy

Wind energy has been harnessed for centuries to propel sailing vessels and as the prime mover for grist mills and water pumps. These uses have waned. Today the most important use of wind energy in Canada is for the generation of electricity. The wind power capacity in Canada reached 684 MW in 2005, a 55 percent increase over 2004. Growth continued since then, and installed capacity nearly tripled by the end of 2007, reaching 1846 MW.

The quality of Canada's wind resource can be measured by its annual average velocity (see Figure 3.29). The country has a high-quality wind resource in remote areas and offshore. A number of large wind farms have been built on land in recent years to take advantage of this resource. Although no offshore wind farms have been built in Canada, the excellent quality of the resource may offset the additional costs incurred from offshore construction.

There is significant potential for the expanded use of wind energy to generate electricity. However, there may be limitations because of the variability of the resource. Wind turbines generate electricity only when the wind is blowing within a particular range of speed. As well, variations in availability cause wide fluctuations in the amount of electricity produced. Moreover, the electricity grid must remain in balance to maintain grid stability, so the variability of wind energy presents a challenge. Electricity storage technology could minimize or eliminate this effect, but major cost-reducing technological advances would still be required.

FIGURE 3.29: CANADIAN WIND SPEEDS AND LARGE WIND FARMS, 2005



Source: Environment Canada, Canadian Wind Energy Atlas, www.windatlas.ca.

The maximum penetration rate of wind power for a given market depends on many factors. It is different for every jurisdiction. Some studies have determined that Canadian markets could support a total installed wind capacity accounting for up to 10 percent of overall installed generation capacity without changes to the electrical system. Grid enhancements could allow for wind power capacity beyond 10 percent. Considering that wind's penetration rate in Canada is 1.5 percent, there is significant room for growth.

3.6.6. Solar energy

The sun's radiant energy can be used to generate electricity, heating, cooling and steam and to provide light. Solar energy has typically been used through passive solar technologies, such as the strategic location of buildings and windows. Today, two other categories of technologies are used: active solar thermal systems, such as solar water- and space-heating technologies, and solar electric (photovoltaic [PV]) systems, which produce electricity.

Canada's use of solar energy is still relatively small, but the market continues to grow. Canadian solar thermal installed capacity[57] in 2005 was 419 000 square metres (m^2) (290 $MW_{thermal}$). Since 1988, growth has averaged 17 percent per year. In 2005, the market for solar thermal collectors was 61 500 m^2, 7 900 m^2 more than in 2004.

While the market is growing, the overall contribution of solar energy to thermal energy use in Canada is still small. For example, the total water-heating energy use for the residential sector in 2004 was 247 petajoules (PJ).[58] Of this amount, solar water heating provided only about 0.013 petajoules,[59] or less than 1 percent.

Canadian total PV installed capacity has experienced sustained domestic market growth. Since 1992, it has averaged 22 percent per year. In 2006, the total PV capacity was 20.5 MW.[60] The market is mainly for off-grid applications, which represent 93 percent of the total solar PV installed capacity.

Ontario's Renewable Energy Standard Offer Program (RESOP) is the most aggressive incentive program for solar PV in Canada. Under the RESOP, eligible solar PV projects with a nameplate capacity of less than 10 MW will enter into 20-year contracts with the Ontario Power Authority. Proponents will be paid a guaranteed fixed rate of $0.42 per kilowatt hour (kWh) of electricity delivered to their local electricity distribution company. As of October 31, 2007, the RESOP had received 114 applications. These projects total 189 MW of solar PV installed capacity, or nine times the current capacity in Canada.[61]

Interactive maps[62] of the PV potential and solar resource of Canada have been developed (see application in Table 3.4 and Figure 3.30). The PV potential varies across Canada. The potential is lower in coastal areas, due to increased cloud coverage, and is higher in the central regions. The PV potential varies even more around the globe. Some areas have a higher PV potential than Canada, while others have a lower one. In general, many Canadian cities have a PV potential that is comparable to that of many major international cities.

TABLE 3.4: YEARLY PV POTENTIAL OF MAJOR CANADIAN AND WORLD CITIES (LATITUDE TILT*)

Canadian city	Annual PV potential (kWh/kW)
Regina, SK	1361
Calgary, AB	1292
Winnipeg, MB	1277
Edmonton, AB	1245
Ottawa, ON	1198
Montréal, QC	1185
Toronto, ON	1161
Fredericton, NB	1145
Québec, QC	1134
Charlottetown, PE	1095
Yellowknife, NT	1094
Halifax, NS	1074
Iqaluit, NU	1059
Vancouver, BC	1009
Whitehorse, YT	960
St. John's, NL	933

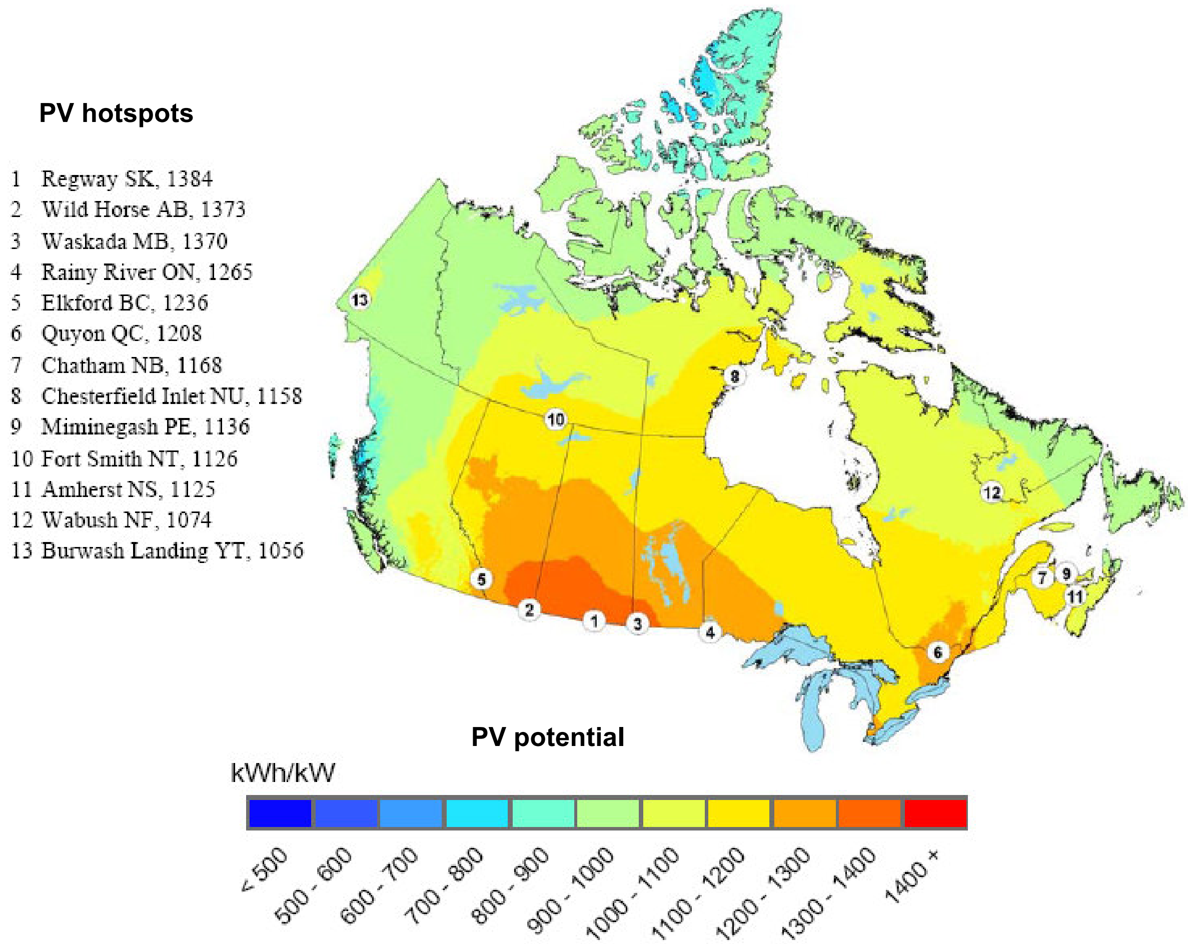
International city	Annual PV potential (kWh/kW)
Cairo, Egypt	1635
Cape Town, South Africa	1538
New Delhi , India	1523
Los Angeles, United States	1485
Mexico City, Mexico	1425
Sydney, Australia	1343
Rome, Italy	1283
Rio de Janeiro, Brazil	1253
Beijing, China	1148
Washington, D.C., United States	1133
Paris, France	938
Tokyo, Japan	885
Berlin, Germany	848
Moscow, Russia	803
London, United Kingdom	728

Source: NRCan, *The Development of Photovoltaic Resource Maps for Canada* (2006), p. 8, http://cetc-varennes.nrcan.gc.ca/fichier.php/codectec/Fr/2006-046/2006-046_OP-J_411-.

*These measurements are taken by tilting the solar panel to the angle of its latitude.

In theory, there is considerable potential for solar energy use in Canada. About 46 percent of Canada's residential electricity needs could be supplied by building-integrated photovoltaics (BIPV) technology.[63] And about 29 percent of the electricity consumed by residential, commercial and institutional buildings could be supplied by solar PV systems. Nevertheless, like wind energy, solar energy is a variable resource. It has similar limitations to its use without the development of economical energy-storage technologies. Furthermore, solar energy technologies are estimated to be expensive relative to other emerging renewables (see Figure 3.28 on p. 57).

FIGURE 3.30: YEARLY PV POTENTIAL MAP (LATITUDE TILT) AND THE 13 "PV HOTSPOTS" IN CANADA



Source: NRCan, *The Development of Photovoltaic Resource Maps for Canada*, p. 8, http://cetc-varennes.nrcan.gc.ca/fichier.php/codectec/Fr/2006-046/2006-046_OP-J_411-SOLRES_PV+map.pdf.

3.6.7. Geothermal energy

Energy can be produced from the earth in at least two manners. First, heat from naturally occurring underground steam can be captured to produce electricity. Canada has a limited steam resource, but electricity generation projects are being considered.

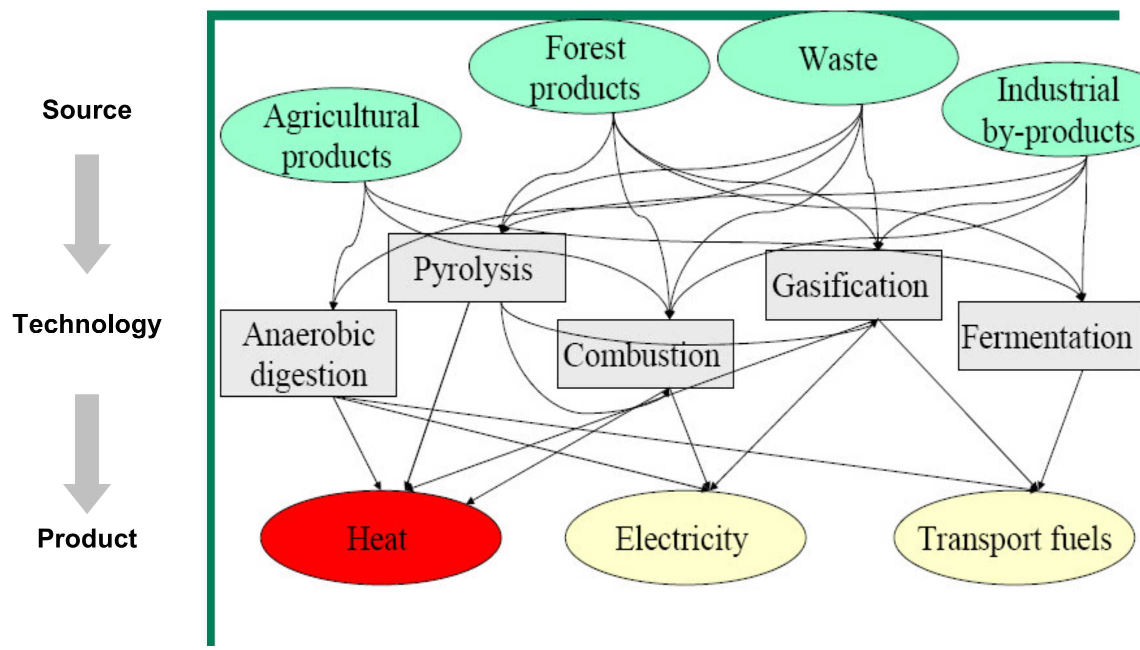
Second, heating and cooling can be produced by taking advantage of the temperature difference between outside air and the ground or ground water (usually at a depth of a few metres). A ground-source heat pump uses the earth or ground water as a source of heat in the winter and as a "sink" for heat removed from indoor air in the summer. By 2006, about 3150 ground-source heat pump units had been installed in residential, commercial and institutional buildings across Canada.[64]

Estimates of the potential for geothermal energy use in Canada are not available, however. Further market penetration requires decreased production costs and access to certified vendors.

3.6.8. Bioenergy

Biological sources can be used to produce energy. The term "biomass" can refer to any plant-derived organic matter available on a renewable basis, in a solid, liquid or gaseous form. Canada has access to considerable sources of biomass, including forest biomass, municipal solid waste and landfill gas.

FIGURE 3.31: THE BIOENERGY MATRIX



Source: International Energy Agency (IEA), IEA Bioenergy Web site, www.ieabioenergy.com.

Biomass has been an important source of energy for centuries. Historically, the most important energy resource in Canada was biomass in the form of wood and wood waste. However, the use of biomass has expanded from traditional uses, such as residential heating. Its uses include electricity generation, biofuels production, intermediate chemicals and various bioproducts (see Figure 3.31). This expansion is the result of such factors as improved economic viability, due to the increasing cost of fossil fuels; the drive for sustainable energy options; and the consideration of biomass combustion as carbon-neutral.[65]

Today in Canada, biomass is used primarily for home heating and, in industry, for generating electricity and process heat, especially in the forest industry. Electricity from biomass – in the form of wood refuse, spent pulping liquor and landfill gas – is second only to hydroelectricity in total electricity generation from renewable energy resources. Five provinces have more than 90 percent of the biomass installed generating capacity in Canada: British Columbia, Alberta, Ontario, Quebec and New Brunswick (see Table 3.5).

TABLE 3.5: CANADA'S BIOMASS INSTALLED GENERATING CAPACITY, BY PROVINCE AND FUEL, 2005 (MW)

Province	Wood refuse	Spent pulping liquor	Landfill gas	Total biomass
Prince Edward Island	2	0	0	2
Nova Scotia	41	25	0	66
New Brunswick	79	49	0	129
Quebec	244	23	29	295
Ontario	183	91	73	346
Manitoba	22	0	0	22
Saskatchewan	0	63	0	63
Alberta	104	35	6	145
British Columbia	184	411	7	602
Canada	**860**	**696**	**114**	**1670**

Sources:
Statistics Canada, *Electric Power Generating Stations 2005* (2006), (Cat. No. 57-206-XIB).

Environment Canada, Waste Management Web site, Landfill Gas section, www.ec.gc.ca/wmd-dgd/default.asp?lang=En&n=4EDBA138-1.

Canada has a significant supply of many types of biomass, ranging from forest and agriculture crops and residues to municipal wastes. Biomass materials are available in different quantities in different parts of the country. Some materials are concentrated in and around urban areas, industrial facilities or farms. Others need to be collected from agricultural fields and cut blocks. Also, some materials (e.g. municipal solid waste) are available year-round. Others are generated on a seasonal basis and require storage. Moreover, natural factors, such as forest fires and insect epidemics (e.g. mountain pine beetle), can have an impact on the amount of biomass available as a feedstock for energy production.

Biofuels and biogases are starting to become part of the energy mix in Canada. The installed generating capacity from landfill gas is relatively small. However, over the next decades, heat and electricity generated from municipal solid waste, municipal wastewater, manure and solid and liquid organic wastes (from the pulp and paper industry and the food and beverage industry) are expected to increase.

Barriers to the use of bioenergy persist. They include the comparatively high cost of production relative to fossil energy resources, resulting in long payback periods and high capital costs. Contributing to the high costs are the location of residues with respect to users, the ability to secure a sufficient supply of residues, biomass quality and prices, access to markets for bioenergy products, potential environmental impacts, the loss of forest productivity and negative public perceptions.

While biomass has many energy benefits, several environmental challenges are associated with them. For example, incinerating solid waste creates a small amount of solid waste and residues that is hazardous waste, due to elevated levels of lead, cadmium, dioxins and salts.

In addition, residential wood burning produces substantial quantities of air pollutants, including fine particles, carbon monoxide, nitrogen oxides, hydrocarbons and volatile organic compounds. When their concentration in the outdoor air increases, these pollutants may cause minor irritations to the eyes or throat, headaches, nausea and serious respiratory trouble for vulnerable people, including children, senior citizens and people with respiratory or heart problems.

In 2005,[66] the residential sector in Canada used 106 PJ of energy from wood. Of this amount, 91 percent was used for space heating. Using wood for space heating represented 11 percent of the total energy use in Canadian households. In Montréal, nearly 100 000 households[67] use wood combustion systems. Because the systems are concentrated in a small area, they are causing air pollution.

3.6.9. Biofuels

In this document, biofuels or renewable fuels are defined as energy resources derived from biological material, mostly plants, that are used as fuels for transportation.

Conventional renewable fuels use grains to produce ethanol, a substitute for gasoline. The principal Canadian agricultural feedstocks for ethanol production are corn and wheat. Canada is a major world producer and exporter of grains.

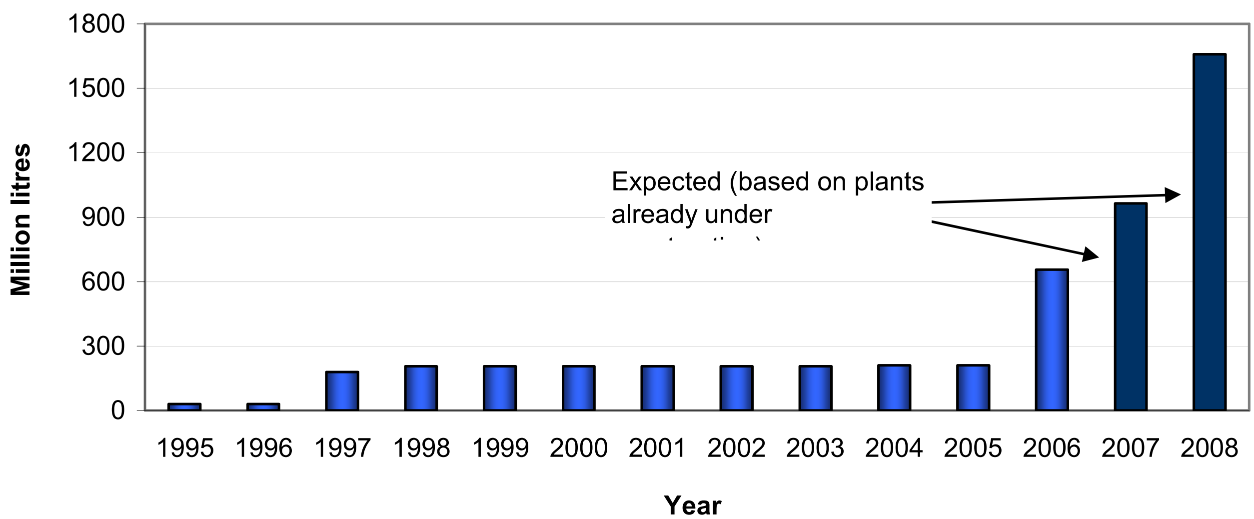
Conventional renewable fuels also use vegetable oils and animal fats to produce biodiesel, a substitute for diesel. Canada produces significant biodiesel feedstocks, including canola, soybeans and tallow.

Next-generation renewable fuels are being developed and introduced in the market. These fuels will be produced with new technologies that could use non-food sources as feedstocks.

Production of biofuels

The production of renewable fuels has increased in Canada since the appearance of ethanol in Manitoba's fuels in the 1980s. In 2006, the domestic production capacity for renewable fuels was about 600 million litres (L) per year (yr) for ethanol and 100 million L/yr for biodiesel (see Figure 3.32). This production capacity is expected to increase to 1.6 billion L/yr by 2008, based on plants that are under construction.

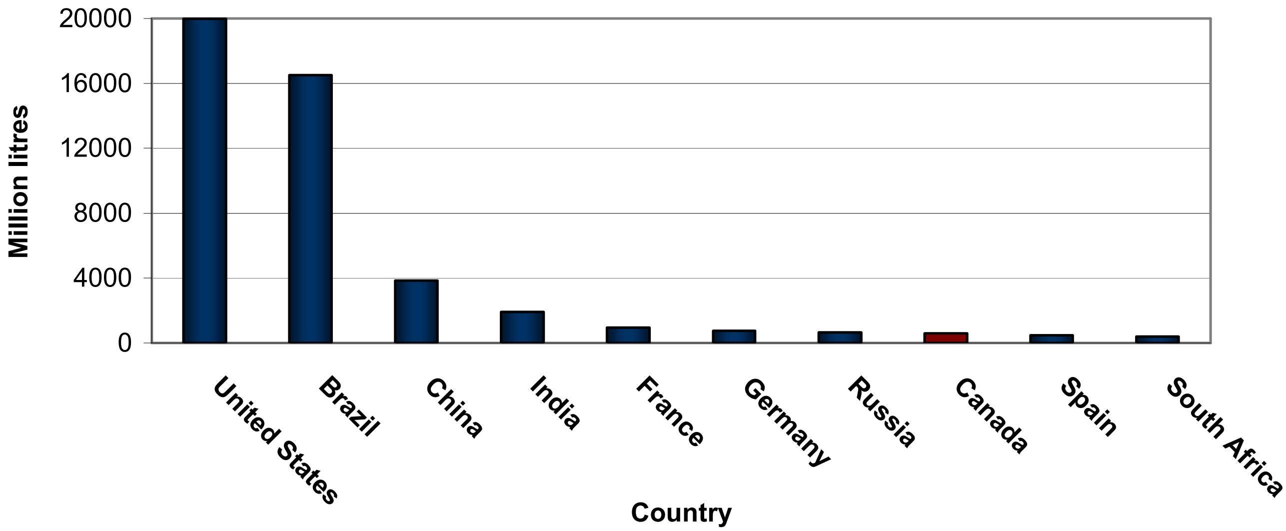
FIGURE 3.32: RENEWABLE FUELS' PRODUCTION CAPACITY



Source: NRCan, based on program reporting and public information.

The global production of renewable fuels has long been on the rise in other countries, driven by such issues as energy diversity and security, environmental benefits and agricultural investment. Canada is one of the top producers of renewable fuels, but it is far behind other nations, such as the United States, Brazil and China (see Figure 3.33). These countries invest significantly in the production of both conventional and next-generation renewable fuels.

FIGURE 3.33: TOP 10 WORLD ETHANOL PRODUCERS, 2006

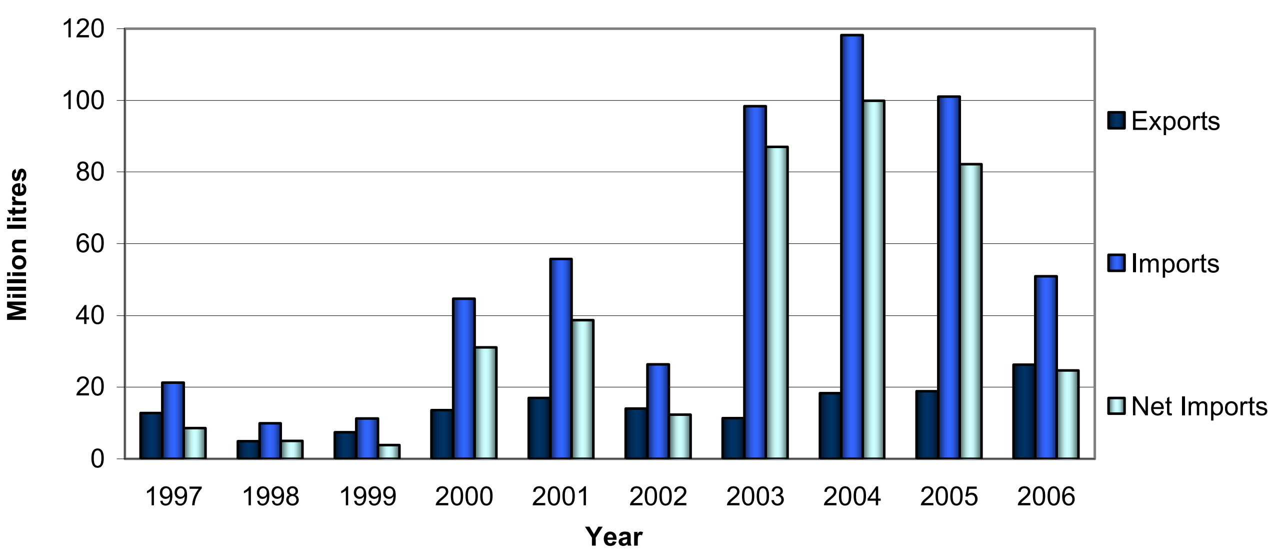


Source: *F.O. Licht's World Ethanol & Biofuels Report*, vol. 5, no. 5 (November 3, 2006).

Exports and imports

The trade of renewable fuels has been increasing over recent years. The trend has been toward the net importation of renewable fuels, such as ethanol, to Canada (see Figure 3.34). The majority of ethanol imports are from the United States, with some from Brazil. There is trade in biodiesel between Canada and the United States; however, export data are not readily available for biodiesel.

FIGURE 3.34: CANADIAN TRADE IN ETHANOL



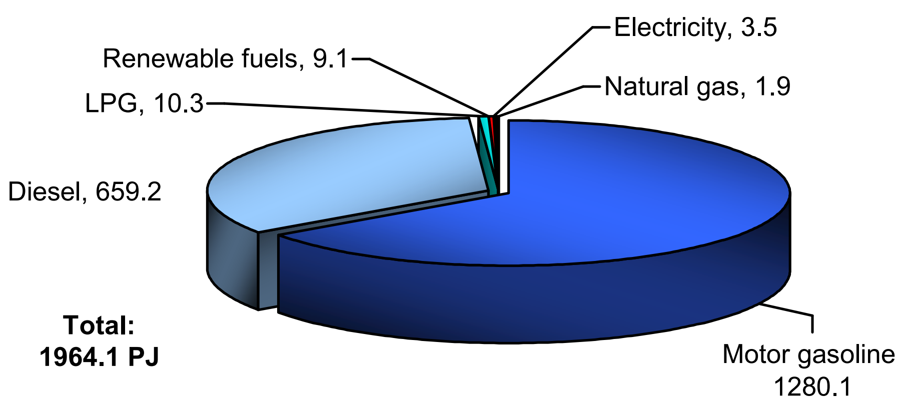
Source: Custom tabulations prepared for NRCan by Statistics Canada's International Trade Division, 2006.

There are no restrictions on the import and export of renewable fuels between Canada and the United States. Canada does impose a relatively minor tariff of $0.049 per litre on ethanol imported from countries that are not members of the *North American Free Trade Agreement*, such as Brazil. Conversely, the United States has a significant tariff on ethanol imported from other countries, including Brazil, of approximately $0.15 per litre (US$0.54 per gallon).

Consumption of biofuels

Vehicles operating on gasoline and made after 1980 can use up to 10 percent ethanol. Many diesel manufacturers offer a warranty on the use of blends that are 5 percent or more biodiesel. In 2005, renewable fuels amounted to 9.1. PJ, or less than 0.5 percent, of on-road transportation energy use in Canada (see Figure 3.35). This renewable fuel consumption was predominately ethanol blended with gasoline in low-level ethanol blends. By 2008, the use of renewable fuels by the on-road transportation sector is expected to account for 2 percent of energy use.

FIGURE 3.35: ENERGY USE BY THE ON-ROAD TRANSPORTATION SECTOR, 2005 (PJ)



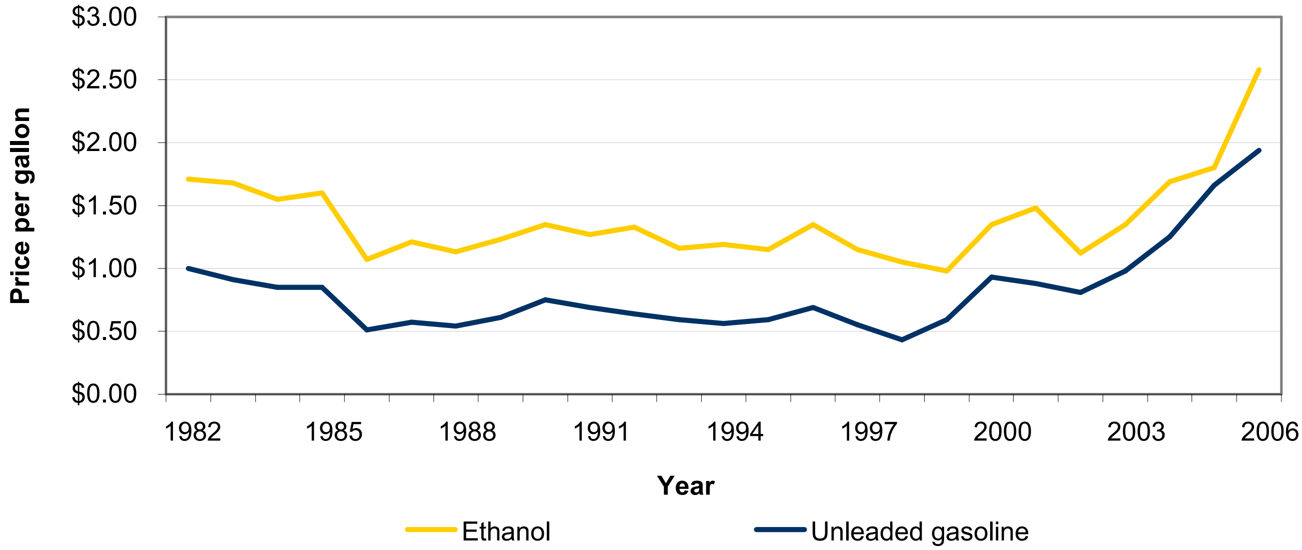
Source: NRCan, National Energy Use Database (1990 to 2005), Energy Use Data Handbook Tables (Canada), Transportation Sector, http://www.oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

*LPG is liquefied petroleum gas.

Prices

Ethanol has a North American price with slight regional variations based on supply and demand. There has been a high level of correlation between the price of gasoline and the price of ethanol (see Figure 3.36). Traditionally, in a non-regulated environment, there has not been a significant correlation between the price of ethanol and feedstock prices.

FIGURE 3.36: ETHANOL AND UNLEADED GASOLINE PRICES IN NEBRASKA, U.S.



Source: Nebraska Ethanol Board and Nebraska Energy Office, http://www.neo.ne.gov/statshtml/66.html

Outlook

During the past few years, federal and provincial governments in Canada have announced several measures to increase the production and use of biofuels. For instance, the Government of Canada intends to regulate the use of 5 percent renewable-fuel content based on the gasoline pool by 2010 and the use of 2 percent renewable-fuel content in diesel and heating oil by 2012. It has also announced programs to encourage the production of renewable fuels, support farmer participation in the biofuels industry and encourage the deployment of next-generation technologies. Several provincial governments have also made announcements on regulations and incentives for renewable fuels.

These governmental measures will improve the domestic investment environment for the production of conventional and next-generation renewable fuels (supply). They will also help develop a market in which producers can sell the fuel (demand).

However, there are challenges that may affect the production of renewable fuels in Canada. These challenges include the rising prices of feedstocks, the recent fall of ethanol prices and the uncertainty of investor interest.

Research and development in feedstocks and technology for next-generation renewable fuels has been extensive. Next-generation renewable fuels are made from non-food sources, such as agricultural residues, forest biomass and municipal waste. These fuels would provide substantially greater environmental benefits than conventional renewable fuels.

Technologies that are at the commercial or pre-commercial stage include the following:

- Synthetic renewable diesel, such as the “SuperCetane” process patented by NRCan
- Synthetic renewable diesel from gasification and other processes, which is at the demonstration stage by such companies as Enerkem Inc.
- Biobutanol, a renewable fuel, including that announced by DuPont and BP p.l.c.

- Cellulosic ethanol produced from agricultural residue, such as wheat straw, which is at the demonstration stage by such Canadian companies as Iogen Corporation and Lignol Energy Corporation

However, next-generation technologies have yet to overcome the hurdles to commercial viability. They continue to face significant financial barriers. Access to capital and consumer investment confidence are the biggest challenges to the commercial development of next-generation technologies.

CHAPTER 4: ELECTRICITY

4.1. CHAPTER SUMMARY

- The structure of the electricity sector has been evolving over the past decade due to policy and technological developments. A decade ago, vertically integrated monopolistic provincial Crown corporations relied on large generation facilities for the power supply. Today, in some provinces, more competitive systems have been adopted, with the private sector playing an increasing role, and many generation, transmission and distribution services have been unbundled.

- Electricity in Canada is generated from a diversified mix of sources. More than half of the electricity comes from hydroelectricity, which is especially important in Quebec, British Columbia, Ontario, Newfoundland and Labrador, and Manitoba because of favourable geography. Other key energy resources for electricity generation include, in order of importance, coal, uranium, natural gas, oil and non-hydro renewables.

- Canada trades a small proportion of its electricity supply with the United States. Exports amounted to $2.5 billion in 2006, while imports totalled $1.2 billion. Canadian utilities with hydroelectric storage capacity have significant export sales during peak periods, while jurisdictions such as Ontario depend on U.S. imports year-round.

- Electricity demand in Canada has grown at an annual average rate of 1.5 percent since 1990. The industrial sector accounts for the largest share of electricity demand, fuelled by the presence of some energy-intensive industrial activities. Residential electricity use varies across the country, because electric space heating, rather than natural gas, is used extensively in some provinces.

- Economic growth and the greater use of electrical appliances and equipment is expected to continue to drive electricity demand. Uncertainty about market rules, project-approval timelines and environmental regulations has dampened the investment climate for large capital electricity projects.

- Increases in Canada's peak demand coupled with limited investment in new generation facilities have reduced reserve margins across the country over the past decade. Certain regions, including British Columbia and Alberta, will need additional resources in the near term to ensure adequate reserve margins. For many jurisdictions in Canada, however, forecasts indicate an improvement in reserve margins.

4.2. Industry Structure

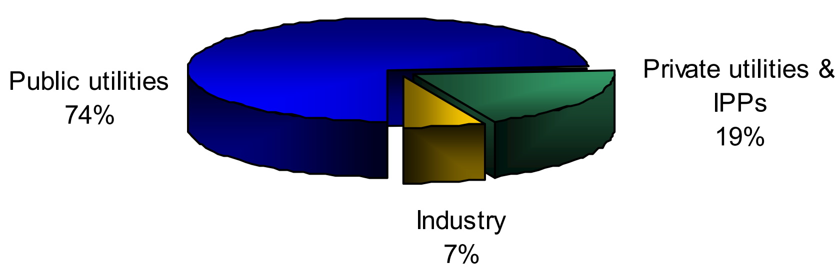
The generation, transmission and distribution of electricity in Canada have been primarily under provincial jurisdiction. Historically, electricity has been provided mainly by vertically integrated provincial Crown corporations, which met growing demand by building large power projects. These projects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

The Government of Canada has played a supporting role by investing in research and development, supporting the commercialization of new technologies and exercising its responsibilities for 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 toward a more competitive system, with the private sector playing an increasing role (see Figure 4.1). In Alberta and Ontario, a bid-based model exists between local distribution companies and both large and small generators. In many other provinces, independent power producers (IPPs) can sell power only to the major utility that provides most of the generation, transmission and distribution services.

The main rationale for this type of restructuring was political support for competitive markets, technological developments (e.g. gas turbines) that allowed smaller generating stations and the need to seek lower electricity costs for industrial customers.

Figure 4.1: Installed Capacity, by Producer Type, 2005



Source: Statistics Canada, *Electric Power Generation, Transmission and Distribution, 2005*, Cat. No. 57-202-X, Table 1, "Installed generating nameplate capacity, by province or territory and type of organization, 2005," pp. 9–10.

Most provinces have also taken another restructuring option. They have unbundled generation, transmission and distribution activities (i.e. split them into separate organizations) in order to meet regulatory requirements in the United States for cross-border trade.

In the late 1980s and early 1990s, the industry invested significantly in new generation and transmission infrastructure. From 1991 to 1993, the industry spent $34 billion on it. This was followed by a period of low capital expenditures. Only $49 billion was spent over eight years as excess capacity met increasing demand. Recently, utilities started to build new capacity to replace aging facilities and meet new demand. As a result, investment has increased again. However, utilities continue to face uncertainties about environmental regulation and project-approval timelines.

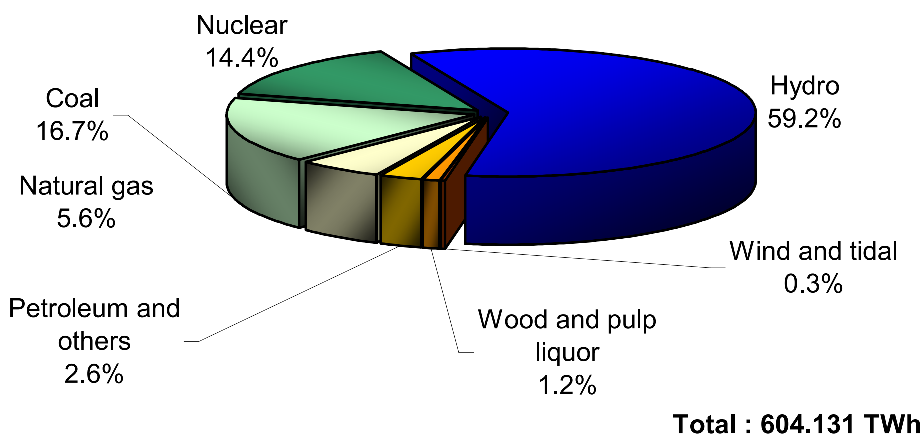
Finally, industrial establishments also generate electricity, primarily for their own use. These establishments include many in the pulp and paper, petroleum refining and aluminum sectors.

4.3. GENERATION

Electricity in Canada is generated from different sources, including hydro, coal, natural gas, oil, uranium and various non-hydro renewable sources. Over time, each resource has fluctuated in viability, importance and market share. This fluctuation is due to changes in fuel prices, technology, government policy, and business decisions.

From 1990 to 2005, total electricity supply in Canada increased by 29 percent, from 467 terawatt hours (TWh) to 604 TWh. Electricity supply in Canada is dominated by hydro (see Figure 4.2). Hydro accounted for 59 percent of the supply in 2005 and 49 percent of the increase in total generation from 1990 to 2005. Coal and nuclear are the second and third most important sources of electricity. Natural gas, bioenergy and wind have relatively small market shares but are increasing in importance. In particular, natural gas-fired generation increased by 240 percent and accounted for 17 percent of total power supply growth from 1990 to 2005.[68]

FIGURE 4.2: ELECTRICITY GENERATION, BY SOURCE, 2005



Sources:
Data on hydro, wind and tidal, and nuclear generation are from Statistics Canada, *Electric Power Generation, Transmission and Distribution, 2005* (2007), Cat. No. 57-202-X, Table 2, "Generation of electric energy, 2005," pp. 10–11.

Data on non-nuclear thermal generation are from Statistics Canada, *Report on Energy Supply-demand in Canada, 2005* (2007), Cat. No. 57-003-XIE, Table 8-1, "Electricity generated from fossil fuels – Total electricity generated," p. 112.

4.3.1. Provincial and territorial differences

Because of the differences in resource endowment, each province has a different electricity source mix (see Table 4.1). British Columbia, Manitoba, Quebec, and Newfoundland and Labrador generate electricity primarily from hydro. Alberta, Saskatchewan and Nova Scotia focus on coal-fired power generation. Ontario's most important source of electricity is nuclear, although hydro and coal play key roles. New Brunswick has a diverse portfolio of power generation sources. Prince Edward Island imports most of its electricity from New Brunswick. The two main sources of electricity generation in the Northwest Territories, Nunavut and Yukon Territory are hydroelectricity and petroleum fuels.

TABLE 4.1: NET ELECTRICITY GENERATION BY SOURCE, BY PROVINCE AND TERRITORY, 2005 (GWH)

Province/territory	Hydro	Nuclear	Coal	Natural gas	Petroleum and other fuels	Bioenergy, wind, tidal	Total
Newfoundland and Labrador	40 498	0	0	268	1 370	0	42 136
	96.1%	*0.0%*	*0.0%*	*0.6%*	*3.3%*	*0.0%*	*100%*
Prince Edward Island	0	0	0	0	7	40	47
	0.0%	*0.0%*	*0.0%*	*0.0%*	*14.9%*	*85.1%*	*100%*
Nova Scotia	1 075	0	8 819	233	2 045	281	12 454
	8.6%	*0.0%*	*70.8%*	*1.9%*	*16.4%*	*2.3%*	*100%*
New Brunswick	3 875	4 378	3 661	1 072	7 462	614	21 062
	18.4%	*20.8%*	*17.4%*	*5.1%*	*35.4%*	*2.9%*	*100%*
Quebec	173 356	4 483	0	298	1 153	1 006	180 296
	96.2%	*2.5%*	*0.0%*	*0.2%*	*0.6%*	*0.6%*	*100%*
Ontario	35 480	77 969	30 608	12 509	1 205	980	158 750
	22.3%	*49.1%*	*19.3%*	*7.9%*	*0.8%*	*0.6%*	*100%*
Manitoba	36 440	0	431	8	17	153	37 049
	98.4%	*0.0%*	*1.2%*	*0.0%*	*0.0%*	*0.4%*	*100%*
Saskatchewan	4 573	0	10 850	4 211	31	355	20 020
	22.8%	*0.0%*	*54.2%*	*21.0%*	*0.2%*	*1.8%*	*100%*
Alberta	2 242	0	46 813	10 988	1 522	2 045	63 610
	3.5%	*0.0%*	*73.6%*	*17.3%*	*2.4%*	*3.2%*	*100%*
British Columbia	60 327	0	10	4 016	197	3 034	67 585
	89.3%	*0.0%*	*0.0%*	*5.9%*	*0.3%*	*4.5%*	*100%*
Territories	580	0	0	82	432	27	1 120
	51.7%	*0.0%*	*0.0%*	*7.3%*	*38.6%*	*2.4%*	*100%*
Canada (total)	**358 446**	**86 830**	**101 192**	**33 685**	**15 444**	**8 534**	**604 131**
	59.3%	***14.4%***	***16.7%***	***5.6%***	***2.6%***	***1.4%***	***100%***

Sources:
Data on hydro, wind and tidal, and nuclear generation are from Statistics Canada, *Electric Power Generation, Transmission and Distribution, 2005* (2007), Cat. No. 57-202-X, Table 2, "Generation of electric energy, 2005," pp. 10–11.

Data on non-nuclear thermal generation are from Statistics Canada, *Report on Energy Supply-demand in Canada, 2005* (2007), Cat. No. 57-003-XIE, Table 8-1, "Electricity generated from fossil fuels – Total electricity generated," p. 112.

4.3.2. Hydro

Hydro is the main source of electricity in Canada. It represented 59.3 percent of supply in 2005, or 358 TWh. Total capacity at the end of 2005 was 72.0 gigawatts (GW). Large quantities of hydroelectricity are produced by Quebec, British Columbia, Newfoundland and Labrador, Manitoba and Ontario.

Hydro is used primarily for meeting baseload demand (i.e. the minimum amount of electricity demand, regardless of time of day or season), due to its low operating costs. To maximize profits, hydroelectric utilities have storage reservoirs. Energy is stored during off-peak periods and released during peak demand periods, when prices are higher.

4.3.3. Coal

In 2005, 21 coal-fired power plants accounted for 16.7 percent of Canada's total generation, or 101.2 TWh. Coal-fired capacity totalled 16.0 GW at the end of 2005. Five provinces (Alberta, Ontario, Saskatchewan, Nova Scotia and New Brunswick) produce essentially all coal-fired electricity in Canada. Coal-fired power is generally used as baseload capacity. However, in Ontario, coal-fired power plants often cease operation during low demand periods.

While Ontario plans to phase out its coal-fired power plants over the next decade, other provinces are considering new installations. Utilities in Alberta and Saskatchewan are considering full-scale “clean coal” demonstration projects. In this case, clean coal refers to coal-fired power generation that releases low quantities of air pollutants and sequesters carbon dioxide in subterranean geological formations.

4.3.4. Nuclear

In 2005, nuclear power plants accounted for 14.4 percent of total generation in Canada, or 86.8 TWh. This total represents 49.1 percent of generation in Ontario, 20.8 percent in New Brunswick and 2.5 percent in Quebec. Nuclear power is used for baseload demand. Of the 22 CANada Deuterium Uranium (CANDU) reactors in Canada, 20 are at three separate locations in Ontario, 1 is in Quebec and 1 is in New Brunswick. However, the CANDU fleet and supporting infrastructure (i.e. the Chalk River Laboratories) are aging and will need to be refurbished or replaced.

Ontario operates the largest nuclear fleet in Canada. The Province has embarked on a policy of refurbishments and new builds, due to the age of its fleet, the importance of nuclear generation to the provincial economy and the fact that nuclear power is the only available electricity source that meets both baseload demand and concerns about air quality and greenhouse gas emissions. Ontario has already refurbished two of its oldest Pickering reactors. In June 2006, it announced that it will make major investments over the next decade to refurbish its remaining units, to the extent that this investment is economic, and to build new units at existing sites.

In 2006, Ontario Power Generation Inc. and Bruce Power initiated federal environmental assessments for new reactors at their Darlington and Bruce sites respectively. This is the first step in the regulatory process for new reactor construction.

Similarly, New Brunswick has started a $1.5-billion refurbishment of its nuclear reactor. The Province is also studying the feasibility of constructing a second reactor, initially for export to the northeastern United States. Quebec is also expected to make a decision soon on refurbishing the Gentilly-2 CANDU-6 reactor.

4.3.5. Natural gas

Natural gas claimed a small but increasing share of total generation (5.6 percent, or 33.7 TWh) in Canada in 2005. Total capacity at the end of 2005 was 10.1 GW. Alberta, Ontario, Saskatchewan and British Columbia are the largest users of natural gas for electricity generation.

In Canada, natural gas is used primarily as a fuel for “peaking” power plants, i.e. plants that supply peak demand. Electricity production from natural gas-fired plants can be increased relatively easily and quickly when needed. But this production has high fuel costs. As a result, it is more suited to meeting peak electric demand levels than other sources.

Natural gas-fired capacity is expected to increase significantly, notwithstanding higher gas prices and a slow decline in Canadian natural gas production. It is a well-suited energy resource for electricity generation in competitive markets due to its short construction times and operational flexibility. Ontario is building some gas-fired facilities, in part to replace coal-fired capacity. Finally, liquefied natural gas is expected to provide additional supply as continental supplies decline (see Section 3.3, “Natural gas”).

4.3.6. Petroleum fuels

In 2005, petroleum fuels had a small share of overall electricity generation (2.6 percent, or 15.4 TWh) in Canada. Petroleum-fired capacity amounted to 6.9 GW at the end of 2005. Fuel oil, a type of petroleum fuel, is occasionally used during periods of peak demand across Canada. And diesel is used in remote locations. As well, in New Brunswick, fuel oil and other petroleum fuels represent the largest share of electricity in the province's diversified electricity portfolio, at 35.4 percent in 2005.

Fuel-oil capacity is expected to decline, as a result of increasing global prices. Some utilities have converted, or are considering converting, their fuel-oil-fired facilities to natural gas or other petroleum fuels.

4.3.7. Biomass

Biomass makes up Canada’s second largest renewable energy resource after hydro. (A detailed review of bioenergy sources is provided in section 3.6.8, “Bioenergy.”) Total capacity of bioenergy in 2005 was 1670 MW, including more than 1500 MW in the forestry industry. Today industrial cogeneration (the combined production of industrial process heat and electricity generation) is the most common method of biomass generation, found mostly in the pulp and paper industry. The prospect for biomass-fired electricity generation has improved because of high natural-gas prices, the shift away from coal-fired generation and variability issues associated with other emerging renewable technologies.

The potential for biomass generation from landfill gas, municipal waste and agricultural operations varies widely by region. As well, its development may be constrained by its relatively high start-up and operating costs.

In fact, emerging technologies vary in cost range, plant size and other aspects (see Table 4.2).

TABLE 4.2: ILLUSTRATIVE POWER GENERATION COSTS – EMERGING TECHNOLOGIES AND CONVENTIONAL GENERATION

Technology[1]	Cost Range ($/MW.h)	Unit/Plant Size[3]	Comments
Wind power	50-100	1-2 MW; wind farms of 50-150 MW	• relatively short installation time • intermittent nature requires back-up/supplement from other generation sources
Small hydro	40-150	less than 25 MW	• well established technology • may encounter NIMBY opposition • limited/no storage; therefore, intermittency can limit attractiveness
Biomass	40-150	10-50 MW	• wide variety of technologies and feedstocks, including forest industry waste, agriculture, municipal waste and landfill gas • base load capability
Geothermal energy	40-100	100-200 MW	• limited sites available • may have high grid connection costs, depending on location • base load capability
Solar PV	200-500	varies at consumer level	• expensive; intermittent • distributed generation (DG) and niche applications, especially where alternatives are high cost
Ocean Energy (wave and tidal currents)	80-190	less than 1 MW	• costs are uncertain (based on limited number of commercial projects) • intermittent, but reasonably predictable (tidal currents) • DG applications in coastal areas
Conventional Technologies[2]			
Recent Power Pool	50-100	250-500 MW	• typical range of prices in the ON and AB competitive wholesale markets; prices set mainly by gas, coal and market conditions in adjacent markets (i.e., in the U.S. and other provinces)
Recent RFPs	78-80	100-200 MW	• proposals "accepted" by the Ontario Power Authority/Ontario Ministry of Energy for RFPs issued in 2004 (mainly natural gas-fired generation)
Heritage hydro	28-33	100s-1000s MW	• costs based on Québec (2.79¢/kW.h) and Ontario (3.3¢/kW.h)

1. Costs for wind, small hydro, biomass, geothermal power, solar PV and ocean energy are from CANMET (NRCan) and the IEA. Fuel cell costs are NEB estimates; IGCC costs are from Ontario MOE and CERI. The demand management costs are based on recent studies undertaken in the U.S. and in Ontario, as referenced in section 3.9.

2. Costs for conventional technologies are based on prices in the Ontario and Alberta competitive wholesale markets, and announced results for Ontario RFPs. Heritage hydro costs are announced costs in Québec and Ontario. In Québec, these costs refer to the first 165 TW.h produced per year and in Ontario refer mainly to the hydro assets of Ontario Power Generation.

3. Plant sizes are illustrative and not directly associated with the costs.

Source: National Energy Board (NEB), *Emerging Technologies in Electricity Generation* (2006), p. 11.

4.3.8. Wind

Wind power experienced a record year for capacity expansion in Canada in 2005. Total capacity at the end of 2005 was 684 MW, a 55 percent increase over 2004. Growth has continued, and installed capacity tripled by the end of 2007, reaching 1846 MW. Factors contributing to this accelerated growth include the establishment of renewable portfolio standards (RPSs), the requests for proposals (RFPs) for wind and other renewables, the strong wind resources in many regions and the short construction lead times for wind projects.

However, the variability of wind resources requires backup power or energy storage to ensure reliability. Access to existing transmission facilities is often a decisive economic factor for project siting and feasibility.

Wind's fast growth as an energy resource is expected to continue. Several RPSs and RFPs have been announced by governments and electric utilities.

4.3.9. Solar

Photovoltaic (PV) cells, or solar cells, are made of semiconductor materials, such as silicon. The cells produce electricity directly from sunlight. They are well suited to distributed energy applications (i.e. energy generation at the point of consumption in residences or commercial buildings or in industrial applications). A total capacity of 16.77 MW is installed in Canada.

PV technology is well proven. However, advancements must be made to reduce costs enough for the technology to be cost-competitive in the Canadian market. Furthermore, barriers to distributed generation, such as restrictive or unclear grid connection standards, make it difficult to install modules.

4.3.10. Geothermal

Geothermal power plants extract naturally occurring underground steam to power a conventional steam turbine and generating unit. Up-front investments are high, but there are no fuel costs, and operating and maintenance costs are competitive with other technologies. Once operational, geothermal power generation is reliable and suitable for baseload power.

A project to build Canada’s first commercial geothermal power plant is in the preliminary stages near Whistler, BC. The long-term prospects for this technology are likely limited because there are few high-quality sites in Canada, and most of them are in British Columbia.

4.3.11. Ocean

Ocean energy in Canada is at the early stage of development, and commercial or near-commercial production will take some time. However, there is a 20-MW tidal power plant in Annapolis, Nova Scotia. The best prospects on the Atlantic and Pacific coasts are tidal current and wave power.

4.4. Trade

Trade in electricity between two countries provides two key benefits. For the seller, it results in revenues from the sale of electricity that might otherwise go to waste. And for the buyer, it provides a mechanism to avoid any reliability issues from unexpectedly high demand or supply outages. Many Canadian provinces and territories are involved in electricity trade with the United States and, to a lesser degree, with other provinces.

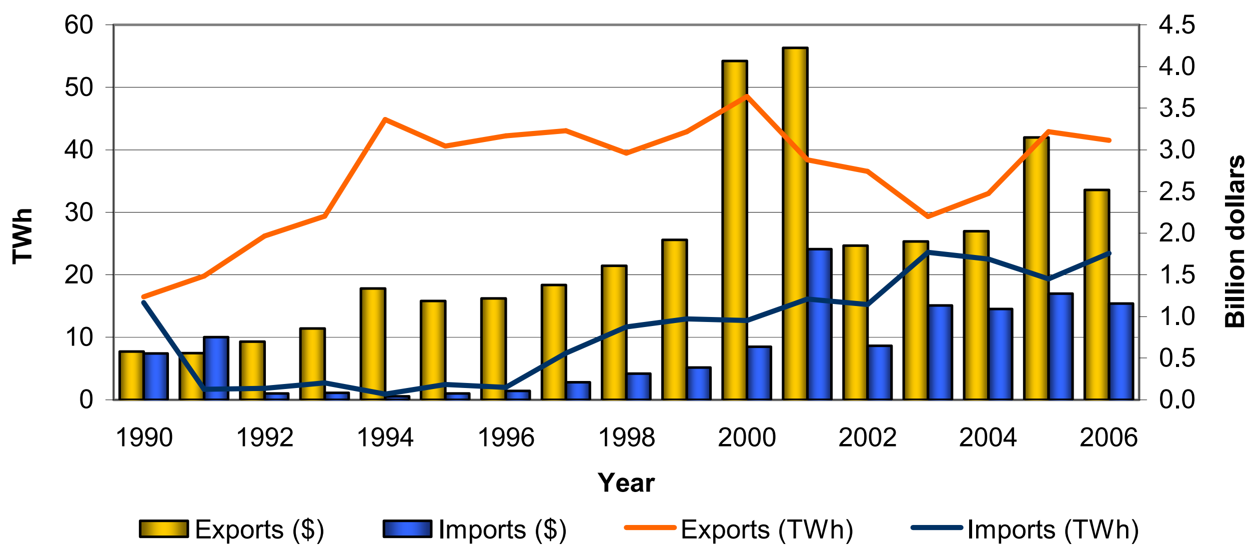
4.4.1. International trade

Electricity exports to the United States are regulated by the Canada's National Energy Board. Historically, Canada has been an exporter of electricity to the United States. There has been substantial variation in the amount of electricity exported among the provinces. At the national level, though, electricity exports have been typically between 7 percent and 9 percent of overall power generation.

Historically, there was a lot of seasonal trading, reflecting winter demand peaks in Canada and summer demand peaks in the United States. Canada was, by and large, a net electricity exporter. Now, to maximize profits, utilities with storage capacity have significant export sales during peak periods. And jurisdictions such as Ontario depend on U.S. imports to supply power during daily peaks for much of the year.

Exports increased in the early 1990s, largely due to surplus generating capacity in Manitoba, Ontario and Quebec. The restructuring of electricity markets, particularly the emergence of independent power producers and improved access to transmission systems, has led to increased opportunities for trade. However, it has not led to increased exports. On balance, exports have declined over the past several years. This decline reflects increased domestic demand and an inadequate increase in generation capacity. In 2006, export sales totalled 41.5 TWh, valued at $2.52 billion (see Figure 4.3).

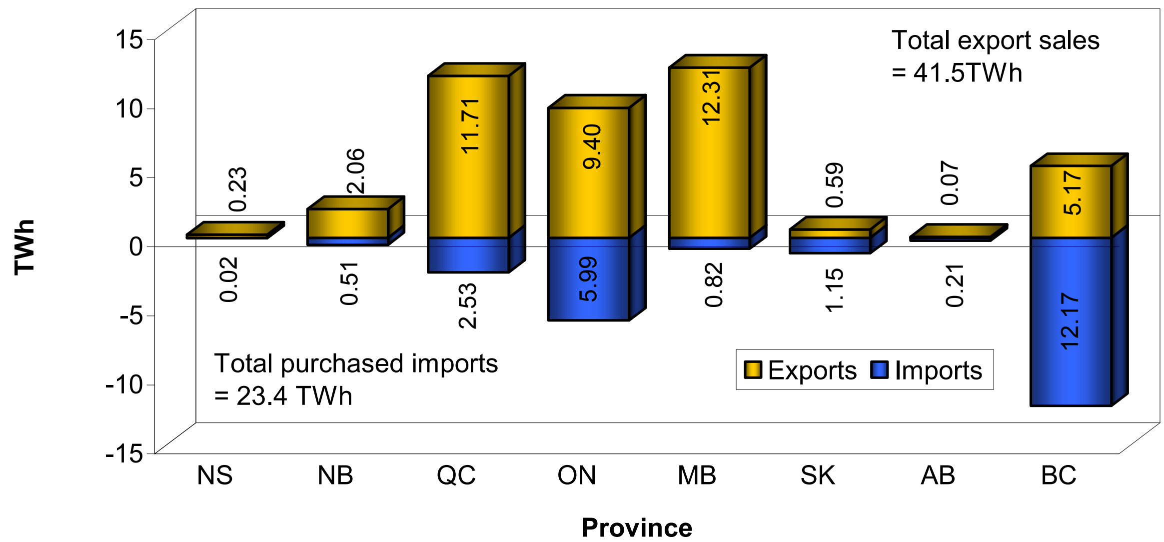
Figure 4.3: Electricity Trade with the United States



Source: Data are from NEB, *Electricity Exports and Imports: Monthly Statistics for December,* 1990–2006, Table 1, “Exports and imports of electricity summary.” These data include non-revenue or inadvertent and service trade.

Since 1996, electricity imports have increased, partly due to higher imports by Ontario. In addition, importers, mainly in British Columbia and Quebec, have taken advantage of energy-trading opportunities as access to U.S. transmission systems improved. In 2006, purchased imports totalled 23. 4 TWh, valued at $1.15 billion (see Figure 4.4).

FIGURE 4.4: ELECTRICITY TRADE WITH THE UNITED STATES, BY PROVINCE, 2005

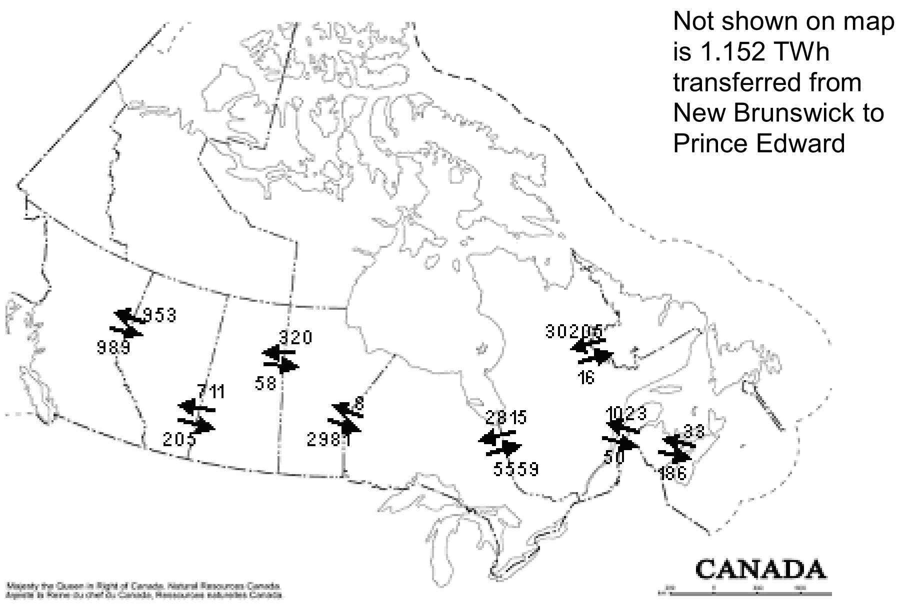


Source: Data are from NEB, *Electricity Exports and Imports: Monthly Statistics for December 2006* (2007), Table 2A, "Export summary report by source, authorization and exchange type," and Table 2B, "Import summary report by destination, authorization and exchange type." These data do not include non-revenue or inadvertent and service trade.

4.4.2. Interprovincial transfers

The large distances between key demand centres has limited the extent of interprovincial trade in electricity. About 44 085 GWh were exchanged among the provinces in 2005. However, exports to Quebec from the Churchill Falls hydro facility, in Newfoundland and Labrador, account for almost 70 percent of this total (see Figure 4.5).

FIGURE 4.5: INTERPROVINCIAL TRADE IN ELECTRICITY, 2004
(GWH)



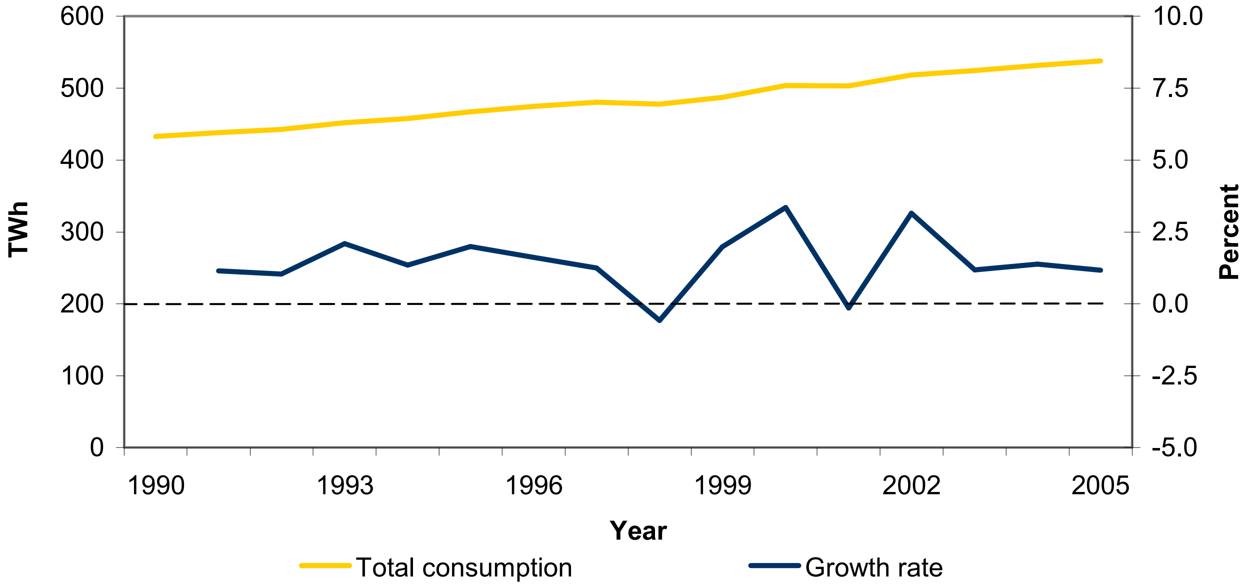
Source: Data are calculated from figures in Statistics Canada, *Electric Power Generation, Transmission and Distribution, 2005* (2007), Cat. No. 57-202-X, Table 3, "Supply and disposition of electric energy, electric utilities and industry, 2005," pp. 12–13.

4.5. CONSUMPTION

4.5.1. Trends

Between 1990 and 2005, electricity consumption in Canada increased from 433 TWh to 538 TWh (see Figure 4.6).

FIGURE 4.6: ELECTRICITY CONSUMPTION AND ANNUAL GROWTH RATE, CANADA



Source: Statistics Canada.[69]

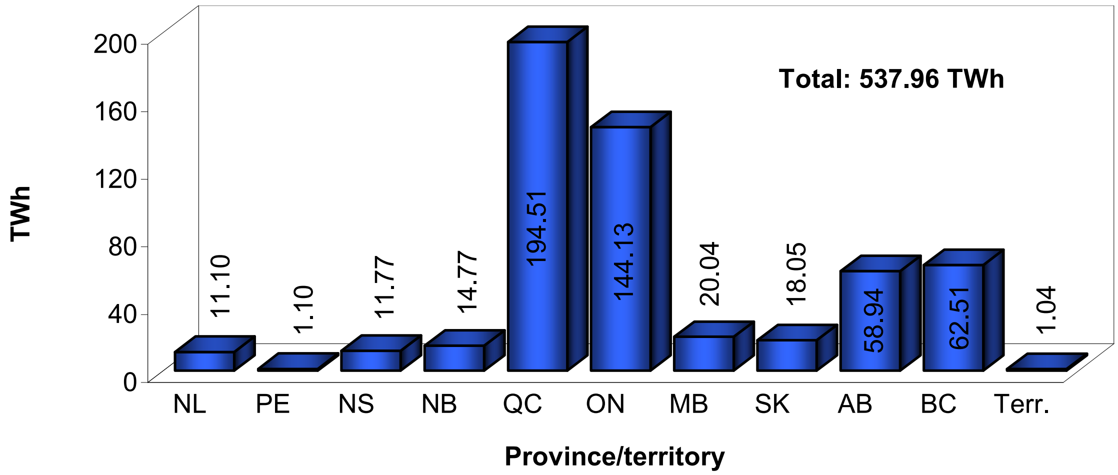
Following the recession of the early 1980s, annual growth in electricity demand exceeded 4 percent for six consecutive years. Since 1990, however, the growth in demand has slowed, with an annual average growth rate of 1.5 percent.

The economic recession in the early 1990s contributed to the slower growth in demand. Higher electricity prices contributed to the slower growth in demand from the early 1990s to the present. However, energy efficiency measures also contributed to the slower growth from the mid-1990s to the present.

4.5.2. Provincial and territorial differences

The four largest provinces by population are also the largest power consumers (see Figure 4.7).

FIGURE 4.7: ELECTRICITY CONSUMPTION, BY PROVINCE AND TERRITORY, 2005

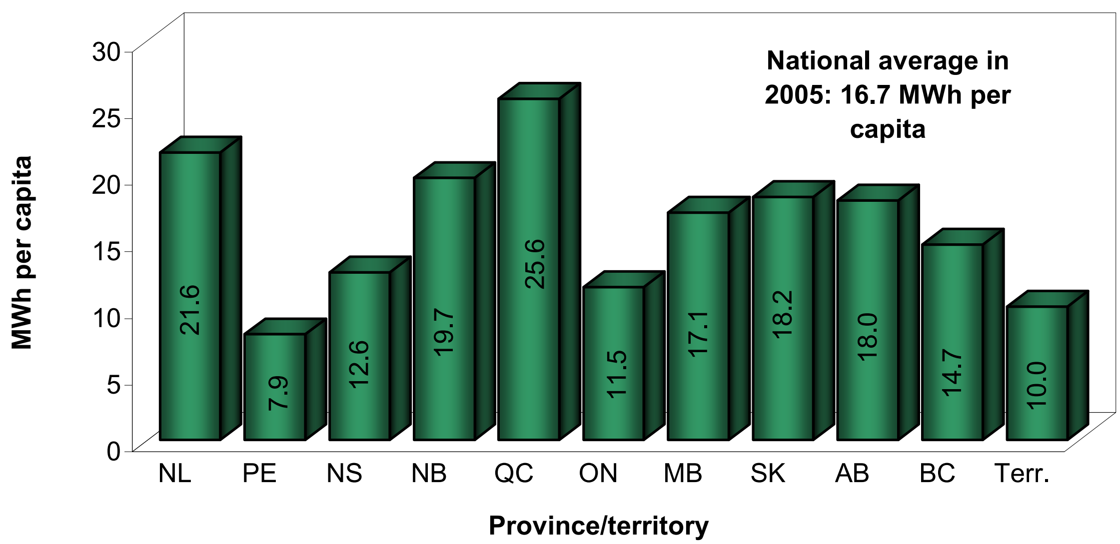


Source: Statistics Canada.[70]

A large amount of power consumed is consumed in Quebec. Indeed, Quebec accounts for 36 percent of demand in Canada, while it has only 24 percent of the population.

There are also differences in per capita consumption (see Figure 4.8).

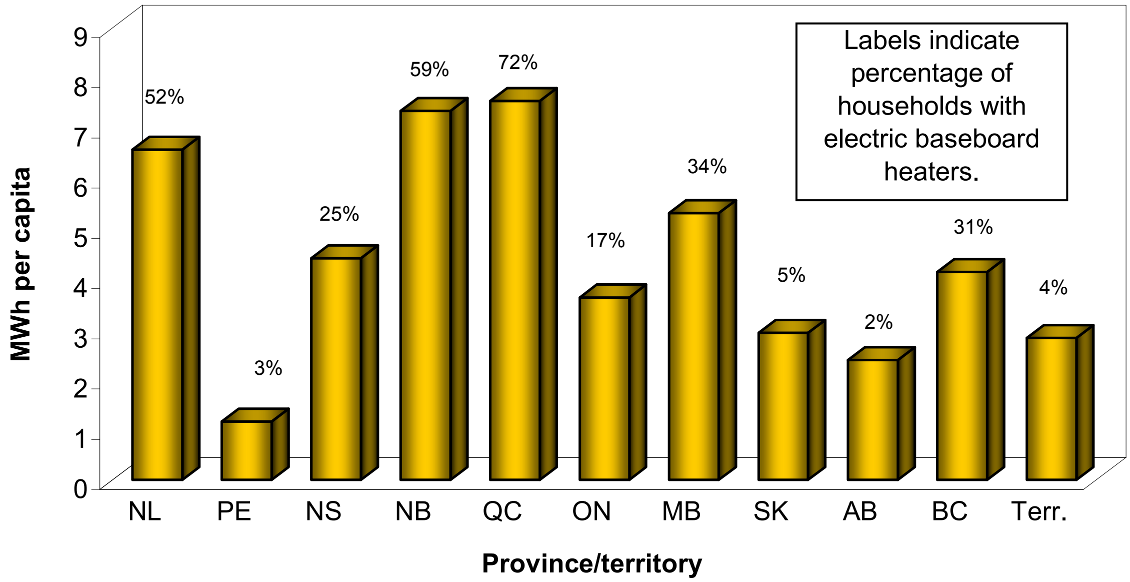
FIGURE 4.8: PER CAPITA ELECTRICITY CONSUMPTION, BY PROVINCE AND TERRITORY, 2005



Source: Statistics Canada.[71]

There are two main reasons for the differences among provinces and territories in per capita consumption. First, *residential* per capita consumption varies. Many households in Quebec, New Brunswick, and Newfoundland and Labrador use electric baseboard heaters to stay warm. In other provinces and territories, households rely on natural gas or heating oil (see Figure 4.9).

FIGURE 4.9: PER CAPITA ELECTRICITY CONSUMPTION, RESIDENTIAL SECTOR, BY PROVINCE AND TERRITORY, 2005



Sources: Statistics Canada and Natural Resources Canada (NRCan).[72]

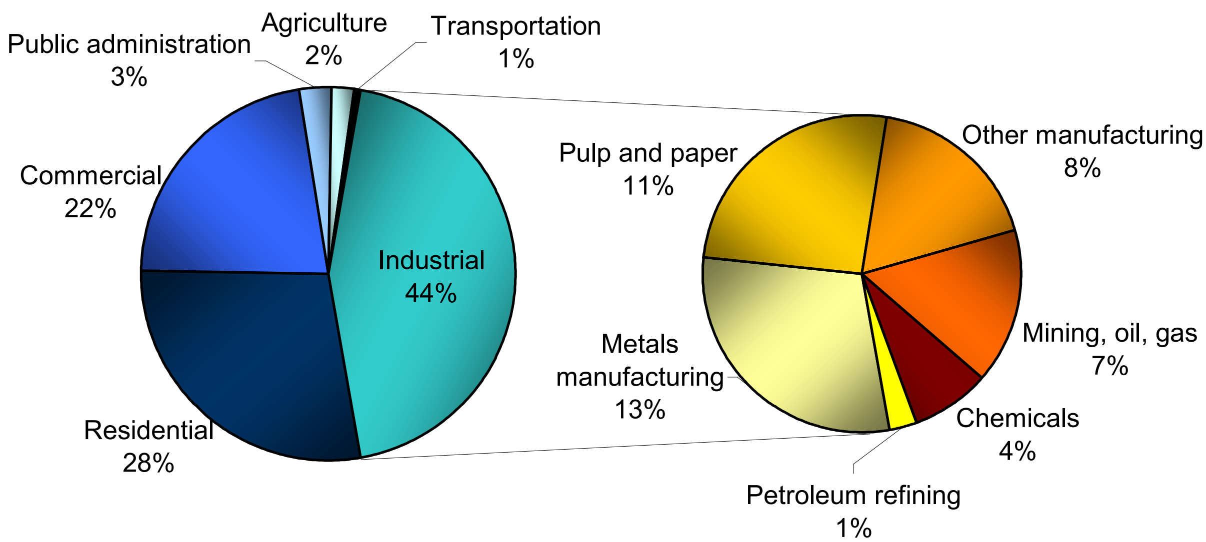
Second, *industrial* per capita consumption rates also vary across provinces and territories. High per capita consumption rates may reflect a provincial/territorial economy based on energy-intensive industrial activities, such as pulp and paper, petroleum refining, mining and/or primary metal manufacturing. These heavy industries use large amounts of electricity. Industry-heavy provinces include Alberta (10.4 MWh per capita), Quebec (13.0 MWh per capita) and Newfoundland and Labrador (10.8 MWh per capita). Their per capita industrial demand is high compared with the Canadian average (7.4 MWh per capita). Provinces such as Ontario, with a large diversified economy, tend to have a lower per capita consumption of electricity (3.4 MWh per capita) than provinces and territories that depend on one or a few heavy industries. Examples of the latter are Newfoundland and Labrador (pulp and paper) and Alberta (oil refining).[73]

4.5.3. Sectoral differences

Canada-wide, the industrial sector accounted for the largest share of electricity demand in 2005, at 44 percent (see Figure 4.10). The residential and commercial sectors accounted for 28 and 22 percent respectively.

Since 1990, electricity demand growth has been fastest in the industrial and transportation sectors, both averaging 1.8 percent annual growth. Meanwhile, in the residential and commercial sectors, demand has grown at annual average rates of 1.0 percent and 1.5 percent respectively.

FIGURE 4.10: ELECTRICITY CONSUMPTION SHARE, BY RESIDENTIAL, COMMERCIAL AND INDUSTRIAL SECTORS, 2005



Source: Statistics Canada.[74]

The industrial sector's sizeable share of total demand is due to Canada's large manufacturing industries, especially its electricity-intensive pulp and paper and smelting and refining industries. The two industries account for a larger share of demand than the commercial sector. Low electricity prices in some jurisdictions have been a major factor to growth in electricity-intensive industries.

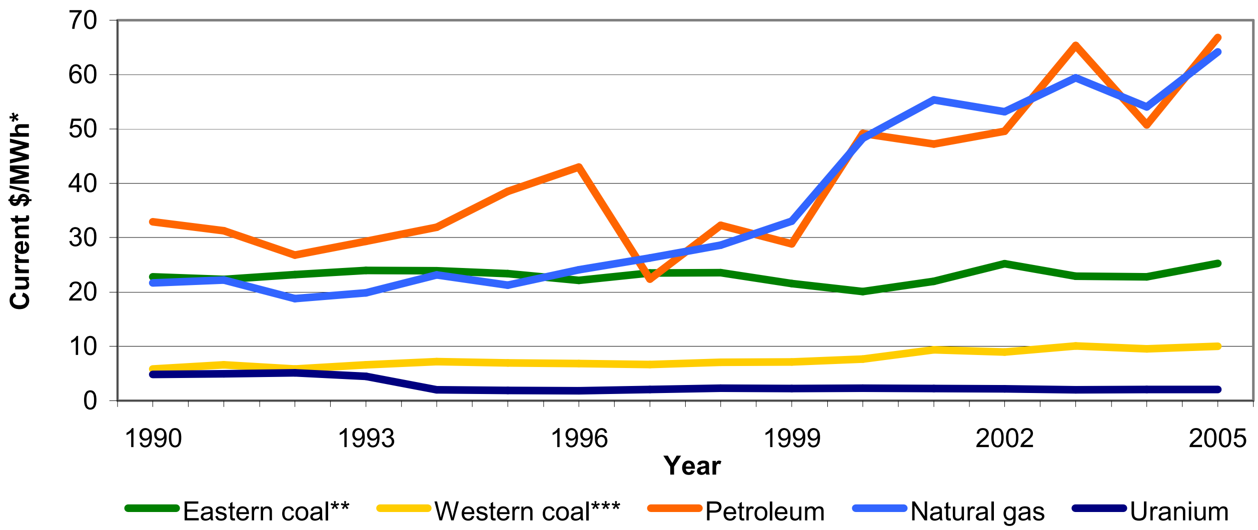
Through the 1980s and 1990s, the industry sector's electrical demand increased. This increase can be attributed partly to some industries becoming more electricity-intensive, in an effort to reduce labour costs and improve product quality. It can also be attributed to the pulp and paper industry's efforts to reduce its environmental footprint.

4.6. Electricity Prices and Cost of Supply

Electricity pricing varies by province or territory according to the volume and type of available generation and whether prices are market-based or regulated. Due to the availability of low-cost electricity from hydroelectric dams, utilities in some provinces can charge low rates for power. Other provinces rely on fossil fuel-fired and nuclear power for electricity generation. This power has higher costs of production than hydro.

In natural gas and petroleum-based power generation, the cost of fuel is a large portion of the total generation cost (see Figure 4.11). As a result, volatile fuel prices mean volatile generation costs using these types of fuels.

Figure 4.11: Unit Fuel Costs, Canada



Source: Statistics Canada, *Electric Power Generation, Transmission and Distribution*, years 1990–2005, Table 6, "Fuel use and electric power generation, electric utility thermal plants, YYYY."

*Fuel costs per megawatt hour were calculated by dividing total fuel cost by total electricity generation for a given fuel.

**Eastern coal refers to coal consumed in Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.

***Western coal refers to coal consumed in British Columbia, Alberta, Saskatchewan and Manitoba.

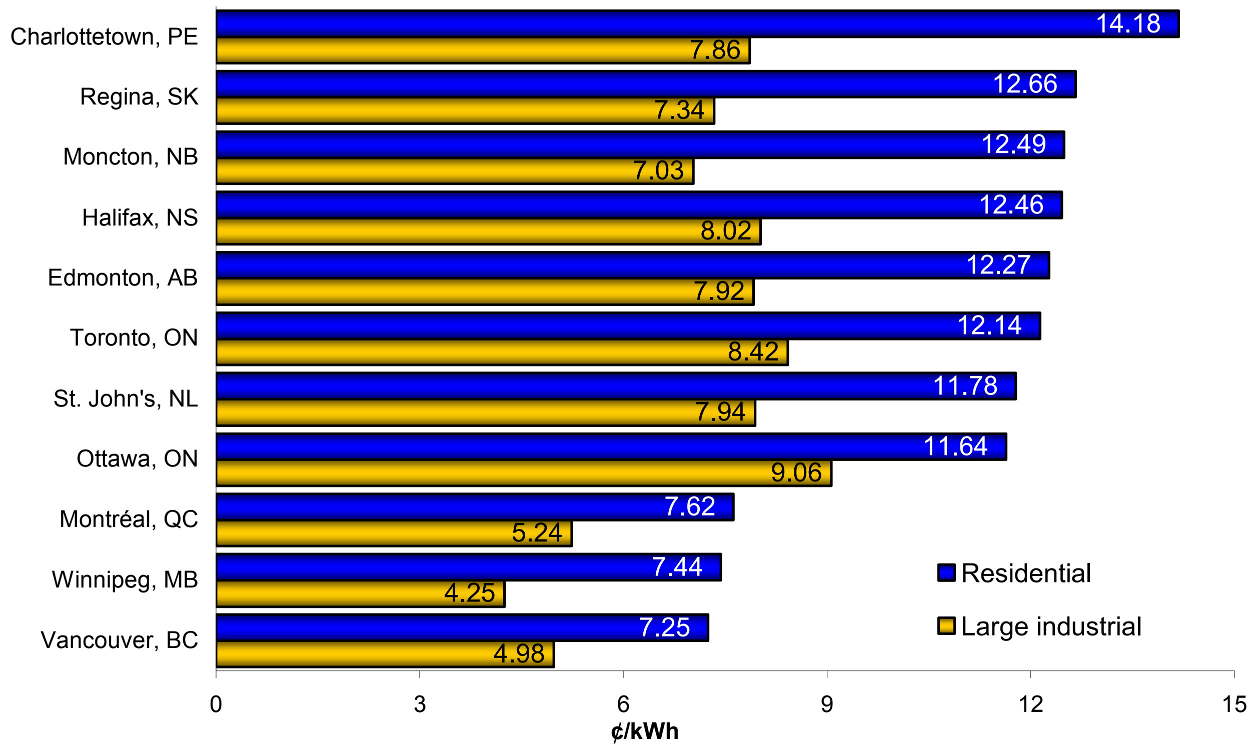
From 2000 to 2005, higher natural gas prices caused upward pressure on electricity prices in regions where a high proportion of natural gas is used to generate electricity. The long-term outlook for gas prices suggests that they will not fall to the low levels seen in the 1990s. Similarly, high prices for oil and, in some cases, coal will continue to put upward pressure on electricity prices in regions where these fuels are used.

The cost of coal consumed for power generation differs in eastern and western Canada (see Figure 4.11). Coal-fired power plants in western provinces get coal from nearby coal deposits. Ontario and the eastern provinces import coal and pay transportation costs.

At the retail level, the price of electricity is affected not only by the cost of production but also by the cost of transmission and local distribution. The latter varies, depending on such factors as geography and population density.

In the provincial capitals, there is a range of electricity prices in the residential and large industrial sectors (see Figure 4.12). The lowest residential and industrial electricity prices are in British Columbia, Manitoba and Quebec. These provinces have access to low-cost large hydroelectricity. The highest residential rates are in Charlottetown, P.E.I. These rates are due partly to a lack of energy resources in the province, which means energy must be bought from neighbouring provinces.

FIGURE 4.12: ELECTRICITY RATES, SELECTED CITIES, CANADA, 2007



Source: Hydro-Québec.[75]

Note: 1¢/kWh = $10/MWh

4.7. ELECTRICITY RELIABILITY

Electricity reliability refers to the ability of the electrical system to supply the total electricity demand of consumers at any given time (adequacy) and to withstand sudden disturbances (security) – in other words, the ability to avoid power outages. Maintaining reliability requires adequate electricity generation and transmission infrastructure (power plants and wires) and effective management of the power system.

4.7.1. Adequate electricity generation and transmission

Overall, the North American Electric Reliability Corporation (NERC) expects that electricity generation in North America will be sufficient to maintain reliability, provided generating facilities are constructed as anticipated and reliability standards are followed.[76]

However, the situation varies across Canadian provinces. According to NERC, electricity supply levels in Ontario are now less of a concern over the short term, given recent increases in generation capacity and a decrease in the rate of demand growth.

At the same time, British Columbia and Alberta need more generation and transmission capacity to maintain reliability. Alberta needs more transmission capacity from northern Alberta, where most electricity generation occurs, to Calgary and other southern demand centres. Both provinces need to increase generation capacity to meet a supply shortage expected in the next three to five years. This need is expected to be met in time to avoid power outages.

Adequate transmission capacity is also vital to ensuring electricity reliability. In most areas of Canada, the expansion and strengthening of the transmission system continues to lag behind the growth in electricity demand and the expansion of generating capacity. Over the next 10 years, total transmission miles are projected to increase by 4.8 percent.[77]

Electricity reliability in both Canada and the United States benefits from existing transmission capacity between the two countries and the resulting bilateral trade in electricity. This essentially allows Canada to rely on U.S. generating capacity at times and vice versa.

In the past, long-term contracts provided the basis for financing large, capital-intensive electricity generation and transmission projects. These contracts allowed for effective risk-sharing between the project developer and electricity purchaser.

However, in today's restructured electricity markets, there is concern that the long-term investments required to maintain adequate generation and transmission capacity will not occur. The International Energy Agency estimates that Canada's electricity sector will require US$190 billion in new investment between 2005 and 2030.[78]

4.7.2. Effective management of the power system

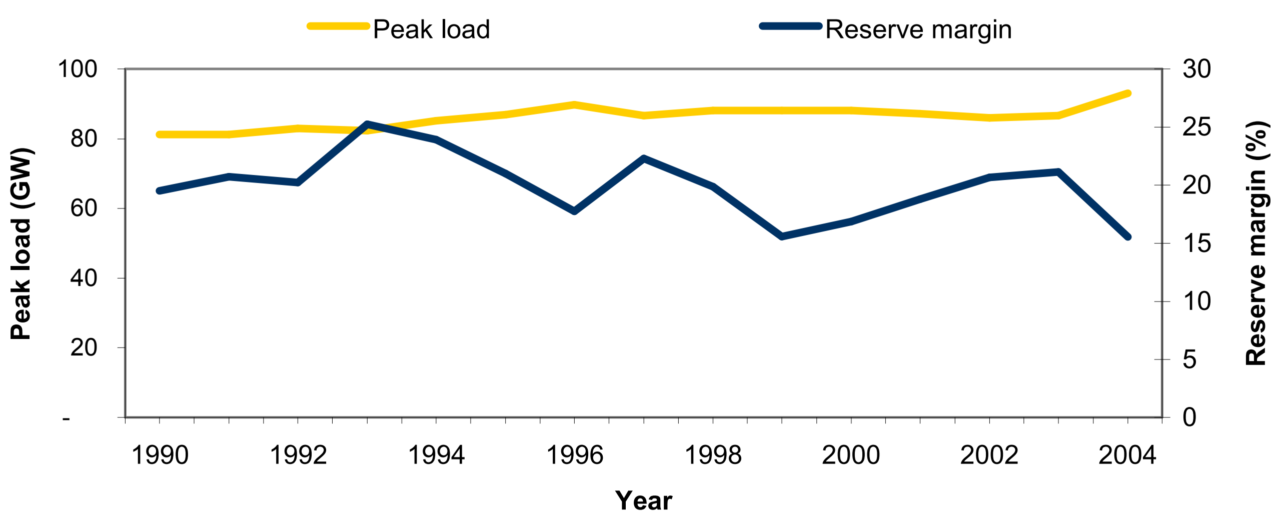
Electricity reliability also requires the effective management of the electricity system – ensuring that enough electricity is generated to meet demand at any given time, and that electricity can be moved effectively from where it is generated to where it is consumed.

In addition, standards and operational procedures are vital to ensuring that unexpected disturbances in one part of the electricity grid do not cause a cascade of failures across the entire system.

To ensure that there is always enough electricity to meet peak demand, electricity system operators maintain reserve margins – the difference between total generation capacity (electricity supply) and peak demand. Reserve margins enable electric utilities to avoid power failures during periods when generation capacity may be offline (such as during routine maintenance or unexpected shutdowns). All other things being equal, the greater the reserve margin, the less likely a power failure will occur.

From 1990 to 2004, Canada's peak demand increased, and investment in new generation facilities was limited. As a result, reserve margins declined (see Figure 4.13).

FIGURE 4.13: PEAK LOAD AND RESERVE MARGIN, CANADA



Source: Statistics Canada, "*Electric Power Capability and Load,*" years 1990–2003, Table 1, "Electric power capability and load, actual (Winter) – Canada."

Reserve margins can also be increased by managing high peak demand – referred to as *demand response*. Demand response is when consumers reduce electricity consumption in peak demand periods in response to either real-time price increases or requests made by the electricity-system operator. In the latter case, large electricity-consuming industrial plants are paid to shut down during the peak demand period to reduce the load on the system.

However, demand response is a long-term strategy for managing demand, arising from planned negotiations. As such, demand response is not an effective way to maintain reliability in response to sudden disturbances in electricity supply. In these circumstances, operators would need to take immediate supply actions.

In Canada, electricity peak demand is forecast to increase by 6.4 percent, or 6000 MW, over the next 10 years. At the same time, generation capacity is expected to increase by 10 percent or 11 000 MW.[79] These figures indicate some improvement in reserve margins compared with the 2006 forecasts. As discussed above, however, Alberta and British Columbia will require additional generation and transmission capacity in the near term to ensure adequate reserve margins.

Governments have also taken steps to ensure the reliable management of the power system. In the United States, mandatory electricity reliability standards have been adopted by many states. In Canada, provinces with major connections with the North American transmission network have adopted, or are working toward adopting, mandatory reliability standards as well.

4.7.3. Summary

In the near term, generation and transmission capacity will likely meet electricity demand under normal conditions. However, requirements for new investment point to the facts that reserve margins have declined and the ability to maintain reliability during sudden disturbances is limited. This creates a real risk of economic and social harm as a result of power failures. Over the next 20 years, the Canadian electricity sector will need significant investment in generation and transmission capacity to maintain overall reliability.

4.8. OUTLOOK

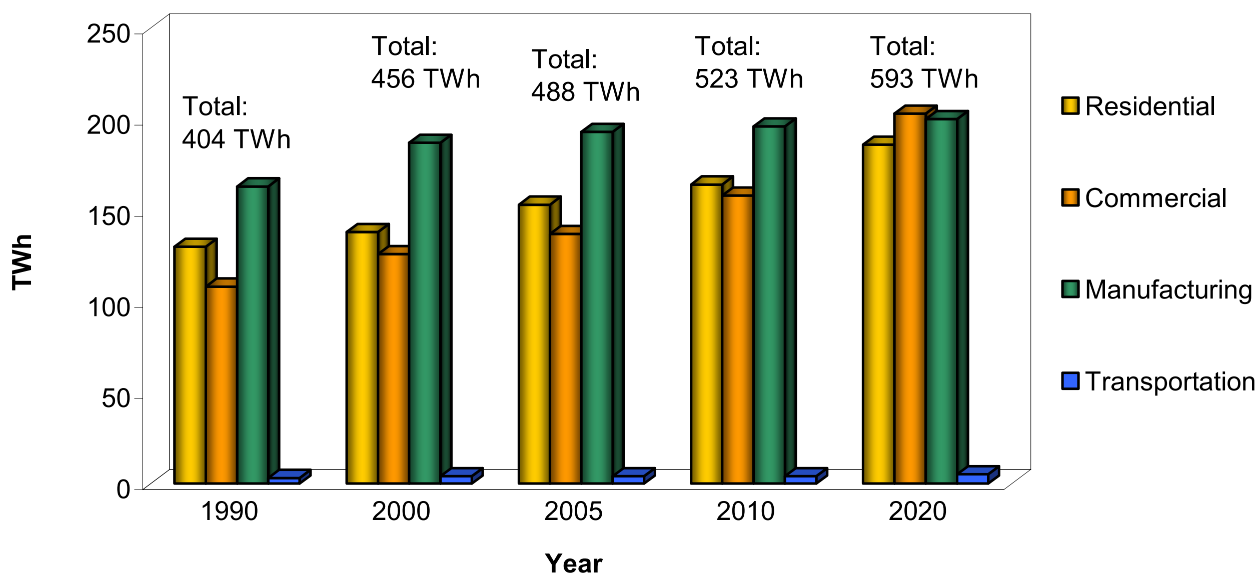
Consumption, prices, generation and exports underpin the face of electricity in the future.[80]

First, the commercial sector is expected to account for 63 percent of the growth in electricity consumption between 2005 and 2020 (see Figure 4.14). This growth reflects expectations of increased consumption in the sector for space cooling and lighting and, to a lesser extent, for office equipment, ventilation and other uses.

Electricity consumption by the manufacturing sector will continue to increase at the low average rate of 0.2 percent per year. This modest increase would arise from assumed high energy costs and a strong Canadian dollar.

Electricity consumption by the commercial and residential sectors, however, will grow much faster. Their average annual rates will be 2.6 and 1.3 percent respectively between 2005 and 2020.

FIGURE 4.14: ELECTRICITY CONSUMPTION, SELECTED SECTORS



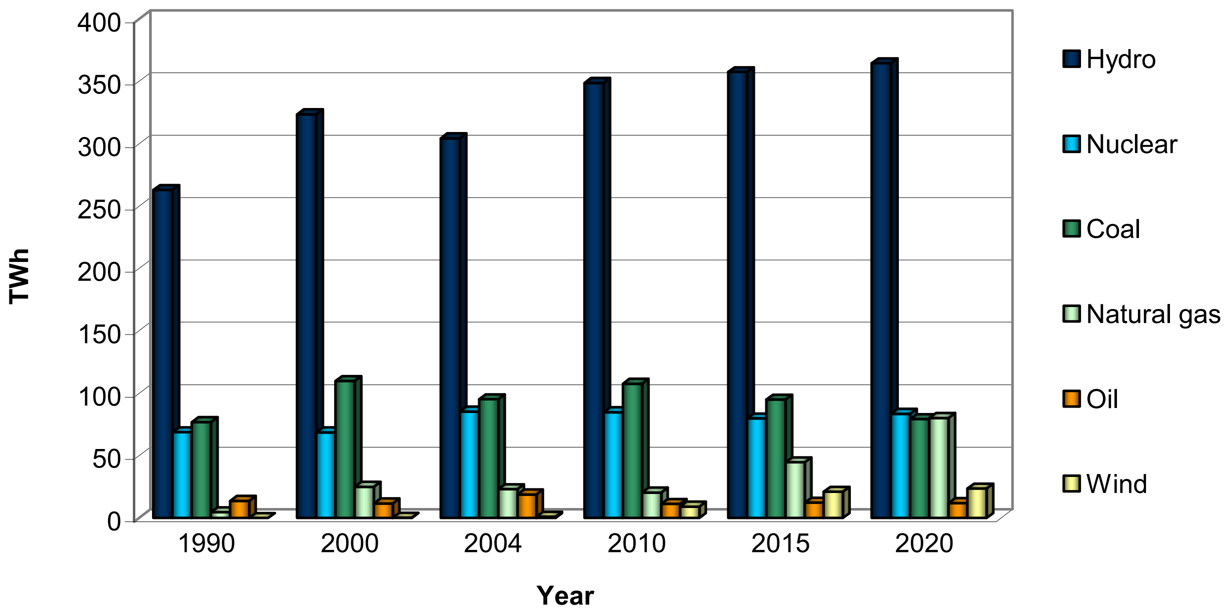
Source: NRCan, *Canada's Energy Outlook: The Reference Case 2006* (2006), Table EL1, "Electricity Demand," p. 45.

Second, electricity prices in Canada are not expected to change significantly between 2005 and 2020, at least in real terms. This means that prices would increase at about the same rate as inflation. There is expected to be long-term, upward pressure on prices for consumers in provinces, such as Ontario and Alberta, where there is a need to develop new generation and transmission facilities to replace aging infrastructure and with an increased use of emerging renewable sources of generation (e.g. wind, solar, biomass). Pending environmental regulations could put additional upward pressure on prices.

In Ontario, a growing reliance on imported power and new generation capacity will contribute to rising electricity prices. In Alberta, stronger demand for coal for power generation will lead to higher prices for coal and electricity. Increased reliance on natural gas in these provinces will also raise electricity prices.

Third, between 2004 and 2020, the main sources of growth in electricity generation will be from hydro, natural gas and wind (see Figure 4.15). Nuclear power generation is expected to remain at its current level, while oil-fired power generation is expected to decrease. The rate of decline of coal-fired power generation depends on the speed and extent to which Ontario closes its coal-fired power plants.

FIGURE 4.15: ELECTRICITY GENERATION, BY SOURCE, HISTORICAL AND PROJECTION



Source: NRCan, *Canada's Energy Outlook: The Reference Case 2006* (2006), Table EL2, "Electricity generation," p. 46.

Finally, net exports of electricity are expected to increase in provinces that invest in new capacity above and beyond that required by increasing domestic demand. Quebec, Manitoba and Newfoundland and Labrador are building hydroelectric facilities to increase exports to the United States and for neighbouring provinces.

CHAPTER 5: SECONDARY ENERGY USE

5.1. CHAPTER SUMMARY

- Energy efficiency improvements in Canada since 1990 resulted in an energy savings of 1096 petajoules (PJ) in 2005, or $20.1 billion.

- Despite these improvements, energy use increased by 22 percent between 1990 and 2005, from 6952 PJ to 8475 PJ. Without the energy efficiency improvements, however, the increase in energy consumption during this period would have been 38 percent.

- The increased energy consumption between 1990 and 2005 was due to the following:

    - The population increased by 17 percent, and economic activity (measured in gross domestic product [GDP]) increased by 51 percent.
    - The industrial sector had increased economic activity, had more energy-intensive operations (such as upstream mining, which includes synthetic crude production, smelting and refining; and pulp and paper) and shifted from conventional to unconventional oil extraction practices.
    - The residential sector had increases in the number of households (27 percent), the size of an average Canadian household, the energy used by small appliances (105 percent) and the use of air conditioning.
    - The transportation sector had an 88 percent increase in the stock of passenger light trucks (sport utility vehicles [SUVs] and vans) compared with a 6 percent decrease in the stock of small and large cars, meaning a greater portion of light-duty vehicles are larger. It also had an increased use of freight-carrying light and heavy trucks, in part due to the increased desire for just-in-time delivery.

5.2. INTRODUCTION

The two general types of energy use are primary and secondary. Primary energy use encompasses the total requirements for all users of energy, the energy required to transform one energy form to another (e.g. coal to electricity) and the energy used to bring energy supplies to the consumer. Secondary energy use refers to the energy used by “final” consumers in various sectors of the economy. For example, secondary use is the energy consumed by vehicles in the transportation sector, the energy consumed to heat and cool homes or businesses in the residential and commercial/institutional sectors, and the energy to run machinery in the industrial and agricultural sectors.

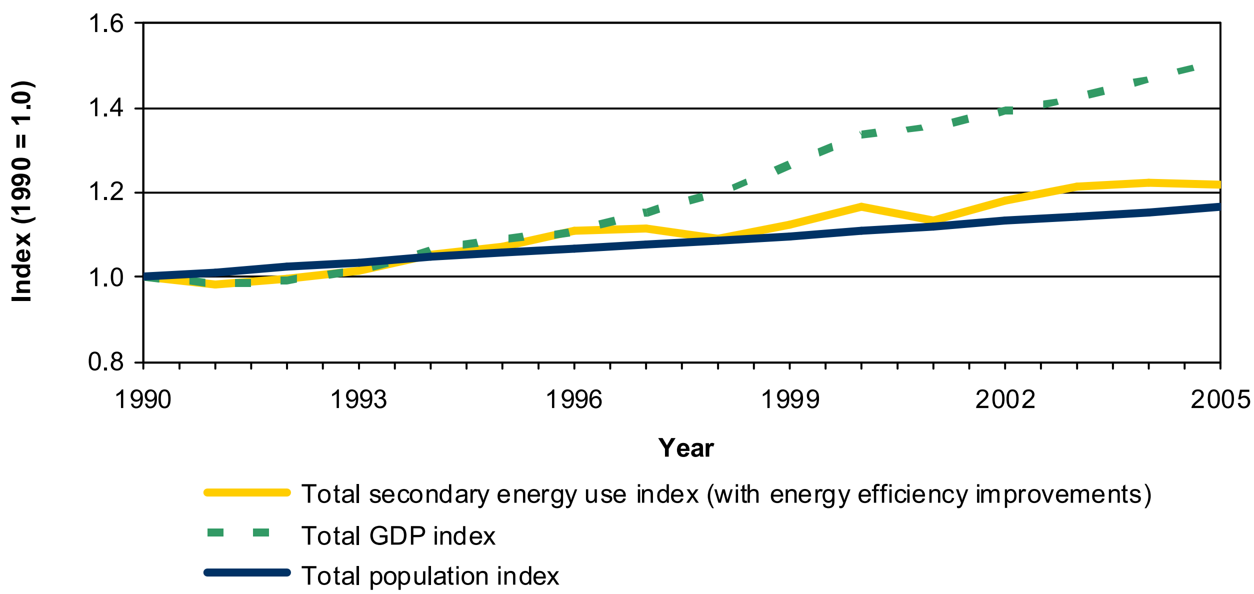
Several key factors drive energy use, including population and economic growth. For example, with a larger population than many other countries, Canada will have more people consuming energy. And energy demand will grow over time in relation to activities stimulating economic growth. Other factors driving energy use include weather, energy prices, economic structure, and individual behaviour and personal preferences.

This chapter provides an overview of Canada’s secondary energy use. This use is described at the sector level from 1990 to 2005. The sectors’ energy use, energy efficiency, key drivers and forecasts of energy consumption are discussed.

5.3. National Trends

Overall, secondary energy use in Canada increased by 22 percent, from 6952 PJ in 1990 to 8475 PJ in 2005 (see Figure 5.1). At the same time the Canadian population grew by 17 percent (approximately 1 percent a year), and GDP increased (more than 3 percent a year). The Canadian population grew by 17 percent (1 percent per year) between 1990 and 2005.[81] At the same time, GDP increased by 51 percent (more than 3 percent per year).[82] Growth in energy use was higher than the population growth rate but less than half the growth rate of the economy.

Figure 5.1: Total Secondary Energy Use, Canadian Population and GDP



Sources:
Natural Resources Canada (NRCan), National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1, "Total end-use sector – energy use analysis."

NRCan, Energy Use Data Handbook Tables (Canada), Total End-Use Sector, Table 5, "Commodity prices and background indicators."

NRCan, Energy Use Data Handbook Tables (Canada), Residential Sector, Table 18, "Residential energy prices and background indicators."

Within the sectors of the economy, the industrial sector continues to be the largest consumer of energy, followed by transportation, residential, commercial/institutional and agriculture (see Table 5.1). Between 1990 and 2005, all sectors experienced growth in energy use, with the transportation and commercial/institutional sectors experiencing the most rapid growth.[83]

TABLE 5.1: TOTAL SECONDARY ENERGY USE BY SECTOR

Sector	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Residential	1286.2	1402.2	9.0	18.5	16.5
Commercial/ institutional	867.0	1153.0	33.0	12.5	13.6
Industrial	2721.8	3209.4	17.9	39.2	37.9
Transportation	1877.9	2501.8	33.2	27.0	29.5
Agriculture	199.2	208.7	4.8	2.9	2.5

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

Natural gas and electricity accounted for almost half the secondary energy use in Canada, followed by oil (diesel fuel oil, light fuel oil, kerosene and heavy fuel oil) and motor gasoline (see Table 5.2). This fuel mix remained relatively constant from 1990 to 2005.

TABLE 5.2: TOTAL SECONDARY ENERGY USE BY ENERGY RESOURCE

Energy resource	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Electricity	1550.1	1924.9	24.2	22.3	22.7
Natural gas	1777.6	2069.7	16.4	25.6	24.4
Motor gasoline	1176.5	1429.2	21.5	16.9	16.9
Oil	1201.3	1457.1	21.3	17.3	17.2
Aviation gasoline	5.5	3.0	–46.4	0.1	0.0
Aviation turbo fuel	181.9	256.4	40.9	2.6	3.0
Still gas and petroleum coke	321.7	434.4	35.0	4.6	5.1
Wood waste and pulping liquor	341.0	462.8	35.7	4.9	5.5
Residential wood	82.2	106.0	29.0	1.2	1.3
Other	314.3	331.8	5.6	4.5	3.9

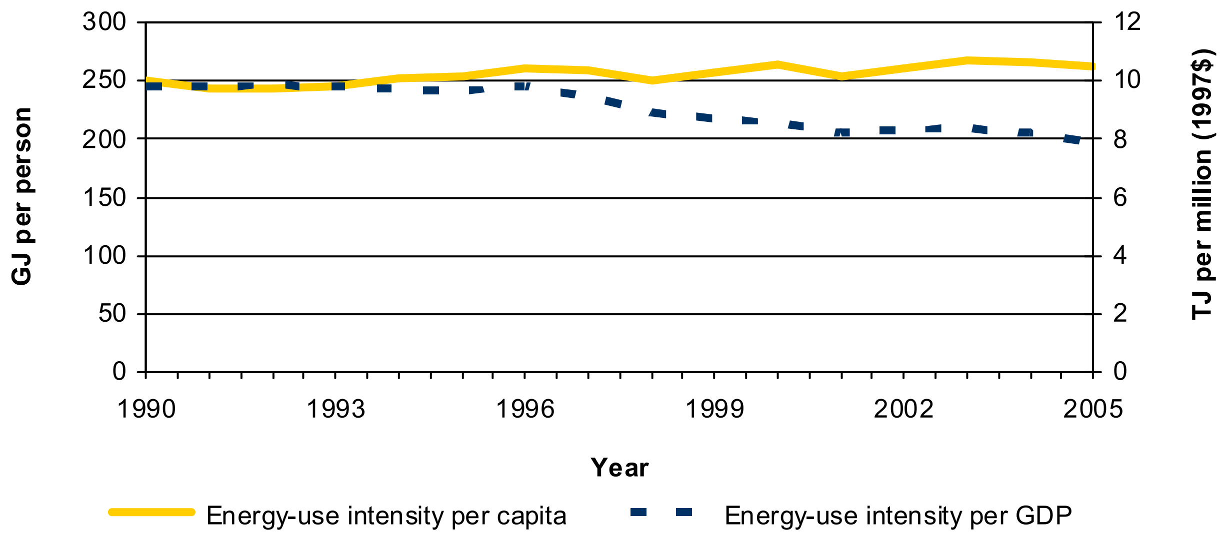
Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

5.3.1. Energy intensity and efficiency

Energy intensity

Energy intensity, defined as the amount of energy required per unit of activity (GDP), improved because it was lower in 2005 than in 1990 (see Figure 5.2). This 19 percent reduction in energy intensity reflects an overall improvement in energy efficiency, i.e. how effectively energy is being used for a given purpose.

FIGURE 5.2: TOTAL SECONDARY ENERGY-USE INTENSITY PER CAPITA AND UNIT OF GDP



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Total End-Use Sector, Table 1 and Table 5.

Energy efficiency

The analysis presented in this section uses a factorization method that separates the changes in the amount of energy used by the residential, commercial/institutional, industrial and transportation sectors of the economy into five factors:

- **Activity**: Activity is defined differently in each sector. For instance, in the residential sector, it is defined as households and the floor space of residences. And in the industrial sector, it is defined as a mix of industrial GDP, gross output and physical industrial output, such as tonnes of steel.

- **Structure**: Structure refers to change in the makeup of each sector. For example, in the residential sector, a relative increase in activity of one household type is considered a structural change. In the industrial sector, a relative increase in activity in one industry over another is a structural change.

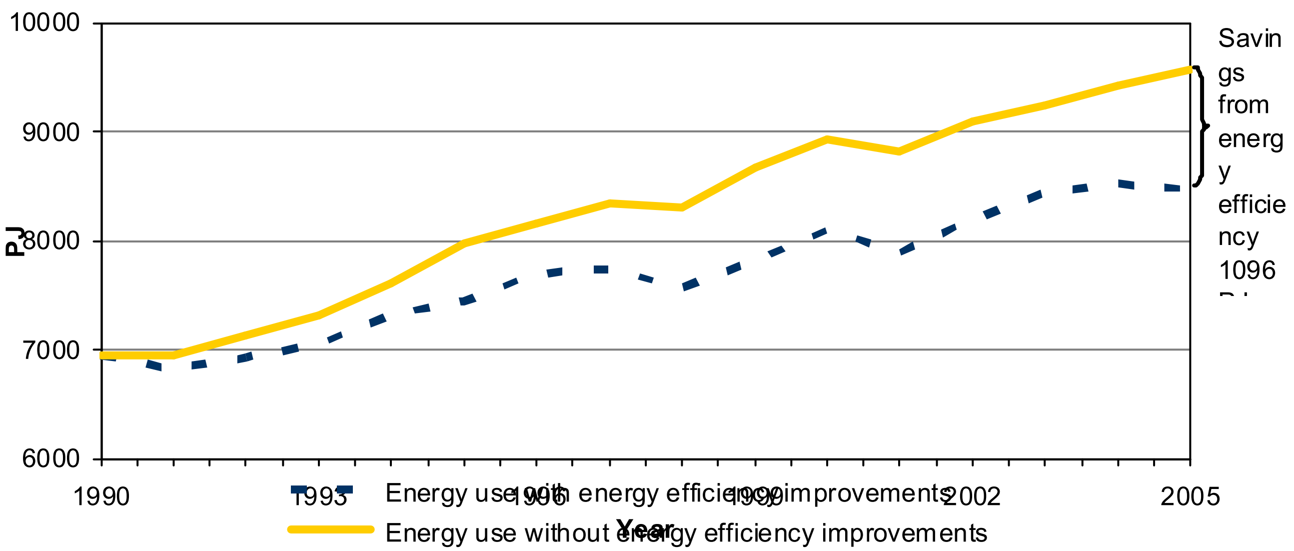
- **Weather**: Fluctuations in weather lead to changes in heating and cooling requirements. This effect is taken into account in the residential and commercial/institutional sectors, where heating and cooling account for a significant share of energy use.

- **Service level**: The increased penetration of auxiliary equipment, in commercial/institutional buildings, or of appliances and space coolers in the residential sector, is considered a service level effect.[84]

- **Energy efficiency**: Energy efficiency refers to how effectively energy is being used, e.g. the length of time an appliance can operate with a given amount of energy.

If there had not been significant ongoing improvements in energy efficiency in all end-use sectors, secondary energy use would have increased by 38 percent between 1990 and 2005, instead of the observed 22 percent (see Figure 5.3). These energy savings of 1096 PJ are equivalent to removing 16 million cars and passenger light trucks from the road.[85]

FIGURE 5.3: SECONDARY ENERGY USE, WITH AND WITHOUT ENERGY EFFICIENCY IMPROVEMENTS



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

The following factors influenced the change in energy use between 1990 and 2005 (see Figure 5.4):

- A 36 percent increase in activity (comprising commercial/institutional and residential floor space, number of households, passenger kilometres and tonne kilometres, industrial GDP, gross output and physical production) resulted in a 2516 PJ increase in energy.[86]

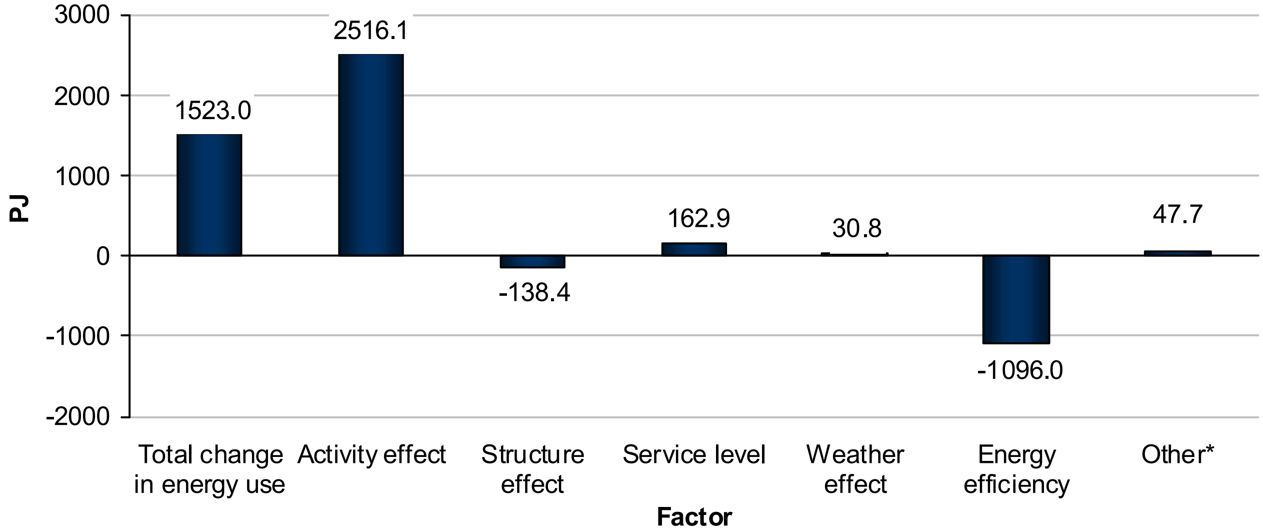
- Changes in the structure of most sectors in the economy increased energy use. However, these increases were offset by a shift in the industrial sector toward industries that are less energy intensive. The net result was a 138 PJ decrease in energy use.

- The winter in 2005 was slightly warmer than in 1990, but the summer was 71 percent warmer.[87] The net result was a 31 PJ increase in secondary energy demands.[88]

- Changes in the service level of auxiliary equipment (e.g. increased use of computers, printers and photocopiers in the commercial/institutional sector), increasing penetration rates of appliances and increased use of space coolers in the residential sector raised energy use by 163 PJ.

- Improvements in energy efficiency saved 1096 PJ of energy.

FIGURE 5.4: IMPACT OF ACTIVITY, STRUCTURE, WEATHER, SERVICE LEVEL AND ENERGY EFFICIENCY ON THE CHANGE IN ENERGY USE, 1990–2005



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

* Other refers to street lighting, non-commercial airline aviation, off-road transportation and agriculture, which are included in “Total change in energy use” but excluded from the factorization analysis.

5.3.2. National energy outlook

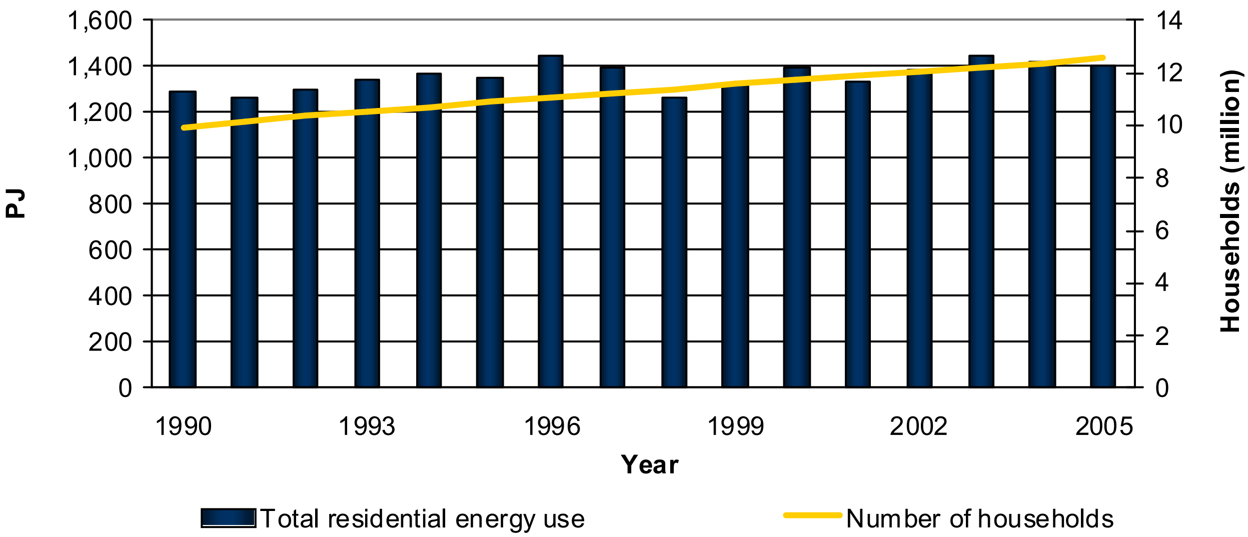
Looking ahead, Canada’s population and economy are expected to grow at a slower rate than in recent years.[89] The population is forecast to increase by 11 percent between 2005 and 2020 (0.7 percent per year), to reach 35 818 million people in 2020. On the economic side, GDP is expected to grow by 43 percent over the same period (2.4 percent per year). Moreover, secondary energy use[90] is forecast to grow by 20 percent (1.2 percent per year).

5.4. Residential Sector

The residential sector has four major types of dwellings: single detached homes, single attached homes, apartments and mobile homes. Households use energy for various activities, including space heating, water heating, appliances, space cooling and lighting. The residential sector accounted for 17 percent of the total secondary energy use in Canada in 2005.[91]

Between 1990 and 2005, residential energy use increased by 9 percent, from 1286 PJ to 1402 PJ (see Figure 5.5). During that period, population grew by 17 percent (4.6 million people)[92] and household stock grew by 2.7 million units.[93] As well, homes built in 2005 were 19 percent bigger than homes built in 1990.[94]

Figure 5.5: Residential Energy Use and Number of Households



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 1, "Secondary energy use and GHG emissions by energy source."

5.4.1. Highlights

- The population growth of 17 percent[95] and the movement toward fewer individuals per household stimulated a rise in the number of households over 1990–2005. This rise caused a 9 percent increase in energy demand.[96]

- The average floor space per household for new homes increased by 19 percent from 1990 to 2005.[97]

- Households tended to choose natural gas systems instead of oil systems over this period, which were, on average, more efficient.[98] This trend increased the energy efficiency of space-heating systems.

- Major appliances became so efficient between 1990 and 2005 that their overall energy use declined by 17 percent. However, an increase in the penetration rate of minor appliances counteracted efficiency gains in the major appliance category. It increased total appliance energy demand by 3 percent.[99]

- Above-average summer temperatures played a part in the rising demand for air conditioning. Space-cooling energy demand increased by 215 percent, from 12 PJ in 1990 to 37 PJ in 2005.[100]

- Major improvements in the energy efficiency of space heaters and improvements to the average household's thermal envelope allowed Canadians to save energy on space heating. These savings and those from other energy efficiency improvements increased consistently from 1990 to 2005. In 2005, the energy savings amounted to 321 PJ, which saved Canadians $6.1 billion in energy costs.[101]

5.4.2. Residential energy sources

The main types of energy used in the residential sector are natural gas, for heating and cooking, and electricity, for all types of residential energy needs. Biomass and petroleum are important energy resources in Atlantic Canada and the North and, to a lesser extent, in Ontario and Quebec. Significant energy is lost in the sector due to energy inefficiencies.

The mix of fuels used in the residential sector changed slightly between 1990 and 2005 (see Table 5.3). Natural gas and electricity became even more dominant. The quantity of heating-oil use declined as did its share of the fuel mix.

TABLE 5.3: RESIDENTIAL SECONDARY ENERGY USE BY ENERGY SOURCE

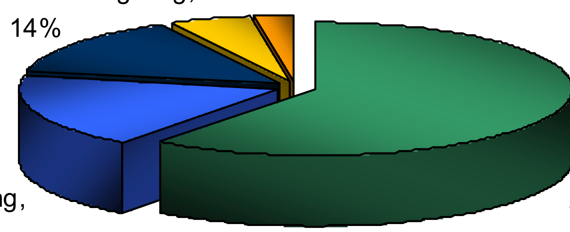
Energy source	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Electricity	467.4	543.6	16.3	36.3	38.8
Natural gas	528.4	646.6	22.4	41.1	46.1
Heating oil	186.4	92.7	−50.2	14.5	6.6
Wood	82.2	106.0	29.0	6.4	7.6
Other	21.9	13.2	−39.5	1.7	0.9

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 1.

5.4.3. Residential energy end uses

Canadian households use energy for various activities, including space heating, water heating, appliances, space cooling and lighting. Space- and water-heating account for most of Canada's residential use, followed by appliances, lighting and space cooling (see Figure 5.6).

FIGURE 5.6: RESIDENTIAL SECONDARY ENERGY USE BY END-USE, 2005



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 2, "Secondary energy use and GHG emissions by end-use."

Since 1990, the share of various energy uses has evolved. Energy end-use for appliances has decreased, while that for space cooling has increased. However, space- and water-heating and lighting have remained relatively constant (see Table 5.4).

TABLE 5.4: RESIDENTIAL SECONDARY ENERGY USE BY END-USE

End-use	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	**2005**	**1990–2005**	**1990**	**2005**
Space heating	782.7	846.1	8.1	60.8	60.3
Water heating	239.0	248.2	3.8	18.6	17.7
Appliances	197.3	203.0	2.9	15.3	14.5
Major appliances	*165.7*	*138.1*	*−16.7*	*12.9*	*9.8*
Other appliances	*31.6*	*64.9*	*105.2*	*2.5*	*4.6*
Lighting	55.7	68.4	22.8	4.3	4.9
Space cooling	11.6	36.5	215.4	0.9	2.6

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 2.

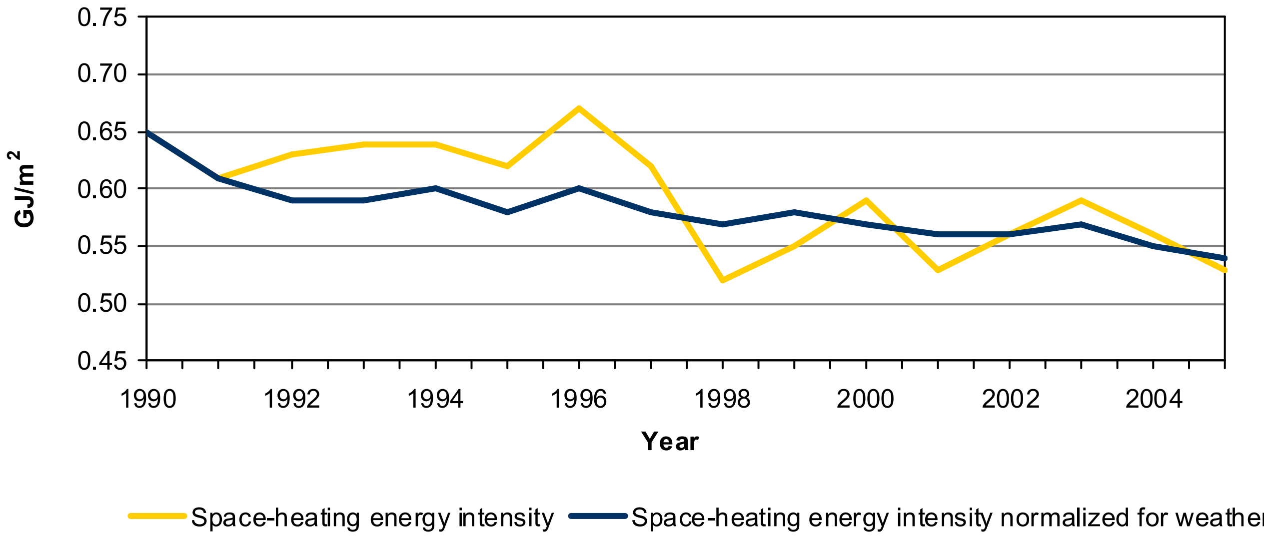
Space heating

Space-heating requirements increased for single attached and single detached homes between 1990 and 2005. Alternatively, energy demand for mobile homes and apartments remained relatively unchanged.[102]

Overall, energy intensity for space heating improved by 18 percent between 1990 and 2005, from 0.65 GJ per square metre (m^2) to 0.53 GJ/m^2 (see Figure 5.7). This decrease occurred for two main reasons: more people chose natural gas over fuel oil systems, and natural gas furnaces became more efficient.

Energy efficiency gains were realized, to a large extent, because normal efficiency systems were replaced with regulated medium- and high-efficiency systems. From 1990 to 2005, medium- and high-efficiency oil and gas systems increased their share of the market, from 3 percent to 27 percent.[103]

FIGURE 5.7: SPACE-HEATING ENERGY INTENSITY



Sources: NRCan, National Energy Use Database, 1990 to 2005 (2007), as follows:

Comprehensive Energy Use Database, Residential Sector, Canada, Table 13.

Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 3(a) and Table 3(b).

There was a decrease in the energy used to heat each square metre of living space in a Canadian home. However, it was not enough to compensate for the increased number of households and the increase in the square metres of homes. In fact, energy required to heat all the dwellings in Canada increased, from 783 PJ in 1990 to 846 PJ in 2005.[104]

Water heating

Canadians are switching from oil-dependent water heaters to natural gas water heaters that are, on average, more energy efficient. In addition, today's minimum efficiency standards mean that new water heaters use less energy per unit. Energy efficiency gains are realized as stock is replaced by more efficient water heaters. Between 1990 and 2005, the effect of these changes was an 18 percent decrease in water-heater energy intensity, from 24 GJ per household to 20 GJ per household.[105]

There was also a decrease in the energy used to heat water per household. However, it was not enough to compensate for the increased number of households. In fact, residential water-heating energy use increased by 4 percent.

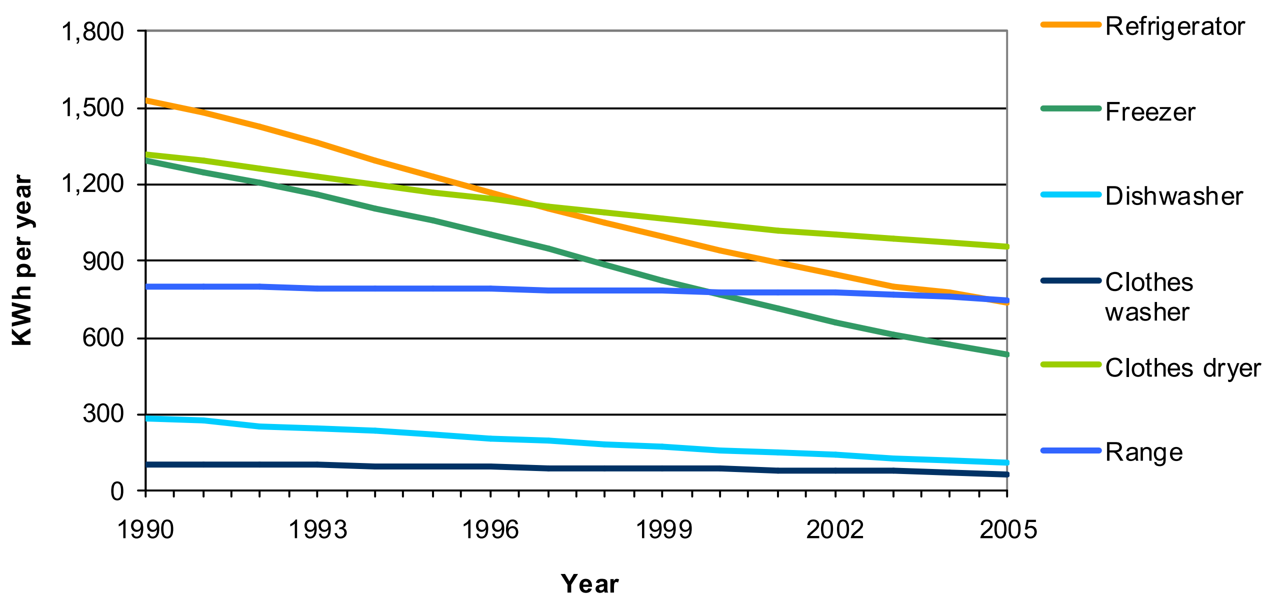
Appliances

The market penetration of major appliances in Canadian homes increased between 1990 and 2005.[106] However, the total energy they consumed decreased by 17 percent at the same time.[107] This can be explained by the average unit energy use of all major household appliances falling every year during the period (see Figure 5.8).

The most noticeable decrease was in the unit energy use of dishwashers. In 2005, they used 61 percent less energy than in 1990, decreasing from 282 kilowatt hours (kWh) per year (yr) to 111 kWh/yr. Significant improvements were also realized for other appliances. For example, a new fridge in 1990 used an average of 956 kWh/yr, versus 469 kWh/yr in 2005 (a decrease of 51 percent).

These improvements in efficiency were mainly due to the introduction of minimum energy efficiency regulations.

FIGURE 5.8: UNIT ENERGY CONSUMPTION OF MAJOR APPLIANCES' STOCK



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 38.

In contrast, energy use for smaller appliances increased by 105 percent, more than offsetting the decrease in energy use from major appliances.[108] Smaller appliances include televisions, video cassette recorders, digital video disc players, radios, computers and toasters. One example of the rapid growth in minor appliances is the increased penetration of personal computers. In 1990, they were present in fewer than one in every seven households; in 2005, they were present in almost three quarters of the dwellings in Canada.

Air conditioners

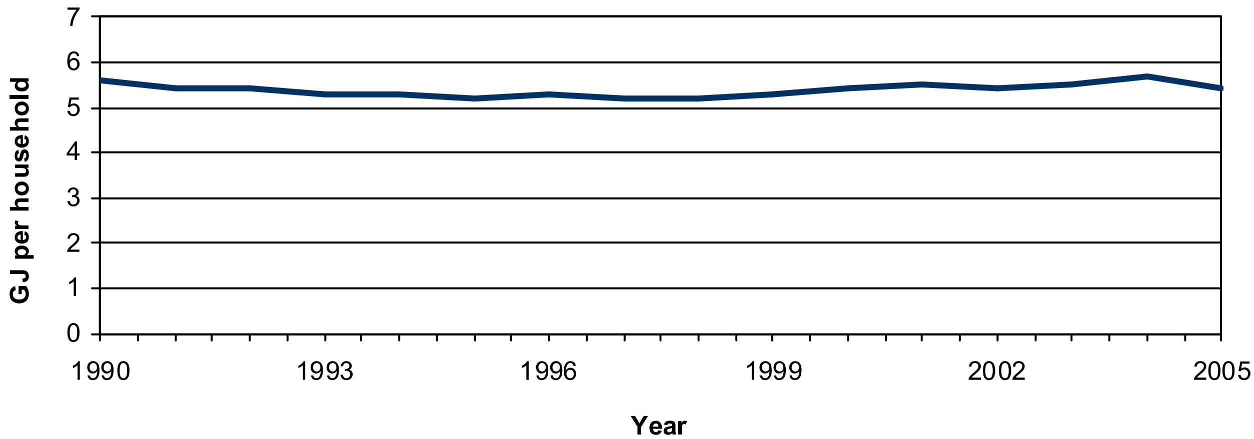
The number of air conditioners more than doubled, increasing market penetration to 41 percent of homes between 1990 and 2000.[109] As a result, the energy required for cooling Canadian houses increased by 215 percent (from 12 PJ to 37 PJ) between 1990 and 2005.[110] During this period, however, some energy savings occurred because the efficiencies of new room and central air conditioners improved by 32 percent and 13 percent respectively.[111]

Lighting

The energy required to light an average household in Canada decreased by 3 percent between 1990 and 2005 (see Figure 5.9). This energy efficiency gain may be linked to the increased use of compact fluorescent lamps (CFLs). CFLs represented 6 percent of light bulbs used in 2005[112] and were present in 32 percent of Canadian households in 2003.[113] The gain may also be linked to the increased penetration of other energy-efficient lighting sources.

Despite the decrease in energy required to light an average household, the energy use for lighting increased by 23 percent. This increase was driven by the increase in the number of households.

FIGURE 5.9: LIGHTING ENERGY INTENSITY



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007*)*, Comprehensive Energy Use Database, Residential Sector, Canada, Table 4.

5.4.4. Residential energy intensity and efficiency

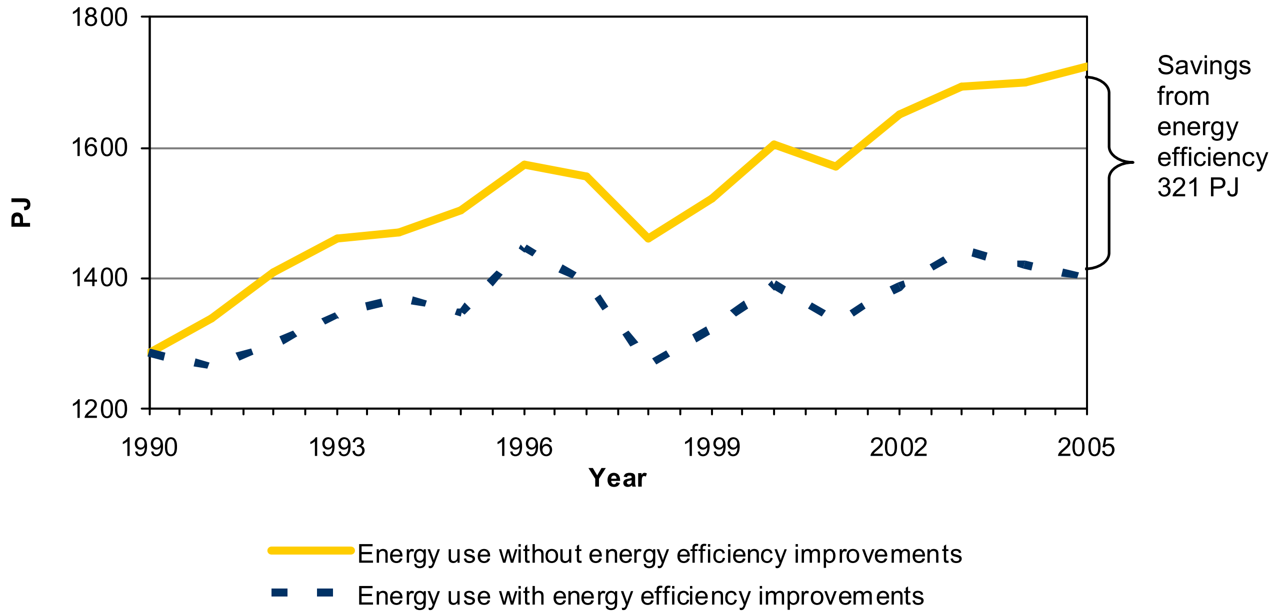
Energy intensity

In the residential sector, energy intensity is usually expressed as energy consumed per household. It can also be expressed as energy consumed per square metre of house area. Energy intensity decreased from 130 GJ per household in 1990 to 111.4 GJ per household in 2005 – although the average household operated more appliances, had a larger home and increased its use of air conditioners.[114] Over the period, energy intensity per square metre decreased, from 1.07 GJ to 0.89 GJ.

Energy efficiency

Energy efficiency improvements in the residential sector include changes to the residential envelope (insulation, windows, etc.) and to the efficiency of energy-consuming items in the home, such as furnaces, appliances and lighting. These improvements have resulted in significant savings since 1990. Overall, energy efficiency in the residential sector improved by 25 percent from 1990 to 2005, saving Canadians $6.1 billion in energy costs, or 321 PJ of energy (see Figure 5.10).

FIGURE 5.10: RESIDENTIAL SECONDARY ENERGY USE, WITH AND WITHOUT ENERGY EFFICIENCY IMPROVEMENTS



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Residential Sector, Table 3(a).

5.4.5. Residential energy outlook

The number of households is forecast to increase by 20 percent (1.2 percent per year) between 2005 and 2020, to reach 15.161 million households.[115] At the same time, population is forecast to increase by 11 percent (0.7 percent per year), indicating a continuation in the decrease in the average number of people per household. Energy demand is forecast to increase by 15 percent over the period, to reach 1609 PJ.

5.5. TRANSPORTATION SECTOR

Transportation is a diverse sector that includes road, air, rail and marine transportation. Canadians use these forms of transportation primarily for moving passengers and freight.

Energy consumption in the passenger subsector comprises all the energy required to move people by cars, trucks, motorcycles, buses, air and rail. Energy consumption in the freight subsector comprises all of the energy required to move goods by truck, rail, ship or air in Canada. Energy for off-road purposes, including snowmobiles and lawnmowers, is also included the transportation sector's consumption.

5.5.1. Highlights

- In 2005, the transportation sector accounted for 30 percent of Canada's total secondary energy use.[116] Transportation energy use increased by 33 percent, from 1878 PJ in 1990 to 2502 PJ in 2005.
- Most transportation energy use occurred in the passenger subsector. However, the freight subsector is growing the fastest.[117]
- Freight energy use grew 61 percent since 1990 to reach 1028 PJ in 2005. This growth was due mainly to an increase in the use of heavy trucks for moving goods and to meet the needs of just-in-time inventory.
- A 13 percent rise in passenger vehicle stock and consumers' preference for larger passenger vehicles[118] led to a 16 percent increase in energy use for the passenger subsector over the 1990 level. As a result, energy use reached 1376 PJ in 2005.[119]
- Off-road energy use accounted for the remaining 97 PJ in the sector in 2005.
- Transportation energy cost Canadians $60.8 billion in 2005, more than the energy cost in any other sector.[120]
- Overall, energy efficiency in the transportation sector since 1990 helped Canadians save 352 PJ of energy in 2005, or $8.5 billion.

5.5.2. Transportation energy use and trends

Between 1990 and 2005, transportation energy use increased by 33 percent, from 1878 PJ to 2502 PJ. Passenger transportation consumed the most energy in 2005 (55 percent). Freight transportation accounted for 41 percent of the consumption, and off-road vehicles accounted for 4 percent (see Figure 5.11).

FIGURE 5.11: DISTRIBUTION OF TRANSPORTATION ENERGY USE, 2005

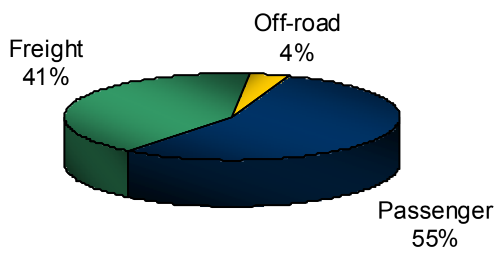
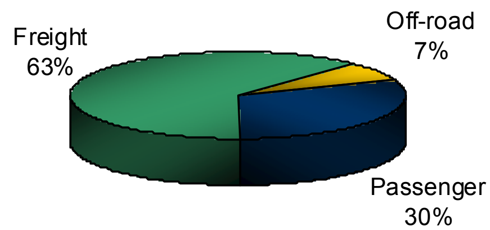


FIGURE 5.12: CHANGE IN TRANSPORTATION ENERGY USE BY SUBSECTOR, 1990-2005

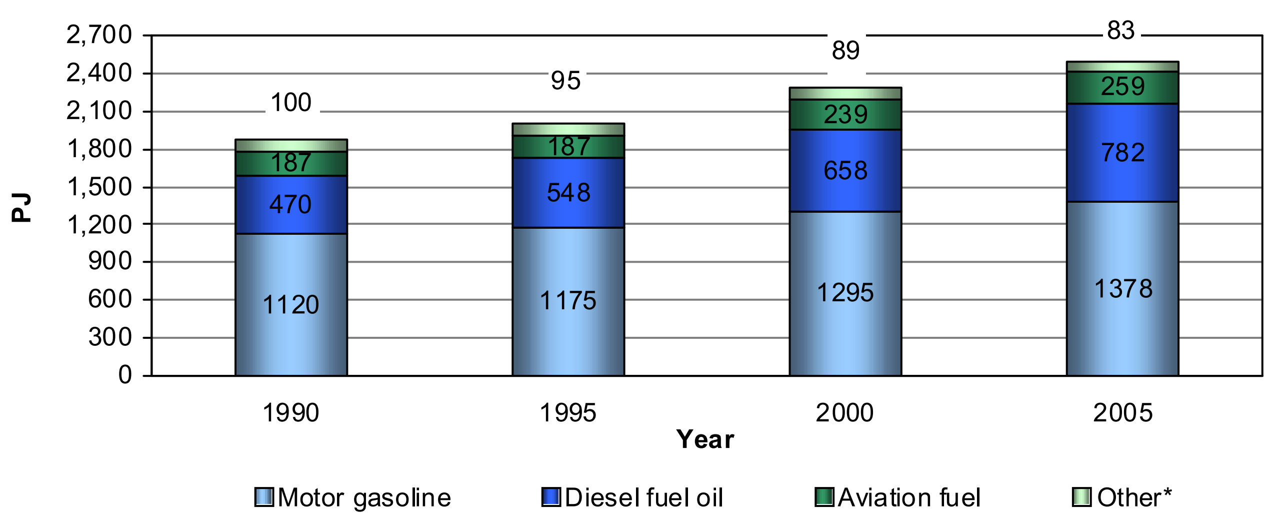


Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Transportation Sector, Canada, Table 1.

In terms of growth, however, freight was the fastest growing transportation subsector between 1990 and 2005 (see Figure 5.12). It accounted for 63 percent of the change in energy use for the sector. Of interest, light and heavy trucks, with a combined increase of 577 PJ, represented 80 percent of the transportation modes that increased between 1990 and 2005.[121] Increasing energy demand from the freight subsector over the years is largely responsible for the 33 percent increase in transportation energy use. In 2005, the freight subsector accounted for 41 percent of transportation demand.[122]

Not surprisingly, motor gasoline was the main fuel used by the transportation sector. However, it was used primarily by passenger vehicles (see Figure 5.13). Diesel fuel, conversely, was used by more modes of transportation. With the large increase in freight activity, the overall use of diesel increased more than that of any other fuel. But the total use of diesel was still less than that of gasoline. Propane and aviation gasoline were the only fuels that decreased in use. As a result, the use of aviation turbo fuel increased.

FIGURE 5.13: TRANSPORTATION SECTOR ENERGY USE BY ENERGY RESOURCE



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Transportation Sector, Canada, Table 1.

*Other includes electricity, natural gas, light fuel oil and kerosene, heavy fuel oil, and propane.

5.5.3. Passenger transportation

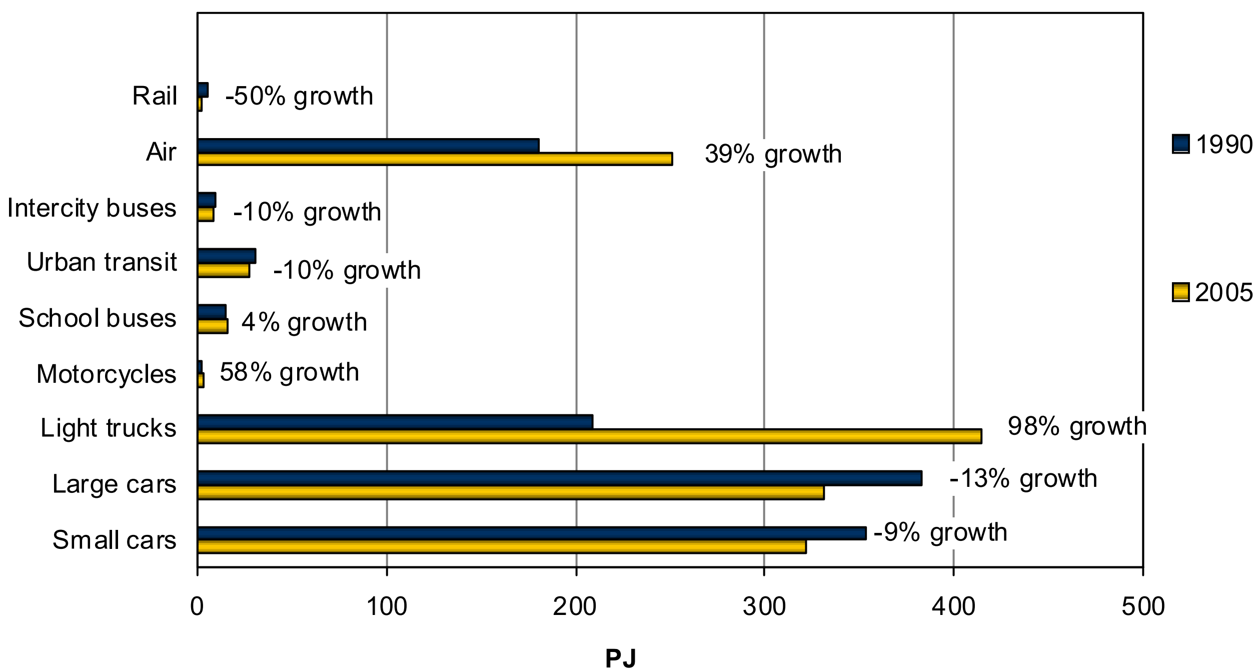
Canadians use light-duty vehicles as the main mode of transportation for personal passenger transport.[123] Air and rail modes are also used, but to a lesser extent. Light-duty vehicles include small cars, large cars, light trucks and motorcycles. For the passenger transportation subsector, energy use is measured in passenger-kilometres (pkm). Passenger-kilometres are calculated by multiplying the number of passengers carried by the distance travelled. For example, two passengers who travel 10 km together in a car represent 20 pkm.

Passenger transportation energy use

Passenger transportation energy use increased by 16 percent, from 1188 PJ to 1376 PJ, between 1990 and 2005. At the same time, Canada saw a 24 percent increase in the number of licensed drivers[124] and a 13 percent increase in passenger-vehicle stock (light-duty vehicles).[125] And there was a 10 percent increase in the average distance travelled (by light-duty vehicles).[126] All these factors led to an overall 34 percent increase in passenger-kilometres travelled.[127]

The rise in the popularity of minivans and SUVs led to a large shift in passenger transportation from cars toward light trucks. Between 1990 and 2005, light-truck energy use increased more than any other passenger transportation mode, rising 98 percent. In fact, the light-truck stock grew by 88 percent and its passenger-kilometres grew by 141 percent over the period (see Figure 5.14).

FIGURE 5.14: PASSENGER TRANSPORTATION ENERGY USE BY MODE



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 7.

The mix of fuels for passenger transport remained relatively constant over time. Motor gasoline was the primary source of energy. It represented 77 percent of the fuel mix in 2005, followed by aviation turbo fuel and diesel fuel (see Table 5.5).

TABLE 5.5: PASSENGER TRANSPORTATION SECONDARY ENERGY USE BY ENERGY RESOURCE

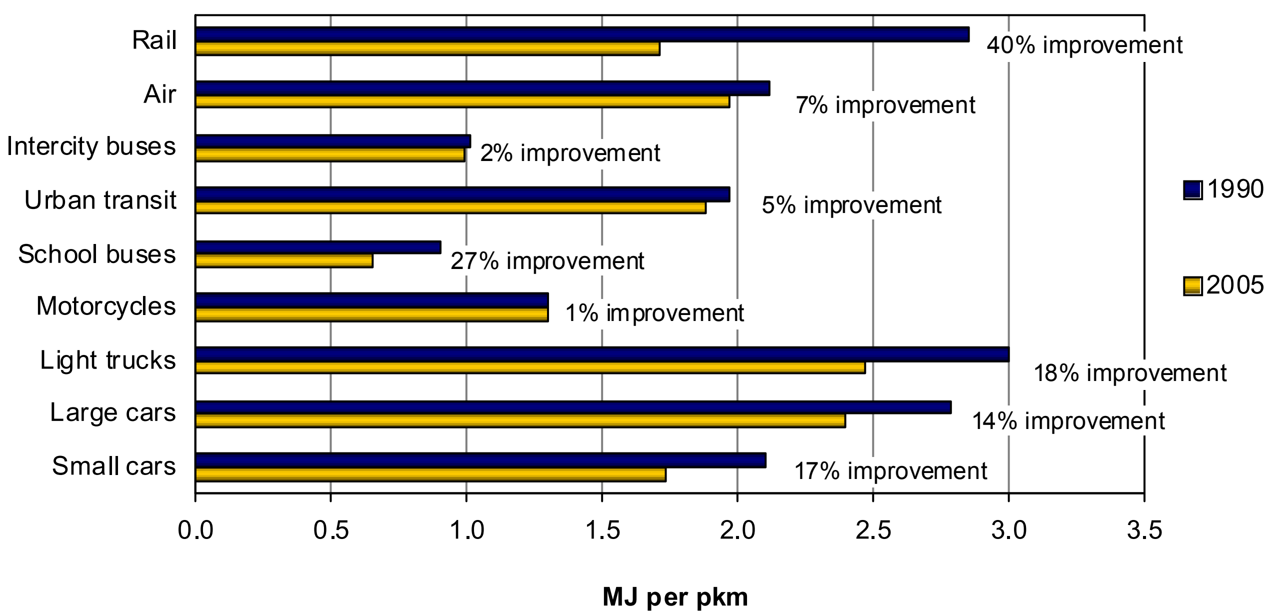
Energy resource	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Electricity	3.1	3.5	14.0	0.3	0.3
Natural gas	0.8	1.4	67.2	0.1	0.1
Motor gasoline	921.8	1057.1	14.7	77.6	76.8
Diesel fuel oil	60.4	56.8	−6.0	5.1	4.1
Aviation gasoline	5.4	2.9	−46.3	0.5	0.2
Aviation turbo fuel	175.5	248.5	41.6	14.8	18.1
Propane	20.6	5.8	−71.8	1.7	0.4

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 2.

Passenger transportation energy intensity

Energy intensity associated with passenger travel has improved from year to year. Between 1990 and 2005, energy intensity improved 13 percent, from 2.36 megajoules (MJ) per passenger-kilometre travelled to 2.05 MJ/pkm (see Figure 5.15). Improvements in vehicle fuel efficiency are responsible for this improvement. All modes of on-road vehicles, except motorcycles, improved their average fuel use, as measured by litres used per 100 km (L/100 km).[128]

FIGURE 5.15: PASSENGER TRANSPORTATION ENERGY INTENSITY BY MODE



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 4.

5.5.4. Freight transportation

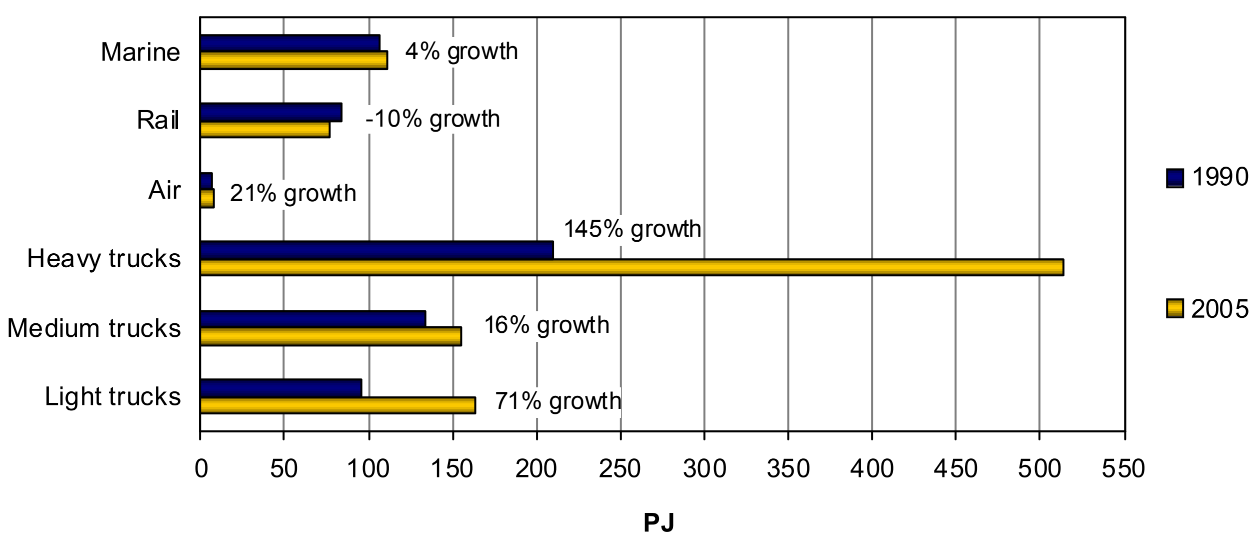
The freight transportation subsector in Canada has four modes: road, air, marine and rail. A major component of the freight transportation subsector is trucking. For the freight transportation subsector, energy use is measured in tonne-kilometres (tkm). One tonne-kilometre represents the movement of one tonne of freight over one kilometre.

Freight transportation energy use

Energy use associated with freight transportation increased by 61 percent, from 637 PJ in 1990 to 1028 PJ in 2005.[129] During the same period, the number of trucks increased by 39 percent.[130] Overall, the average distance travelled for all types of freight trucks (i.e. heavy, medium and light) increased only 10 percent. But heavy trucks increased their average distance travelled by 26 percent, to reach 89 332 km/yr.

Overall, energy use increased for all modes of transportation except rail, which experienced a decline in energy use (−10 percent) (see Figure 5.16). Light- and heavy-trucking transport experienced the largest growth in energy use.

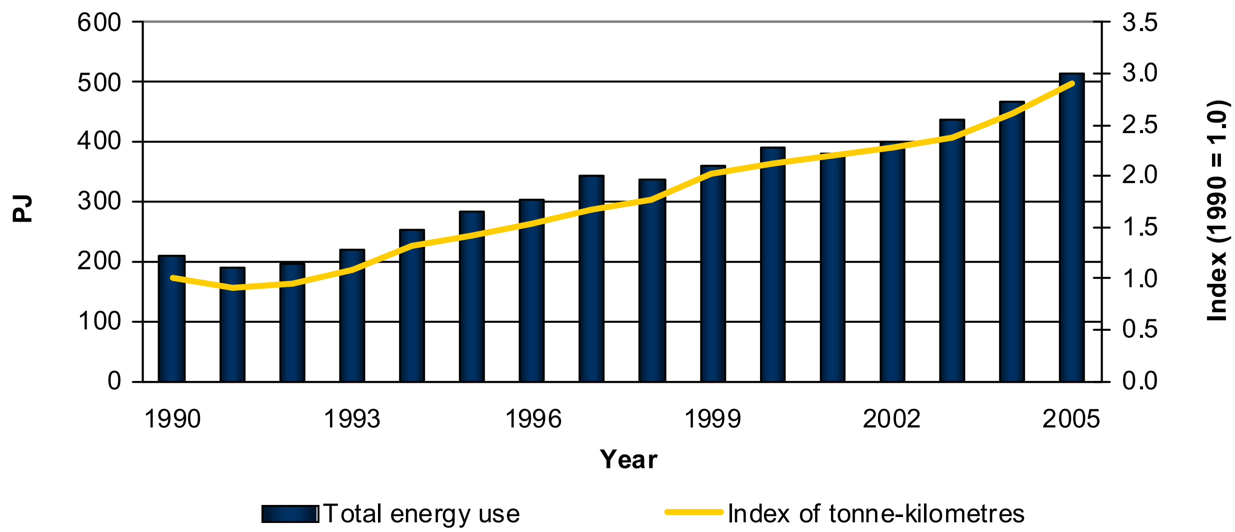
FIGURE 5.16: FREIGHT TRANSPORTATION ENERGY USE BY MODE



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 8.

The majority of energy consumed for freight continued to be related to trucking activities. The need for a just-in-time inventory helps explain the increase in heavy-truck energy use (see Figure 5.17).

FIGURE 5.17: HEAVY-TRUCK ENERGY USE AND TONNE-KILOMETRE



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 8.

The mix of fuels used in the freight transportation subsector remained relatively constant between 1990 and 2005 (see Table 5.6). Diesel fuel oil continued to be the main source of fuel, comprising more than 71 percent of fuel consumed for freight transportation.

TABLE 5.6: FREIGHT TRANSPORTATION SECONDARY ENERGY USE BY ENERGY RESOURCE

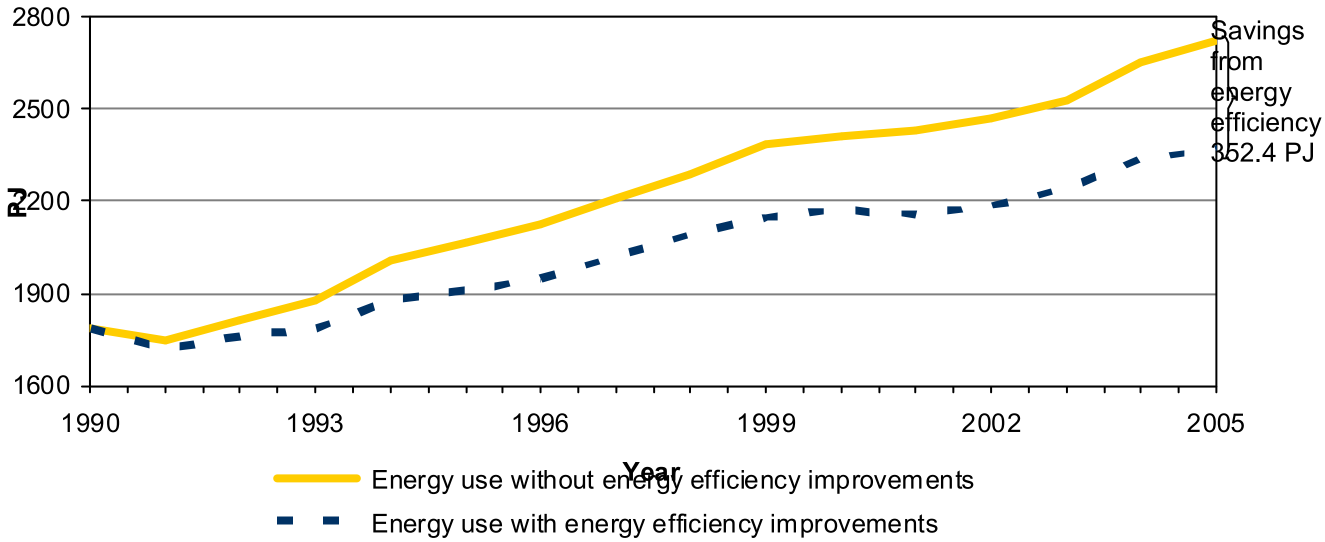
Energy resource	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Natural gas	0.8	0.5	−43.3	0.1	0.0
Motor gasoline	145.3	223.0	53.5	22.8	21.7
Diesel fuel oil	409.4	725.0	77.1	64.3	70.5
Heavy fuel oil	60.1	67.5	12.2	9.4	6.6
Aviation gasoline	0.1	0.0	−52.7	0.0	0.0
Aviation turbo fuel	6.4	7.8	21.6	1.0	0.8
Propane	14.7	4.4	−69.8	2.3	0.4

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 8.

5.5.5. Transportation energy efficiency

Overall, energy efficiency in the transportation sector improved by 19 percent from 1990 to 2005,[131] leading to a savings of $8.5 billion and 352 PJ of energy (see Figure 5.18).[132] These savings were largely a result of improvements in the energy efficiency of heavy trucks and passenger light-duty vehicles.

FIGURE 5-18. TRANSPORTATION ENERGY USE, WITH AND WITHOUT ENERGY EFFICIENCY IMPROVEMENTS



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 9.

5.5.6. Transportation energy outlook

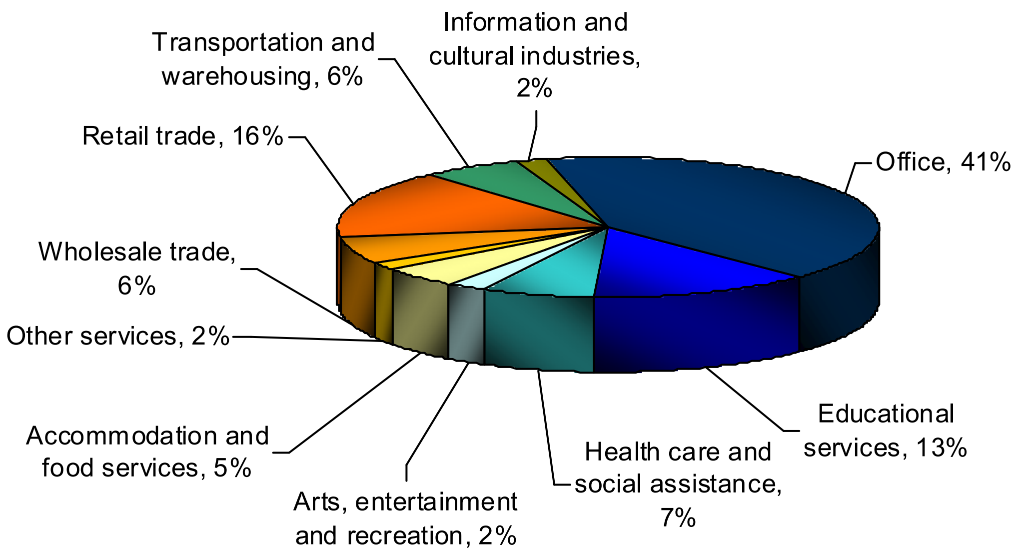
Total transportation energy use (excluding pipeline) is forecast to increase by 29 percent over 2005–2020 to reach 3190 PJ. [133] This represents a slower growth rate than that experienced over 1990–2004 (31 percent).

5.6. Commercial/Institutional Sector

In the commercial/institutional sector, energy is used for heating, operating auxiliary equipment (such as computers), lighting, water heating, auxiliary motors and space cooling. The sector includes activities related to trade, finance, real estate, public administration, education and commercial services. These activities have been grouped into 10 subsectors (see Figure 5.19).

In 2005, the commercial/institutional sector consumed 14 percent of the total secondary energy use in Canada. [134]

Figure 5.19: Distribution of Commercial/Institutional Floor Space by Subsector, 2005



Source: NRCan, Energy Efficiency Trends in Canada, 1990 to 2005 (2007), "Commercial/Institutional Sector."

5.6.1. Highlights

- Between 1990 and 2005, the commercial/institutional sector was the second fastest growing sector with respect to energy, increasing by 33 percent, or 286 PJ (from 867 PJ to 1153 PJ).
- Over the period, GDP in the commercial/institutional sector increased by 57 percent (from $439 billion to $688 billion). The total number of employees increased by 30 percent, from 9.3 million to 12.2 million.[135]
- Over the period, commercial/institutional floor space increased by 28 percent, or 143 million m^2.[136]
- Space heating consumed the most energy in the sector over the period. It also contributed to 38 percent of the increased energy use of end-uses that increased.[137]
- Natural gas and electricity accounted for 86 percent of the energy used in the commercial/institutional sector in this period.[138]

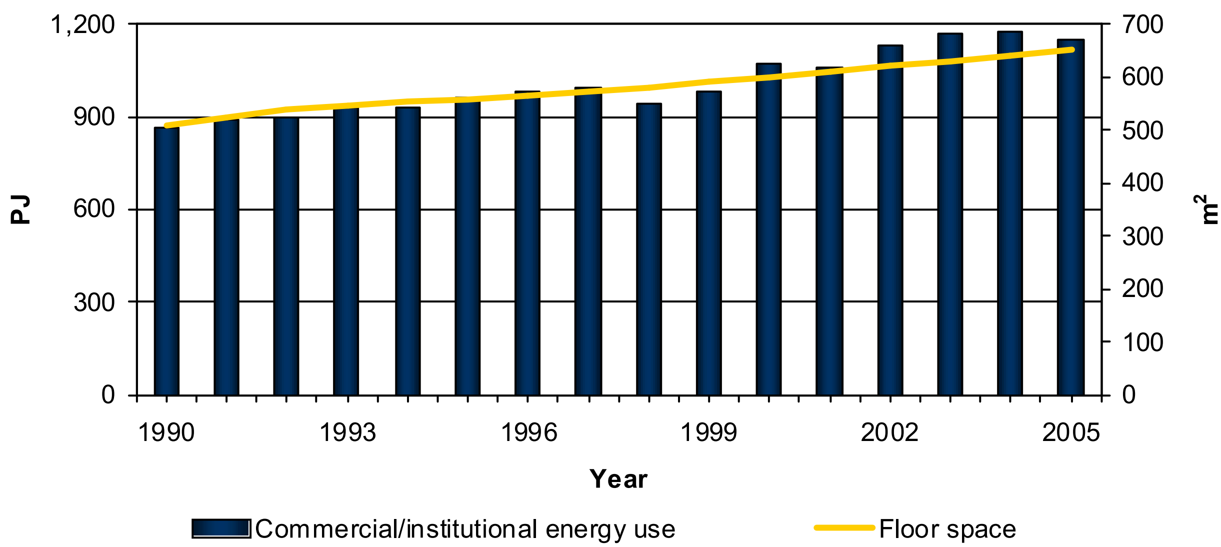
- Due to a higher space-cooling rate from 1990 to 2005 and the fast growth of electronic equipment, energy use for space cooling increased by 225 percent. Energy growth for auxiliary equipment increased by 101 percent.

- Between 1990 and 2005, energy efficiency saved the commercial/institutional sector $1.6 billion in energy costs, or 75.4 PJ of energy.[139]

5.6.2. Commercial/institutional energy use and trends

From 1990 to 2005, commercial/institutional energy use increased by 33 percent, from 867 PJ in 1990 to 1153 PJ in 2005 (see Figure 5.20). At the same time, GDP for the sector grew 57 percent, and the floor space grew by 28 percent. [140]

FIGURE 5.20: COMMERCIAL/INSTITUTIONAL ENERGY USE AND FLOOR SPACE



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Commercial/Institutional Sector, Table 1.

Natural gas and electricity were the main energy resources for the commercial/institutional sector. They accounted for 86 percent of total energy use (see Table 5.7). There was a rapid growth in the use of heavy fuel oil (a 228 percent rise) and light fuel oil and kerosene (a 77 percent rise) since 1999. The reason for this growth is still unknown. It may be due, in part, to these fuel types being erroneously attributed to the commercial sector because fuel marketers (included in the commercial/institutional sector) are buying petroleum products from refineries and then re-selling the fuels to other sectors (e.g. industrial, transportation).[141]

TABLE 5.7: COMMERCIAL/INSTITUTIONAL SECONDARY ENERGY USE BY FUEL TYPE

Energy resource	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Electricity	390.1	482.3	23.6	45.0	41.8
Natural gas	387.1	504.9	30.4	44.7	43.8
Light fuel oil and kerosene	62.0	83.1	34.2	7.1	7.2
Heavy fuel oil	11.4	55.6	389.9	1.3	4.8
Steam	0.2	0.5	170.7	0.0	0.0
Other	16.3	26.5	62.9	1.9	2.3

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Commercial/Institutional Sector, Canada, Table 1.

Space heating accounts for the largest share of energy use in the sector, with more than half of the sector's energy used for space heating (see Table 5.8). The remaining energy use is spread among the other end-uses. Two of them have seen large increases in their energy use. Auxiliary equipment used more energy due to increasing computerization of the workplace. And space cooling used more energy due the higher cooling rate of commercial/institutional buildings.

TABLE 5.8: COMMERCIAL/INSTITUTIONAL SECONDARY ENERGY USE END-USE

End-use	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Space heating	472.5	585.3	23.9	54.5	50.8
Water heating	68.0	98.6	44.9	7.8	8.5
Auxiliary equipment	82.3	165.6	101.1	9.5	14.4
Auxiliary motors	90.7	88.1	−2.9	10.5	7.6
Lighting	113.8	108.0	−5.2	13.1	9.4
Space cooling	30.6	99.6	225.2	3.5	8.6
Street lighting	8.9	7.9	−11.7	1.0	0.7

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Commercial/Institutional Sector, Canada, Table 4.

5.6.3. Commercial/institutional subsectors

In 2005, the offices subsector accounted for the largest share of energy use (35 percent) in the commercial/institutional sector (see Table 5.9). Retail trade (17 percent) and educational services (14 percent) were the next largest users.

The offices subsector also had the largest increase in energy use, using 129 PJ more energy in 2005 than in 1990. This subsector was followed by retail trade, with a 47 PJ increase.

TABLE 5.9: COMMERCIAL/INSTITUTIONAL SECONDARY ENERGY USE BY SUBSECTOR

Subsector	Secondary energy use (PJ)		Growth rate (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Wholesale trade	54.8	64.1	16.9	6.4	5.6
Retail trade	145.4	192.1	32.2	16.9	16.8
Transportation and warehousing	58.2	54.0	−7.2	6.8	4.7
Information and cultural industries	18.4	27.6	50.0	2.1	2.4
Offices	270.0	399.5	48.0	31.5	34.9
Educational services	120.3	158.9	32.0	14.0	13.9
Health care and social assistance	81.8	105.3	28.7	9.5	9.2
Arts, entertainment and recreation	24.8	36.3	46.3	2.9	3.2
Accommodation and food services	65.6	86.3	31.5	7.6	7.5
Other services	18.8	21.1	12.5	2.2	1.8

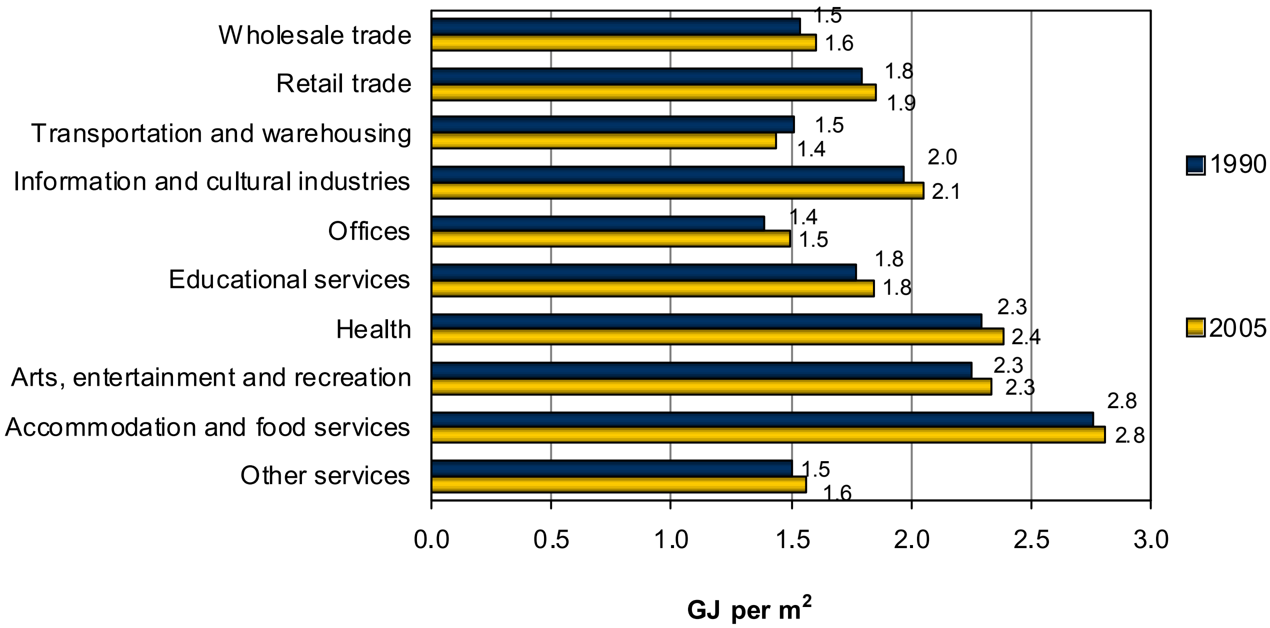
Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Commercial/Institutional Sector, Canada, Table 2.

5.6.4. Commercial/institutional energy intensity and efficiency

Energy intensity

In the commercial/institutional sector, energy intensity refers to the amount of energy used per unit of floor space (gigajoules per square metre [GJ/m^2]). It is used as an aggregate measure of energy use over activity to measure the amount of energy required to provide a given level of activity in the sector.

FIGURE 5.21: COMMERCIAL AND INSTITUTIONAL ENERGY INTENSITY BY SUBSECTOR

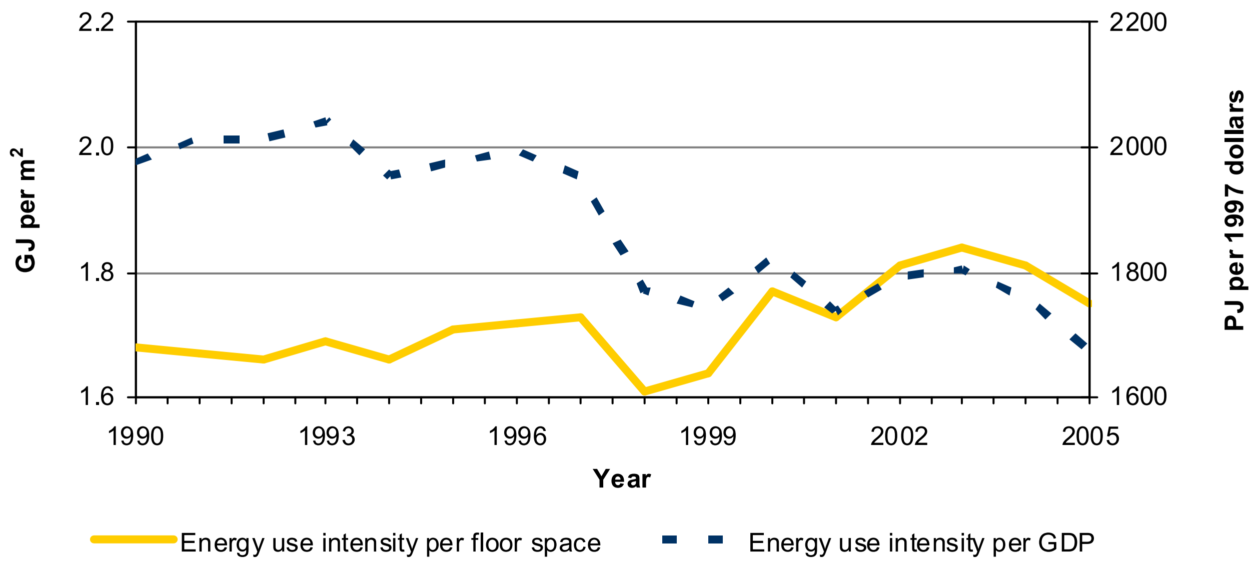


Source: NRCan, Energy Efficiency Trends in Canada, 1990 to 2005 (2007), “Commercial/Institutional Sector.”

Accommodation and food services topped the list as the most energy-intensive subsector, consuming 2.8 GJ/m^2 in 2005 (see Figure 5.21). Next on the list was the health care and social assistance subsector, which consumed 2.4 GJ/m^2.[142] Hence the combined intensity of these two subsectors increased by 3 percent over the period.[143] Their intensive character may be attributed to a combination of factors. These factors include the energy-intensive nature of their activities (e.g. restaurants, laundry) and services (e.g. extensive hours of operation) and their use of electronic equipment with large energy needs (e.g. medical scanners).

Overall, the commercial/institutional sector experienced an increase of 4 percent in energy intensity in terms of energy consumed per unit of floor space (GJ/m^2) (see Figure 5.22). But it improved its energy intensity by 15 percent when measured against economic activity (petajoules per 1997 dollars).

FIGURE 5.22: COMMERCIAL/INSTITUTIONAL SECONDARY ENERGY-USE INTENSITY PER FLOOR SPACE AND UNIT OF GDP

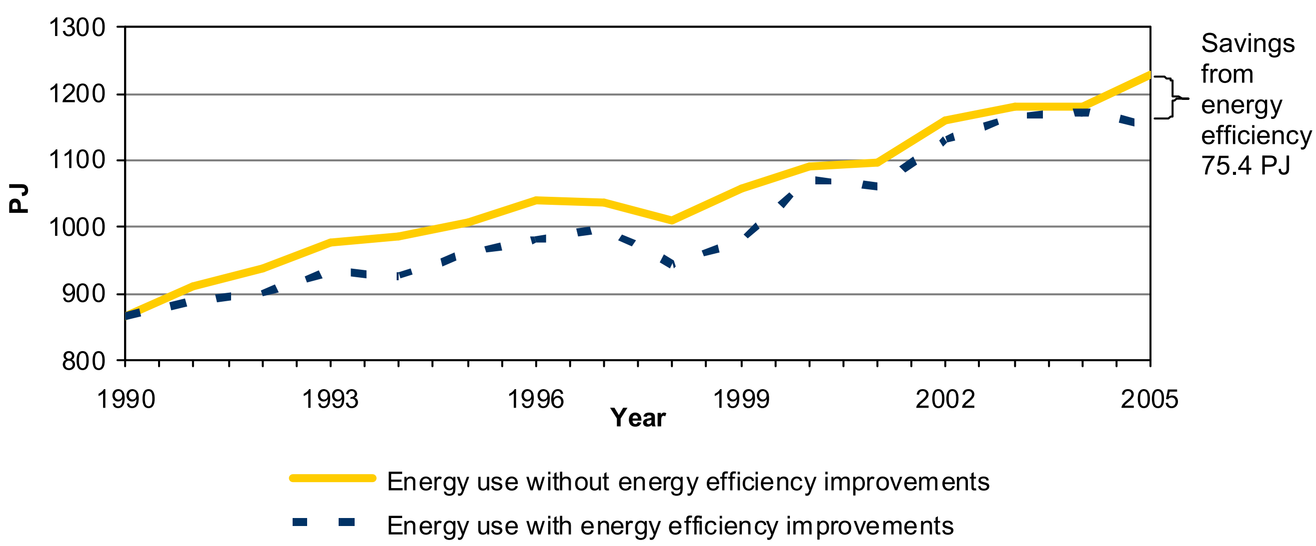


Source: NRCan, Energy Efficiency Trends in Canada, 1990 to 2005 (2007)," Commercial/Institutional Sector."

Energy efficiency

Energy efficiency improvements in the commercial/institutional sector are similar to those in the residential sector. They include changes to the thermal envelope of buildings (e.g. insulation, windows) and the increased efficiency of energy-consuming items in commercial/institutional buildings (e.g. furnaces, auxiliary equipment, lighting). The estimated energy efficiency improvements resulted in a 75.4 PJ energy savings for the sector between 1990 and 2005 (see Figure 5.23).[144]

FIGURE 5.23: COMMERCIAL/INSTITUTIONAL ENERGY USE, WITH AND WITHOUT ENERGY EFFICIENCY IMPROVEMENTS



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End Use Sector, Table 1.

5.6.5. Commercial/institutional energy outlook

Looking ahead, the commercial/institutional floor space and energy use are expected to increase at higher rates.[145] Floor space is expected to grow by 39 percent (2.2 percent per year) between 2005 and 2020. At the same time, the sector's energy use is expected to grow by 44 percent (2.4 percent per year) to reach 1635 PJ.

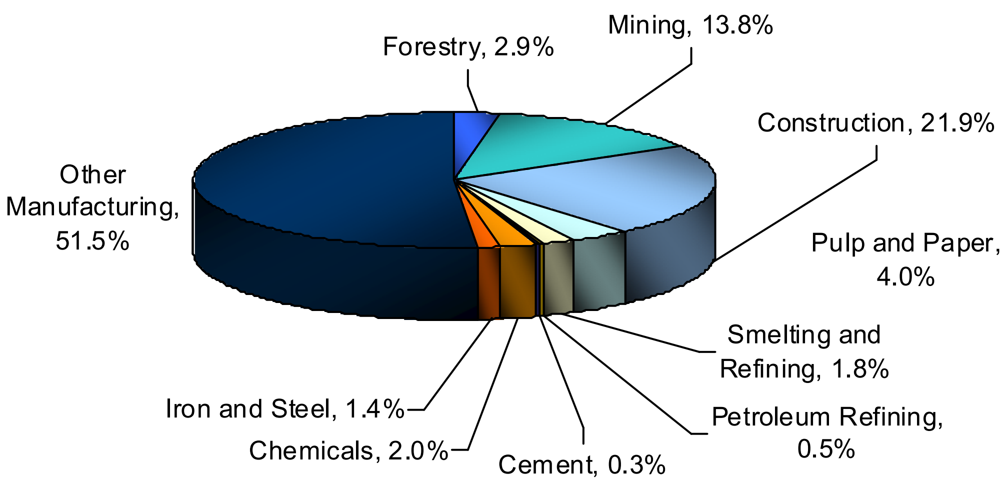
5.7. Industrial Sector

The industrial sector includes all manufacturing industries, all mining activities (including oil and gas extraction), forestry and construction.

In this section, analysis is presented for 10 aggregated industries. In Canada, the industrial sector accounted for 27 percent of total GDP (excluding agriculture) in 2005.[146] At the same time, it accounted for 38 percent of the total secondary energy use.[147]

Energy use in the industrial sector is linked to the state of the economy. The most commonly used measure of economic activity is GDP. In 2005, the main contributor to GDP was “other manufacturing,” which includes industries related to food and beverage, textile and computers and electronics. Construction and mining were the only two industries contributing more than 10 percent to industrial GDP (see Figure 5.24).

Figure 5.24: Distribution of Industrial GDP by Industry, 2005



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Industrial Sector, Aggregated Industries, Canada, tables 7 to 16.

5.7.1. Highlights

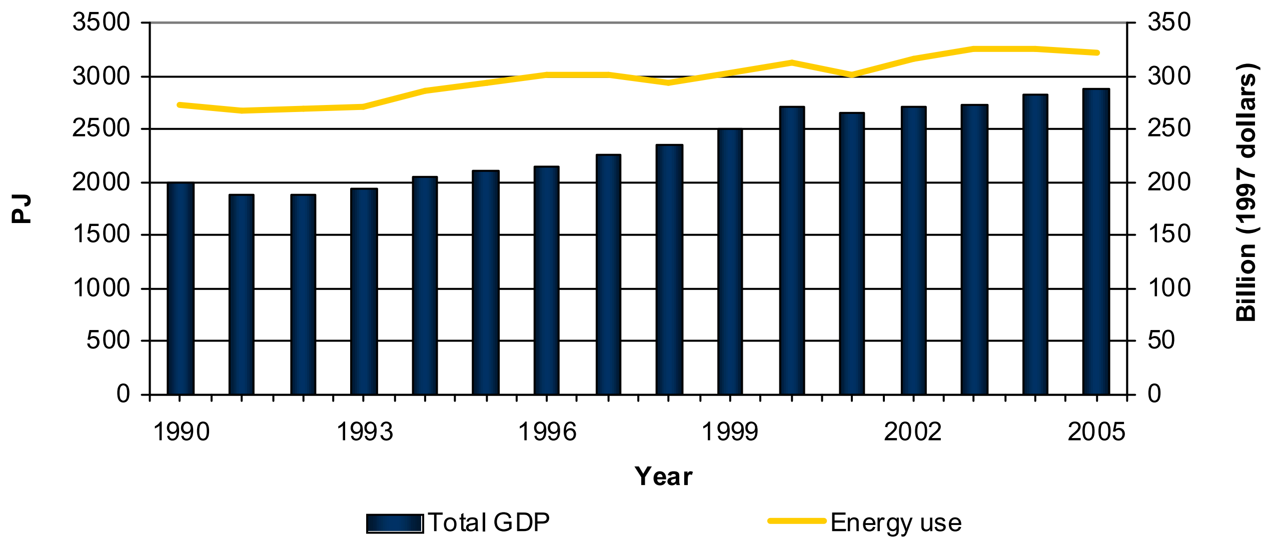
- In 2005, the industrial sector accounted for 38 percent of Canada’s total secondary energy use. Industrial energy use increased by 18 percent, from 2722 PJ in 1990 to 3209 PJ in 2005.[148]
- Energy intensity (energy per unit of GDP) improved by an average of 1.3 percent per year since 1990.
- The mining and the pulp and paper industries accounted for 46 percent of the energy use in the industrial sector.[149]
- The shift from conventional oil extraction to oil sands’ operations accounts largely for the 18 percent increase in industrial energy demand.

- Energy efficiency improvements since 1990 helped save 347.3 PJ.[150] Without these savings, energy use would have grown by 31 percent, instead of the 18 percent observed. Overall, this saved industry $3.9 billion in energy costs.[151]

5.7.2. Industrial energy use and trends

From 1990 to 2005, industrial energy use increased by 18 percent, from 2722 PJ to 3209 PJ (see Figure 5-25). At the same time, GDP increased 44 percent, from $200 billion (in 1997 dollars) to $288 billion (in 1997 dollars).[152]

FIGURE 5.25: INDUSTRIAL ENERGY USE AND GDP



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Industrial Sector, Canada, Aggregated Industries, Table 1.

Overall, fuel shares remained relatively constant between 1990 and 2005. Fuel consumption for all fuel types increased – except for heavy fuel oil, which experienced a 37 percent decrease (see Table 5.10).

TABLE 5.10: INDUSTRIAL SECONDARY ENERGY USE BY ENERGY RESOURCE

Energy resource	Secondary energy use (PJ)		Growth (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Electricity	658.4	858.6	30.4	24.2	26.8
Natural gas	837.2	896.6	7.1	30.8	27.9
Diesel fuel oil, light fuel and kerosene	126.7	156.8	23.8	4.7	4.9
Heavy fuel oil	201.1	126.1	−37.3	7.4	3.9
Still gas and petroleum coke	321.7	434.3	35.0	11.8	13.5
LPG* and gas plant NGL**	27.0	53.6	98.3	1.0	1.7
Coal	49.4	58.6	18.4	1.8	1.8
Coke and coke oven gas	131.3	123.7	−5.8	4.8	3.9
Wood waste and pulping liquor	341.0	462.7	35.7	12.5	14.4
Other	27.9	38.3	37.3	1.0	1.2

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Industrial Sector, Aggregated Industries, Canada, Table 1.

*LPG is liquefied petroleum gas.

**NGL is natural gas liquids.

The forestry, mining, smelting and refining, cement, and pulp and paper industries experienced the largest growth in energy use between 1990 and 2005 (see Table 5.11). Given the forestry and cement industries' relatively small energy consumption, the other three industries were the main contributors to energy growth in the industrial sector over this period.

TABLE 5.11: INDUSTRIAL SECONDARY ENERGY USE BY INDUSTRY

Industry	Secondary energy use (PJ)		Growth (%)	Share (%)	
	1990	2005	1990–2005	1990	2005
Construction	66.9	59.7	−10.8	2.5	1.9
Pulp and paper	747.5	823.7	10.2	27.5	25.7
Smelting and refining	183.3	264.7	44.4	6.7	8.2
Petroleum refining	334.9	360.6	7.7	12.3	11.2
Cement	59.3	69.0	16.3	2.2	2.1
Chemicals	223.2	186.6	−16.4	8.2	5.8
Iron and steel	219.4	236.9	8.0	8.1	7.4
Other manufacturing	531.8	539.6	1.5	19.5	16.8
Forestry	7.7	20.9	170.7	0.3	0.7
Mining	347.8	647.8	86.2	12.8	20.2

Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Industrial Sector, Aggregated Industries, Canada, Table 3.

Energy use in the mining industry increased from 348 PJ to 648 PJ, an 86 percent increase from 1990 to 2005. The growth was driven by industries categorized as "upstream mining," which includes oil and gas extraction. The shift from conventional oil extraction to oil sands' operations increased energy use significantly. The upstream mining industries alone accounted for 17 percent of the energy use in the industrial sector in 2005. It rose from 214 PJ in 1990 to 530 PJ in 2005, a 148 percent increase.

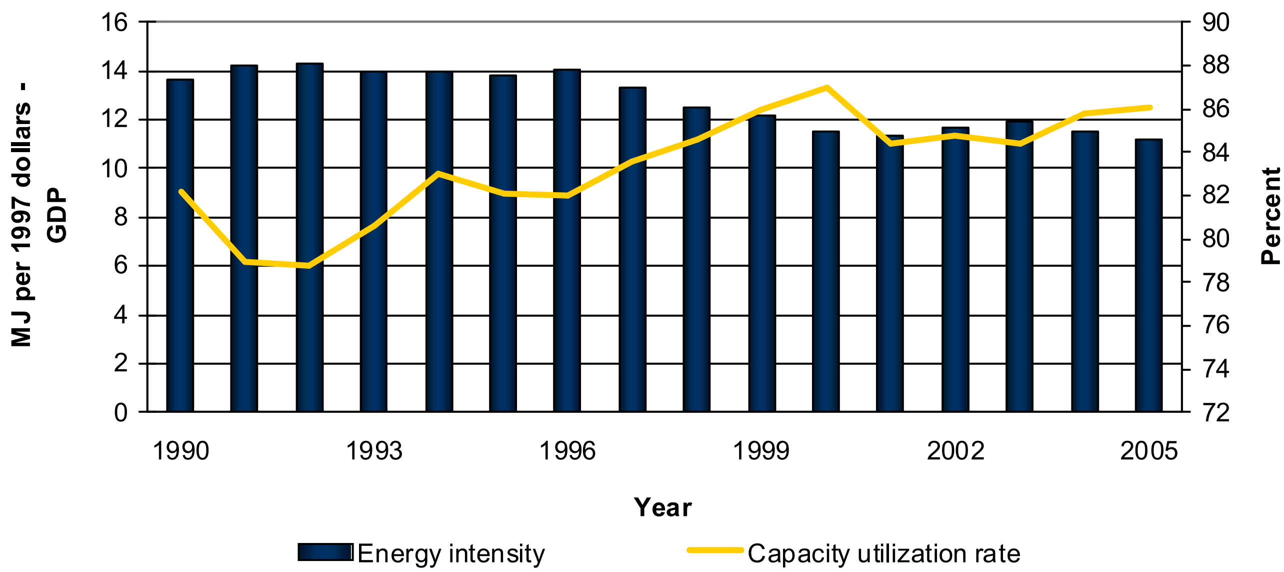
The smelting and refining industry was the second largest contributor to the energy growth. This growth was driven by economic growth, as GDP increased by 104 percent. Finally, pulp-and-paper energy use was driven by the pulp mill industry, which saw its market pulp production increase by 51 percent.

5.7.3. Industrial energy intensity and efficiency

Energy intensity

Several factors influenced the growth in energy use and energy intensity in the industrial sector. Since 1990, energy intensity decreased at an average rate of 1.3 percent per year, from 13.6 MJ per 1997 dollars – GDP in 1990 to 11.2 MJ per 1997 dollars – GDP in 2005 (see Figure 5.26).

FIGURE 5.26: CAPACITY UTILIZATION AND ENERGY INTENSITY PER YEAR

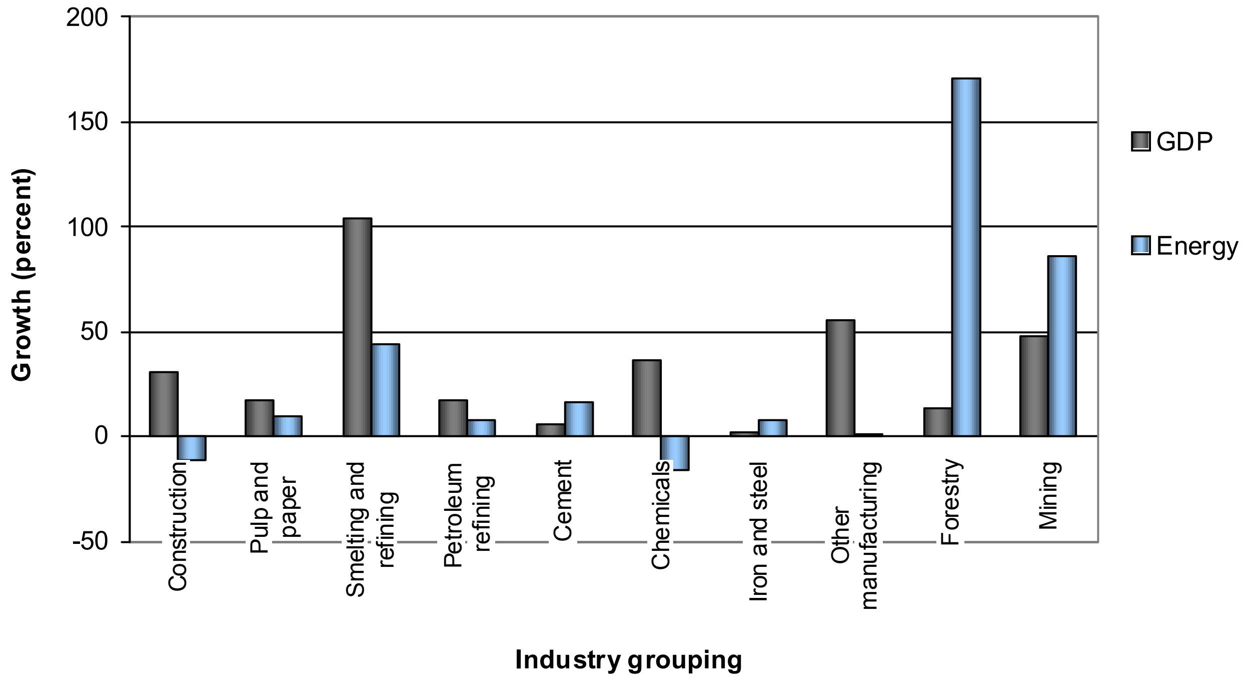


Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Use Data Handbook Tables, Industrial Sector, Table 2 and Table 7.

Energy efficiency improvements in capital and management practices influenced energy intensity. Another key variable is capacity utilization (see Figure 5.26). It is calculated by taking the actual production level for an establishment (measured in dollars or units) and dividing it by the establishment's maximum production level under normal conditions. Since 1990, capacity utilization increased by 5 percent. This increase means that industries are getting closer to their optimum production level and thus becoming more efficient.[153]

Six of the 10 aggregated groupings of industries reduced their energy intensity over 1990–2005 (see Figure 5.27). The industries that decreased their energy intensity had improved their energy efficiency and shifted toward less energy-intensive activities.

FIGURE 5.27: GDP AND ENERGY-USE INCREASE, 1990–2005



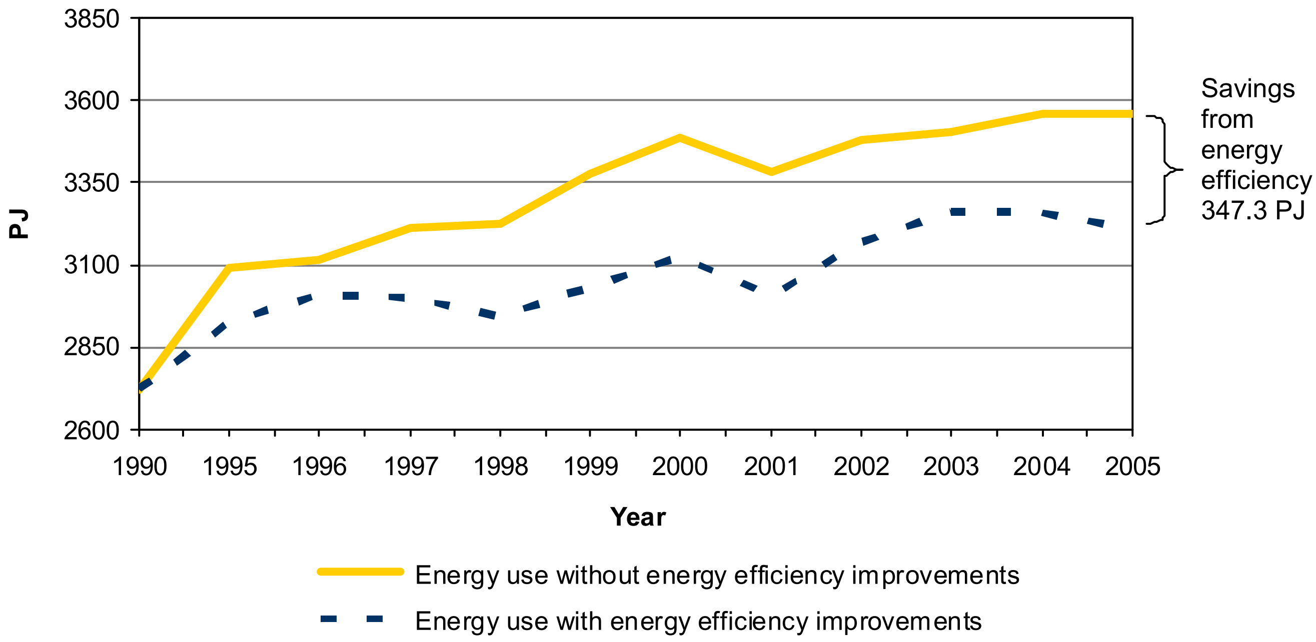
Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Comprehensive Energy Use Database, Industrial Sector, Aggregated Industries, Canada, tables 7 to 16.

The four industries that experienced an increase were mining, iron and steel, cement, and forestry. The biggest increase in energy intensity (MJ per 1997 dollars) was in forestry, with a 139 percent increase.[154] This increase was due mainly to the use of diesel fuel oil (for hauling). In the mining industry, the move toward non-conventional oil production contributed to the increase in energy intensity.

Energy efficiency

Since 1990, energy efficiency in the industrial sector improved by 13 percent.[155] In 2005 alone, Canadian industry saved $3.9 billion in energy costs and 347 PJ of energy (see Figure 5.28).[156] The energy savings due to energy efficiency improvements made by some industries were offset by increased consumption by the upstream mining, fertilizer and forestry industries.

FIGURE 5.28: INDUSTRIAL SECONDARY ENERGY USE, WITH AND WITHOUT ENERGY EFFICIENCY IMPROVEMENTS



Source: NRCan, National Energy Use Database, 1990 to 2005 (2007), Energy Efficiency Trends Analysis Tables (Canada), Industrial Sector, Table 7(a).

5.7.4. Industrial energy outlook

Looking forward, the energy use by the industrial sector (which comprises manufacturing, construction, coal mining and other mining industries but excludes oil and gas and petroleum refining industries) is forecast to increase by 10 percent between 2005 and 2020 (at an average of 0.6 percent per year), from 3338 PJ in 2005 to 3664 PJ in 2020. [157] Driving this increase is GDP, which is forecast to grow by 33.6 percent from 2005 to 2020 (at an average of 2.0 percent per year).

CHAPTER 6: ENERGY SCIENCE AND TECHNOLOGY

6.1. CHAPTER SUMMARY

- Innovation through the development of new technologies is a way to increase the level of productivity and competitiveness of an economic sector. Other ways to innovate comprise the adoption of new technologies, including imported technologies.

- In recent years, Canada has been investing about $1 billion per year on energy research and development (R&D). Three quarters of this amount is from the private sector. Public-sector investments declined markedly in the mid-1980s and early 1990s.

- Private-sector R&D investments appear to be lower in the energy sector, in relative terms, than in other leading sectors of the Canadian economy. In part, this reflects the commodity nature of the energy R&D sector.

- In defining science and technology (S&T) priorities, fossil fuels are the leading area of investment for the private sector. Nuclear energy leads public-sector investment.

- The public sectors of Japan and the United States are investing higher amounts in energy S&T than the public sectors of other industrialized countries. Based on gross domestic product (GDP), Canada's public sector investments are comparable with those of most other industrialized countries. Considering that Canada is a large energy producer and consumer, however, the importance of these investments is low.

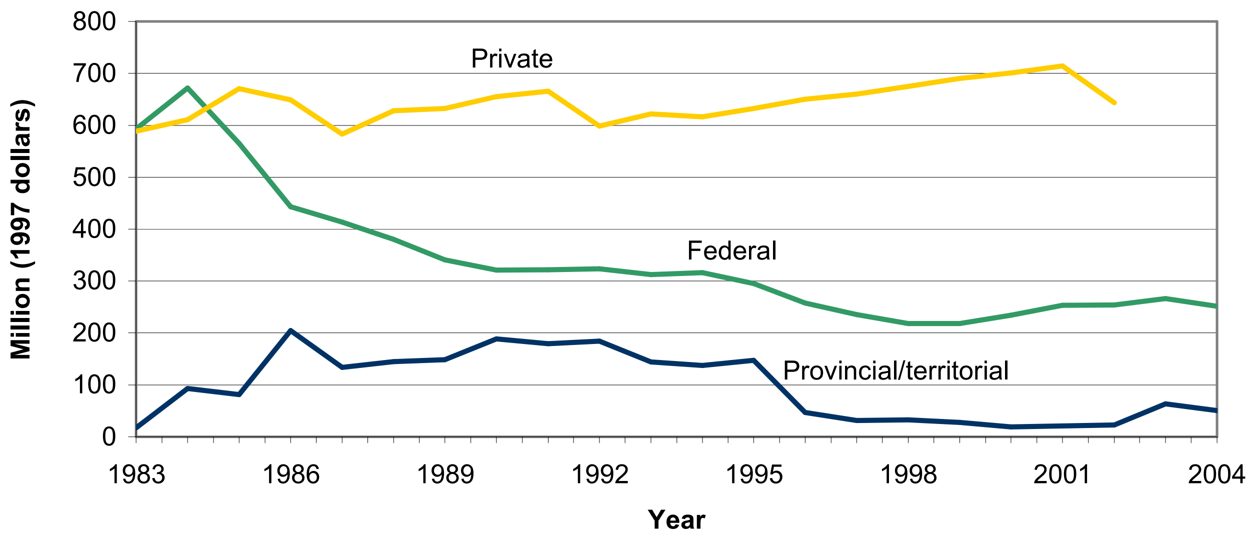
6.2. Energy R&D Investments in Canada

Innovation through the development of new technologies is an important way to increase the level of productivity of an economic sector and ensure its competitiveness in international markets. Energy-related R&D expenditures are one indicator of the level of innovation in the energy sector. Other ways to ensure innovation through S&T include the adoption of new technologies, including imported technologies. (Due to conceptual and data limitations, these other ways of innovating are not discussed in this chapter.)

6.2.1. Expenditure trends

In recent years, Canada invested about $1 billion per year on energy-related R&D (see Figure 6.1). Federal energy R&D funding peaked following the oil crises of the 1970s, dropped sharply in the mid-1980s and continued to decline until 1999. The influx of funding related to climate change resulted in a small increase, starting in 2000.

Figure 6.1: Canadian Energy R&D Expenditures*



Sources:
Private-sector data are from custom tabulations compiled by NRCan from Statistics Canada's survey data.

Public-sector data are compiled from information provided to NRCan by other federal, provincial and territorial departments.

* Industry spending from 1996 to 1999 is only a projected estimate.

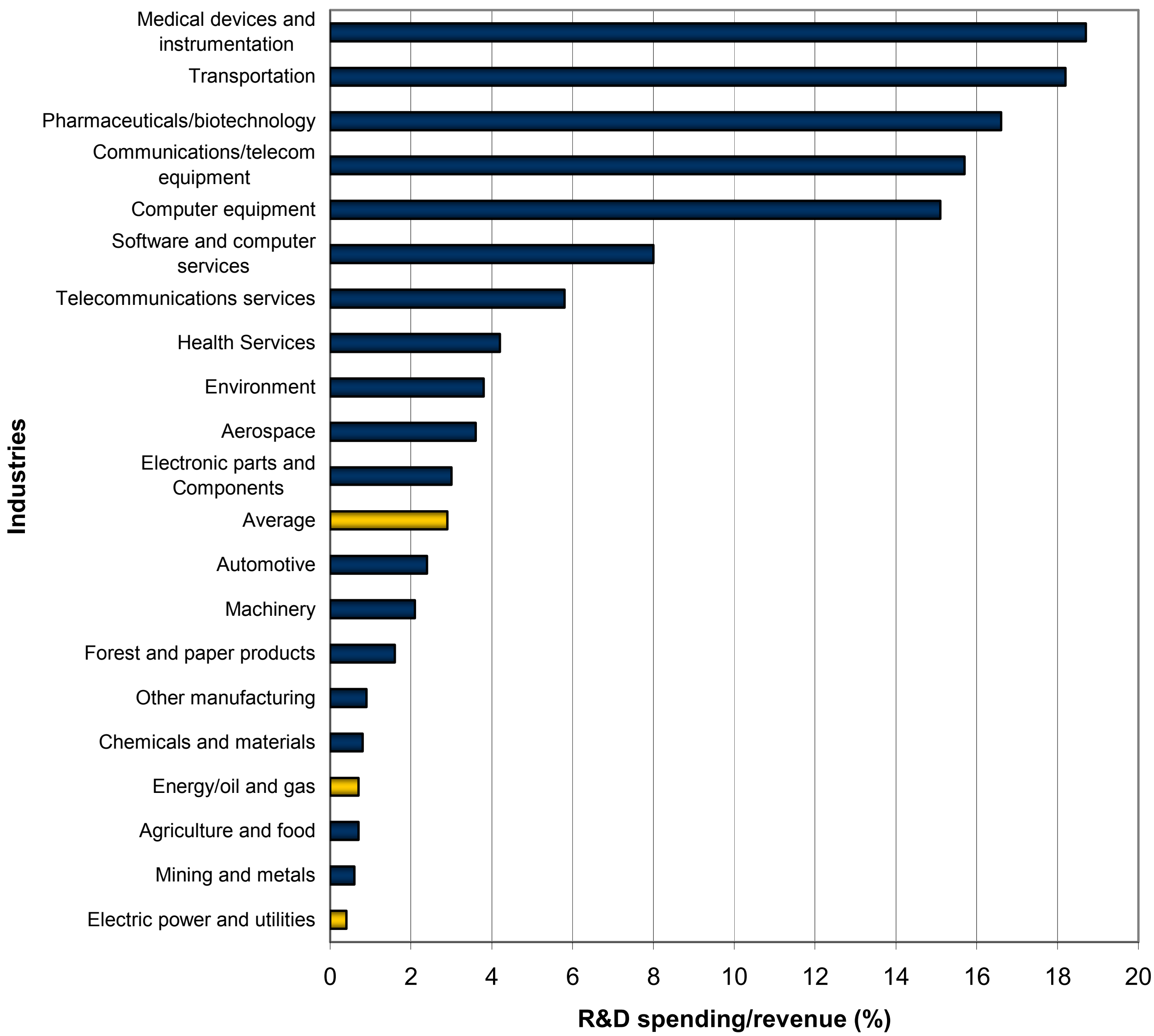
Funding dedicated to climate change came to an end in March 2008. However, funding for the ecoENERGY Technology Initiative – to support the Government of Canada's broader clean air agenda – started in 2007 and will continue for four years.

Provincial and territorial funding in the late 1980s helped off-set federal funding decreases. But by the mid-1990s, it had fallen to low levels.

Although some variations were exhibited in private-sector funding, this funding was relatively stable. It was about double that of public-sector funding.

Private-sector R&D investment in the energy sector was less than the average for all sectors of the Canadian economy, in relative terms (see Figure 6.2). The low spending in the energy sector reflects, in part, the commodity nature of the sector. As a commodity, it has low margins and is capital-intensive in comparison with telecommunications or pharmaceuticals, for example.

FIGURE 6.2: PRIVATE-SECTOR RESEARCH SPENDING INTENSITY, 2006

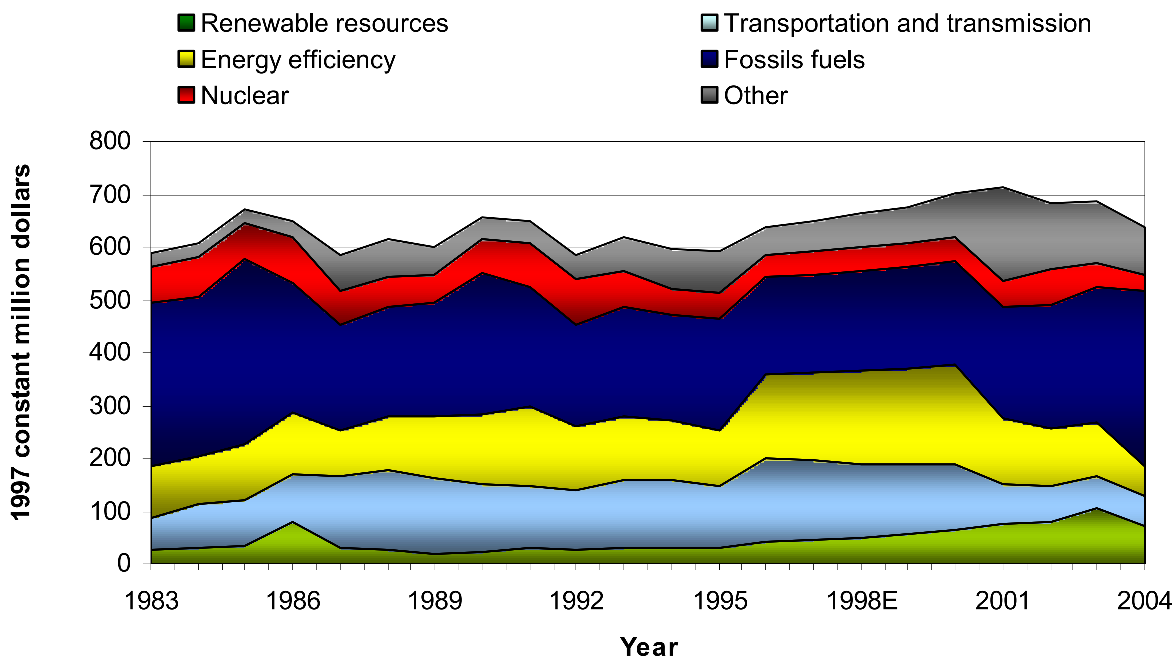


Source: RE$EARCH Infosource Inc. (2007), Canada's Top Corporate R&D Spenders Report.

6.2.2. Private-sector investment portfolio

Over the past 20 years, the largest private-sector investment occurred in fossil fuels S&T. At the same time, investment in renewable energy resources grew significantly (see Figure 6.3). Nuclear, energy efficiency, and transportation and transmission were also major research areas. Expenditures in energy efficiency increased in the mid-1990s but have since dropped to traditional levels. Spending on fossil fuels research remained stable. Spending on other areas, including system analysis and generic environmental issues, also increased.

FIGURE 6.3: PRIVATE-INDUSTRY S&T INVESTMENT IN CANADA*



Source: Custom tabulations were prepared for NRCan by Statistics Canada from survey data.

*Industry spending from 1996 to 1999 is only an estimate.

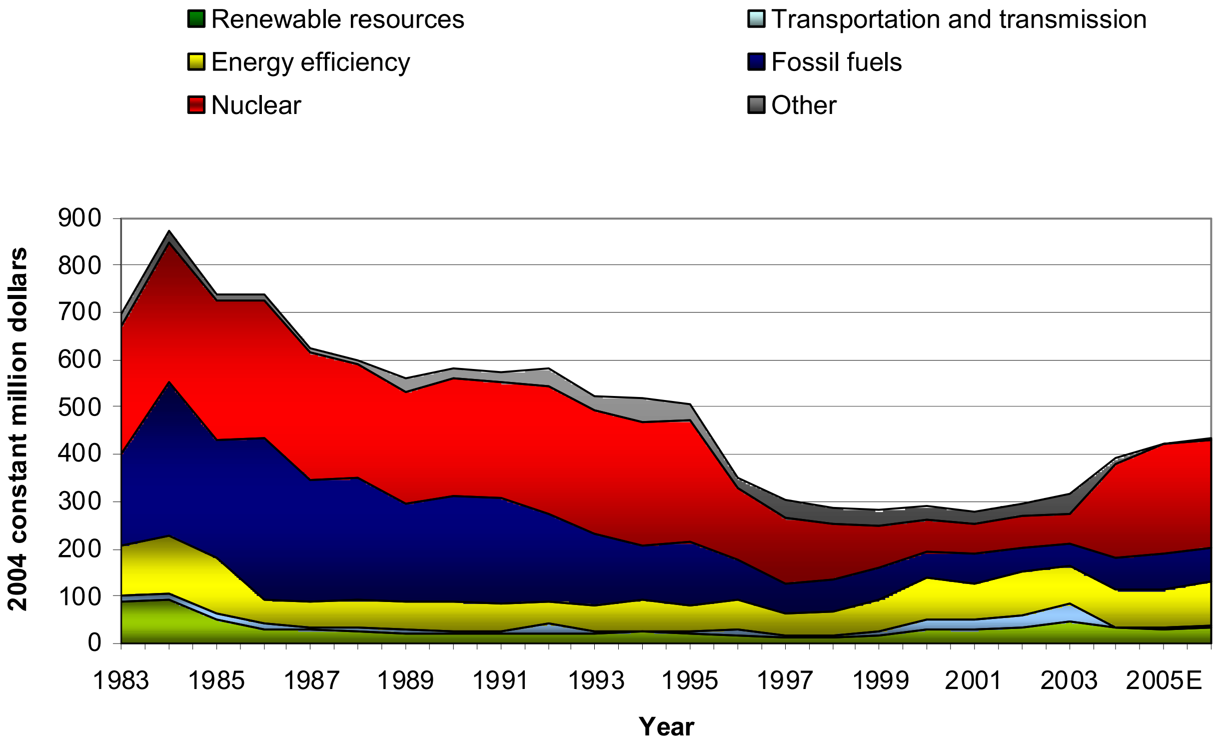
Note: "Transportation and transmission" concerns energy commodities (e.g. pipelines), not the transportation of goods and people.

6.2.3. Public-sector investment portfolio

Over the last 20 years, public funding for S&T in most energy areas decreased (see Figure 6.4). The largest decrease was in fossil fuels. Moreover, funding for nuclear S&T was reduced in the mid-1990s. Since then, the S&T funding of Atomic Energy of Canada Limited remained constant. Additional funding was provided for specific initiatives, though, such as the development of the advanced CANada Deuterium Uranium (CANDU) reactor.

Energy efficiency funding is near record highs. But renewable-energy funding has not recovered from the decrease in 1985.

FIGURE 6.4: PUBLIC-SECTOR ENERGY S&T INVESTMENT*



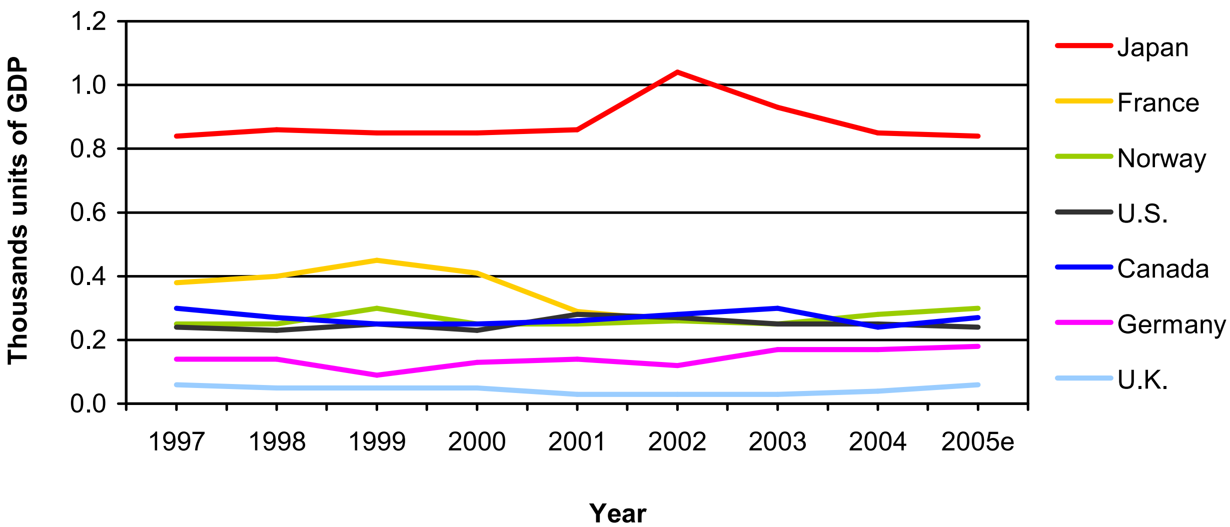
Source: Compiled from information provided to NRCan by other federal, provincial and territorial departments.

*Numbers from 2005 are estimates; those from 2006 are projections.

6.3. International Public-Investment Comparisons

In absolute terms, energy R&D investments by the public sectors of Japan and the United States are higher than those of other member countries of the Organisation for Economic Co-operation and Development (OECD). However, the United States and Japan are also the world's two largest economies. When GDP is considered, Canadian investment is similar to that of other OECD countries (see Figure 6.5).

Figure 6.5: Government Energy R&D Spending*

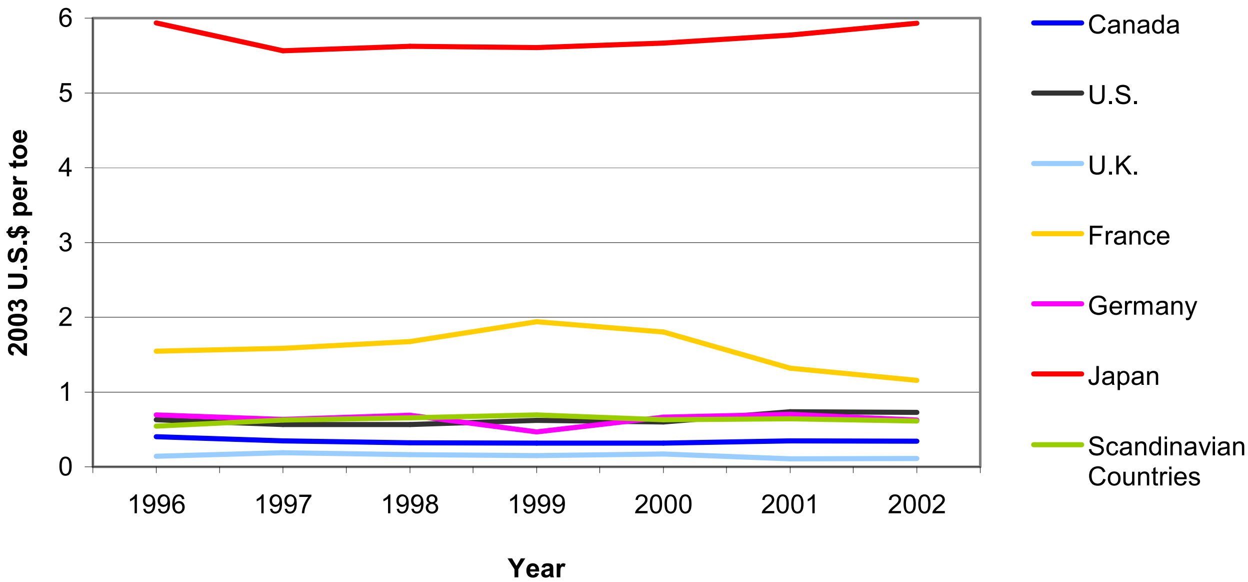


Source: International Energy Agency (IEA), *Energy Policies of IEA Countries – 2006 Review* (2006), Annex B, Table B3, p. 370.

*Numbers from 2005 are estimates.

The energy S&T investments of countries should also be considered in the context of the relative importance of energy production and consumption in the countries. Unlike most other OECD countries, Canada is both a major producer and a major consumer of energy. Canada's total investment in energy R&D, considering production and consumption, is low relative to other OECD countries (see Figure 6.6). Canada invests far less in proportion than Japan or France.

FIGURE 6.6: S&T INVESTMENT RATIO TO DEMAND PLUS PRODUCTION



Source: NRCan calculations use data from IEA, *Energy Policies of IEA Countries – 2004 Review* (2004).

6.4. ENERGY S&T PRIORITIES

Within the private sector, energy S&T priorities reflect individual businesses' issues and planning strategies.

From the public sector's perspective, identifying national energy S&T priorities is a significant challenge. Canada's resource base is diverse; there are a wide range of issues, often with regional character; and so many promising opportunities to consider.

Given the limited amount of comprehensive, quantitative, objective analysis, consultative or opinion-based approaches have been useful starting points. Recommendations by expert bodies, including their views on priorities for energy S&T, have been compiled for comparison (see Table 6.1). The expert bodies include the following:

- National Advisory Panel on Sustainable Energy S&T (a panel of 10 experts)
- Canadian Academy of Engineering (structured decision making with engagement of more than 100 energy experts who examine 27 energy pathways)
- Energy Technology Working Group of the Council of Energy Ministers (provincial-territorial consultation and consensus building)
- National Round Table on the Environment and the Economy (focus on existing and "near" commercial technologies)
- Energy Dialogue Group (views of energy associations)
- Council of Canadian Academies (survey of senior energy experts)

There is consensus among the experts that energy S&T priorities, where public- and private-sector interests intersect, include clean coal, carbon capture and storage, electricity system infrastructure, and bioenergy.

At the level of the Government of Canada, several considerations define its energy S&T priorities. These considerations include regional variances in specific knowledge and technology needs and limitations in research development and demonstration resources. Whereas the former leads to a large number of priorities, the latter constrains the number of priorities that may be pursued effectively.

TABLE 6.1: SUMMARY OF STAKEHOLDER VIEWS ON ENERGY S&T PRIORITIES, 2007

	National Advisory Panel	Canadian Academy of Engineering	Energy Technology Working Group	National Round Table on the Environment and the Economy	Energy Dialogue Group	Council of Canadian Academies
Supply/conversion	▪ Gasification	▪ Gasification	▪ Low rank clean coal	▪ Clean coal (with carbon capture and storage)	▪ Clean coal	
	▪ Carbon capture and storage	▪ Carbon capture, transportation, long-term storage and/or use	▪ CO_2 geological storage	▪ Carbon capture and storage		▪ Clean fossil technologies (CO_2 sequestration, …)
	▪ Bioenergy	▪ Bioconversion	▪ Energy and higher value products ▪ Production, storage, pre-processing, transportation ▪ Biorefining		▪ Ethanol ▪ Biomass	▪ Clean renewable energy (wind, biofuels,…)
	▪ Gas hydrates ▪ Nuclear fusion (university) ▪ Solar PV (materials science, nanotechnology)	▪Water ▪Natural gas hydrates ▪Bituminous carbonates ▪Lower impact surface mineable oil sands ▪ Higher valued products from heavy oil and bitumen ▪ Alternative H_2 for oil sands ▪ Advanced nuclear fission ▪ Nuclear power for in situ oil sands ▪ Nuclear fusion (expertise) ▪ Wind and solar ▪ Tidal and wave ▪ Geothermal	▪ Unconventional oil and gas ▪ Oil sands; upgrading ▪ Heavy oil ▪ Solar thermal ▪ Ocean energy ▪ Hydro ▪ Small-intermediate fossil fuel conversion		▪ Methane hydrates ▪ Arctic/unconventional oil and gas ▪ Oil sands ▪ Conventional oil and gas ▪ Propane ▪ Nuclear ▪ Wind ▪ Hydroelectricity ▪ Geothermal	▪ Energy recovery technologies (oil sands, gas hydrates)
	▪ Electricity transmission, distribution and storage	▪ Electrical infrastructure (RE access, energy storage)	▪ Grid integration ▪ Integrated "smart" technologies	▪ Cogeneration ▪ Renewables (wind)		
End-use	▪ Fuel cells (research) ▪ Freight transportation ▪ Buildings ▪ Industry (high energy) ▪ Applied social science research (i.e. take-up) ▪ Venture capital		▪ Fuel cells (mobile, stationary) ▪ Hydrogen infrastructure ▪ Buildings and communities ▪ Bio-processes	▪ Freight transportation particularly important ▪ Assumed on-going efficiency improvements ▪ Emphasis on deployment of all technologies	▪ Hydrogen and fuel cells ▪ Sustainable communities	▪ Fuel cells and hydrogen economy
Lexicon	▪ Priorities ▪ Other basic and applied research	▪ Priorities ▪ Lead or adapt: basic and applied research	▪ "Leading in world" ▪ "Aspire to lead in adaptation"	▪ Existing and near commercial	▪ Established, maturing, emerging, on-the-horizon	▪ Survey results

[green box] **General consensus among stakeholders**

ANNEX 1: PROVINCIAL AND TERRITORIAL TABLES

TABLE A-1: PROVINCIAL AND TERRITORIAL ECONOMIC INDICATORS AND ENERGY STATISTICS, 2006[158]

	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	Territs
Total GDP (in 2002 billions of dollars)*	16.56	3.65	26.60	20.87	245.26	448.37	37.42	36.94	184.82	147.87	5.88
Energy GDP (in 2002 billions of dollars)*	4.46	–	1.39	1.01	10.08	12.17	1.96	6.30	48.41	8.50	0.40
Energy GDP (%)	26.9	–	5.2	4.8	4.1	2.7	5.2	17.1	26.2	5.7	6.8
Population (in thousands)	510	139	934	749	7 652	12 687	1 178	985	3 376	4 310	104
Unemployment (%)	14.8	11.0	7.9	8.8	8.0	6.3	4.3	4.7	3.4	4.8	n/a
Energy-sector direct employment	n/a	n/a	n/a	n/a	6 235	50 516	n/a	8 648	116 099	6 553	n/a

*GDP is measured here in billions of chained 2002 dollars. Due to methodological differences, these numbers are not directly comparable with GDP figures presented in Chapter 2 (which are reported in constant 2002 dollars).

TABLE A-2: ENERGY STATISTICS, 2005

(TERAJOULES)[159]

	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	Territs	**Canada**
Primary energy production												
*Crude and NGL**	681,438	–	39,467	–	–	5,362	31,274	939,614	4,413,723	132,118	45,215	6,288,211
Natural gas	22,466	–	157,081	–	–	9,740		356,739	5,545,814	1,134,128	23,897	7,249,865
Coal and derivatives	–	–	137	4,862	–	124,776	–	165,260	564,883	665,368	–	1,525,286
*Electricity***	145,796	144	4,278	29,711	641,722	408,510	131,375	16,794	11,088	217,177	2,088	1,608,683
Total	849,700	144	200,963	34,573	641,722	548,388	162,649	1,478,407	10,535,508	2,148,791	71,200	16,672,045
Electricity generation												
Coal	–	–	31,749	13,181	–	110,189	1,551	39,061	168,526	37	–	364,294
Natural gas	965	–	840	3,861	1,071	45,033	29	15,161	39,554	14,455	294	121,263
Oil	4,959	23	7,316	26,861	4,152	3,343	54	112	158	360	1,486	48,824
Hydro	145,796	144	4,278	13,950	625,583	127,822	131,375	16,794	11,088	217,177	2,088	1,296,095
Nuclear	–	–	–	15,761	16,139	280,688	–	–	–	–	–	312,588
Biomass	–	–	606	2,209	2,123	3,433	361	945	4,346	10,924	92	25,039
Energy consumption												
Industrial	37,880	2,897	28,548	55,830	556,397	664,023	54,400	92,802	528,028	254,517	7,803	2,283,125
Commercial	24,455	6,613	52,041	34,931	303,247	528,453	57,900	65,393	242,142	153,496	8,082	1,476,753
Residential	15,784	3,788	28,714	27,295	274,721	537,177	43,575	41,788	176,220	144,276	2,793	1,296,131
Transportation	45,159	10,125	73,001	61,544	456,248	841,022	82,293	119,224	359,180	335,327	5,647	2,388,770
Agriculture	377	1,638	3,992	1,973	28,791	48,066	23,403	40,578	48,225	11,238	415	208,696
Demand by fuel												
Oil and NGL	n/a	n/a	n/a	n/a	856,900	1,386,900	111,000	186,100	1,056,600	467,500	13,100	4,632,800
Natural gas	n/a	n/a	n/a	n/a	212,000	1,081,800	91,200	234,700	886,600	287,400	3,100	2,828,600
Coal and derivatives	n/a	n/a	n/a	n/a	24,100	452,800	9,300	145,200	505,000	18,800	–	1,270,200
Electricity	n/a	n/a	n/a	n/a	737,500	410,000	76,900	15,000	14,400	209,800	2,100	1,522,900
Other	n/a	n/a	n/a	n/a	132,400	119,400	9,000	21,500	75,800	193,100	–	642,500

*NGL is natural gas liquids.
**Includes hydro and nuclear generation, but excludes secondary generation from fossil fuels.

TABLE A-3: CANADIAN CRUDE OIL PRODUCTION, 2006*[160]

	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC	NU	YT	NT	**Canada**
	Thousands of barrels per day													
Heavy oil	–	–	–	–	–	–	–	333.5	183.5	–	–	–	–	517.0
Light/medium oil	303.8	–	–	–	–	2.2	21.4	94.7	359.7	28.8	–	–	18.7	829.3
Condensates	–	–	12.0	–	–	–	–	–	11.0	3.9	–	–	–	26.9
Pentanes	–	–	–	–	–	–	–	0.5	140.8	8.0	–	–	1.5	150.8
Bitumen	–	–	–	–	–	–	–	–	636.9	–	–	–	–	636.9
Synthetic crude oil	–	–	–	–	–	–	–	–	495.9	–	–	–	–	495.9
Total production	303.8	–	12.0	–	–	2.2	21.4	428.7	1827.8	40.7	–	–	20.2	2656.8
Percent	11.4	–	0.5	–	–	0.1	0.8	16.1	68.8	1.5	–	–	0.8	100.0

* Due to rounding, numbers may not add to totals.

ENDNOTES

[1] *Oil & Gas Journal*, vol. 105.48 (December 24, 2007), p. 25; and *Oil & Gas Journal*, vol. 77, no. 53 (December 31, 1979), p. 71.

[2] Energy Information Administration (EIA) *International Energy Outlook 2007*, www.eia.doe.gov/oiaf/ieo/excel/ieoreftab_1.xls

[3] Natural Resources Canada (NRCan), *Canada's Energy Outlook: The Reference Case 2006*, p.iv.

[4] International Energy Agency (IEA), *Energy Balances of OECD Countries* (2007), www.iea.org/Textbase/country/index.asp

[5] EIA (2007), www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Balances

Data, which are presented in millions of tonnes of oil equivalent, have been converted to petajoules by using the factor 41.9.

Data on Canada's energy demand are from NRCan, *Canada's Energy Outlook: The Reference Case 2006*, Figure PR1, "Primary Energy Demand," p. 51.

[6] IEA, *World Energy Outlook 2007*, Table 1.2, p. 80.

[7] Ibid., Table 1.3, p. 82.

[8] EIA (2007), www.eia.doe.gov/oiaf/ieo/excel/figure_45data.xls.

[9] NRCan, *Mineral and Metal Commodity Reviews*, 2006 review of coal, pp. 20.1–20.16, www.nrcan-rncan.gc.ca/mms/cmy/com_e.html.

[10] EIA (2007), www.iea.org/Textbase/stats/electricitydata.asp?COUNTRY_CODE=29&Submit=Submit

[11] IEA, *Renewables Information 2007*, Table 1, "Selected Renewables Indicators by Country for 2005," p. 6; and for Canada, Table 2, "Net Generating Capacity of Renewable and Waste Products (MW)," and Table 3, "Gross Electricity Generation From Renewable Sources (GWh)," pp. 109–110.

[12] See Section 3.6, "Renewable Energy," of this document for further details on major hydroelectric projects under consideration.

[13] IEA, *Oil Crises & Climate Challenges: 30 Years of Energy Use in IEA Countries*, Table A6, (2004), p. 210, www.iea.org/Textbase/nppdf/free/2004/30years.pdf.

[14] Statistics Canada, www.statcan.ca/english/Subjects/Standard/naics/2007/naics07-menu.htm

[15] The modified version will cover petroleum and coal product manufacturing (NAICS 324) in its entirety (which includes asphalt paving, roofing and saturated materials manufacturing [NAICS 32412]) because certain data are unavailable at the five-digit NAICS code level of disaggregation. Moreover, this modified version will not include other metal ore mining (NAICS 21229) as data are generally not available for this industry.

[16] A broader definition of the energy sector would also include the following industries:
- Oil and gas pipeline and related structures construction (NAICS 23712)
- Power and communication line and related structures construction (NAICS 23713)
- Petrochemical manufacturing (NAICS 32511)
- Industrial gas manufacturing (NAICS 32512)
- Other basic organic chemical manufacturing (NAICS 32519)
- Power boiler and heat exchanger manufacturing (NAICS 33241)
- Metal tank (heavy gauge) manufacturing (NAICS 33242)
- Mining and oil and gas field machinery manufacturing (NAICS 33313)
- Engine, turbine and power transmission equipment manufacturing (NAICS 3336)
- Gasoline stations (NAICS 447)
- Fuel dealers (NAICS 45431)

[17] Statistics Canada, CANSIM (2007), Table 379-0027, Gross domestic product (GDP) at basic prices, by NAICS; Canada; seasonally adjusted at annual rates; 2002 constant prices; vectors v41881502, v41881504, v41881517, v41881519, v41881521, v41881578, v41881699 and v41881478. Total energy is the sum of all vectors except v41881478. Share of energy is total energy divided by v41881478.

[18] Statistics Canada, CANSIM (2007), Table 281-0024, Employment (Survey of Employment, Payrolls and Hours [SEPH]) by type of employee for selected industries, annual (persons); vectors v1699194, v1700294, v1700587, v1700613, v1701080, v13922126, v13922413 and v1695625. Total energy is the sum of all vectors except for industrial aggregate, v1695625. Share of energy is total energy divided by v1695625.

[19] Statistics Canada, CANSIM (2007), Table 281-0027, Average weekly earnings (SEPH) by type of employee for selected industries, annual (dollars); vectors v1740728, v1740730, v1740733, v1740735, v1740736, v13922633 and v1740722. Natural Resources Canada (NRCan) calculated an average wages and salaries estimate for the energy sector based on the above vectors (except for total industry, v1740722).

[20] Excludes pipeline transportation (NAICS 486) as data were not available.

[21] NRCan, Trade Retrieval and Aggregation System (TRAGS) (2007), based on Statistics Canada, *Canadian International Merchandise Trade*, Cat. No. 65-001-XIB.

[22] Statistics Canada, CANSIM (2007):

Table 029-0007, Capital and repair expenditures, industry sector 21, mining and oil and gas extraction, annual (dollars); capital vectors v754048, v754195 and v754167; repair vectors v754051, v754198 and v754170; capital and repair vectors v754047, v754194 and v754166.

Table 029-0008, Capital and repair expenditures, industry sector 22, utilities, annual (dollars); capital vectors v754230 and v754237; repair vectors v754233 and v754240; capital and repair vectors v754229 and v754236.

Table 029-0012, Capital and repair expenditures, industry sectors 48–49, transportation and warehousing, annual (dollars); capital vector v755329, repair vector v755332, capital and repair vector v755328.

Table 029-0009, Capital and repair expenditures, industry sectors 31–33, manufacturing, annual (dollars); capital vector v754671, repair vector v754674, capital and repair vector v754670.

Table 029-0005, Capital and repair expenditures, by sector and province, annual (dollars); capital vector v753950, repair vector v753953, capital and repair vector v753949.

[23] Statistics Canada, CANSIM (2007):

Table 301-0003, Annual survey of manufactures, principal statistics by NAICS, incorporated businesses with employees having sales of manufactured goods greater than or equal to $30,000 (dollars unless otherwise noted); vectors v761859, v766535, v767679, v770105, v770240, v770300, v761876, v766536, v767696, v770106, v770241, v770301, v761978, v766542, v767798, v770112, v770247 and v770307.

Table 301-0006, Principal statistics for manufacturing industries, by NAICS, annual (dollars unless otherwise noted); vectors v3281324, v32870340, v32871183, v32870561, v32870582, v32870589, v41554012, v41554094, v41554139, v41554252, v41554262, v41554266, v32877075, v32876095, v32876935, v32876315, v32876335 and v32876342.

[24] Statistics Canada, CANSIM (2007), Table 326-0021, “Consumer price index (CPI), 2005 basket, annual (2002 = 100 unless otherwise noted); vectors v41693271, v41693536 and v41693537.

[25] Statistics Canada, Detailed Average Household Expenditure by Household Income Quintile for Canada and Provinces, Cat. No. 62F0032XDB. Energy is the sum of line 20310, electricity; line 20320, natural gas; line 20330, other fuels; and line 30500, gasoline and other fuels. Disposable income is line 1700, household income before taxes, minus lines 49000–49300, personal taxes.

[26] Data presented in this chapter may differ slightly from similar data in Chapter 2 due to differences in data sources and concepts.

[27] In section 3.2, “Oil,” statistics on oil volumes are presented in units of measurement commonly used in the marketplace. As a result, statistics on upstream markets are presented in barrels; those on downstream markets, in litres. Because some sources publish statistics in cubic metres, some of the data in this section have been converted from their original sources, as follows: one cubic metre is equivalent to 6.29 barrels of oil and one cubic metre is equivalent to 1000 litres of oil.

[28] Alberta Energy and Utilities Board (EUB), *Alberta’s Energy Reserves 2006 and Supply/Demand Outlook 2007–2016*, Report No. ST98-2007, Reserves and production summary table, p. 3.

Canadian Association of Petroleum Producers (CAPP), *Summary of 2006 Oil and Natural Gas Reserves*, p. 4.

Also published in *Oil & Gas Journal*, vol. 105.48 (December 24, 2007), p. 25. In its assessment of Canada’s total proven oil reserves, the *Oil & Gas Journal* uses the combined total of EUB’s established oil sands reserves and CAPP’s conventional oil reserves.

[29] CAPP does not segregate conventional oil and gas capital investment into categories. In financial reports, most companies report the combined total of conventional oil and gas investment.

[30] Statistics Canada*, Energy Statistics Handbook* (October to December 2006), Cat. No. 57-601-XIE, tables 3.1 and 3.2, pp. 39–40.

[31] Statistics Canada, *Pipeline Transportation of Crude Oil and Refined Petroleum Products* 2001, (Cat. No. 55-201-XIB), Text Table 1.

[32] Most of the section on oil in this report uses barrels as the unit, which is the common measurement for crude oil. The section on petroleum products in this report uses litres as the unit, which is the measurement most familiar to consumers.

[33] A detailed forecast is available in Natural Resources Canada (NRCan), *Canada's Energy Outlook: The Reference Case 2006*, pp. 35–36.

[34] This price assumption represents the views of experts in 2006 and reflects long-term market fundamentals. A discussion on oil prices is provided in NRCan, *Canada's Energy Outlook: The Reference Case 2006*, pp. 10–11. Since 2006, some forecasters have revised upward their long-term price outlook.

[35] Proved reserves of natural gas are estimates of the quantities of gas remaining in known drilled reservoirs that are economic to produce and are connected to pipelines and markets or can be connected easily.

[36] EIA, *U.S. Natural Gas Statistics* (2006), "Natural Gas Reserves Summary as of Dec. 31," Dry Natural Gas, http://www.eia.doe.gov/oil_gas/natural_gas/info_glance/natural_gas.html.

Statistics Canada, *Energy Statistics Handbook* (2006), Table 6.4, "Natural gas – Deliveries of marketable gas by province."

[37] NEB, *Northeast British Columbia's Ultimate Potential for Conventional Natural Gas* (2006), p. 13.

[38] A detailed forecast is available in NRCan, *Canada's Energy Outlook: The Reference Case 2006*.

[39] Information and statistics on reserves are from World Energy Council, *2007 Survey of Energy Resources*, Table 1-1, p. 9, and the section on Canada, p. 25.

[40] "Proved amounts in place" is the resource remaining in known deposits that has been carefully measured and assessed as exploitable under present and expected local economic conditions and existing available technology. "Proved recoverable reserves" are the tonnage within the proved amount in place that can be recovered in the future under present and expected local economic conditions with existing available technology.

[41] "Estimated additional amount in place" is the indicated and inferred tonnage additional to the proved amounts in place that is of foreseeable economic interest. It includes estimates of amounts that could exist in unexplored extensions of known deposits or in undiscovered deposits in known coal-bearing areas, as well as amounts inferred through knowledge of favourable geological conditions. Speculative amounts are not included.

[42] Information and statistics on production are from NRCan, *Mineral and Metal Commodity Reviews* (2007), 2006 review of coal, pp. 20.2–20.3.

[43] Ibid, pp. 20.3–20.4, and Table 1, "Canada, coal production and trade, 2004–06," pp. 20.8–20.10.

[44] Ibid, pp. 20.4–20.5, and Table 4, "Canadian coal consumption," p. 20.11.

[45] Ibid, p. 20.4.

[46] The coal year starts April 1 and ends March 31 of the following year.

[47] Reserve estimates are calculated as a function of price. Higher prices would mean higher reserve estimates, because more mineral deposits would be deemed economically recoverable.

[48] Further information on reserves and production information provided in this section are available from NRCan, *Canadian Minerals Yearbook 2004*, Mineral and Metal Commodity Reviews, "Uranium," www.nrcan.gc.ca/ms/cmy/2006CMY_e.htm.

[49] OECD Nuclear Energy Agency and the International Atomic Energy Agency, *Uranium 2005*: *Resources, Production and Demand*, Appendix 5, "Energy Conversion Factors."

[50] NRCan, *Survey of Mineral Exploration, Deposit Appraisal and Mine Complex Development Expenditures* (2006).

[51] RFPs are a method for governments to solicit proposals from interested parties. After proposals are received, the government selects the best proposals and typically signs long-term supply contracts.

[52] RPSs are typically legislated requirements for utilities to source a certain percentage of its electricity from renewable energy.

[53] SOCs provide a guaranteed sales price to electricity generators that meet certain conditions. For example, in Ontario, a standard offer price of $0.11/kWh is available for wind farms smaller than 10 MW.

[54] Statistics Canada, *Electric Power Generating Stations 2005* (2006), Cat. No. 57-206-XIB.

[55] International Energy Agency, *Review and Analysis of Ocean Energy Systems Development and Supporting Policies: A Report by AEA Energy & Environment on behalf of Sustainable Energy Ireland for the IEA's Implementing Agreement on Ocean Energy Systems* (2006), p. 11.

[56] A. Cornett, *Inventory of Canada's Marine Renewable Energy Resources (*2006), National Research Council Canada, Canadian Hydraulics Centre, Technical Report No. CHC-TR-041.

[57] Science Applications International Corporation, *Final Report: Survey of Active Solar Thermal Collectors, Industry and Markets in Canada* (2005), p. iii. Survey funded by NRCan, final report at www.cansia.ca/downloads/STC_survey_2005_English.pdf

[58] NRCan, *Energy Use Data Handbook Tables, Canada*, Residential Sector, Table 5, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/res_00_5_e_2.cfm?attr=0

[59] Science Applications International Corporation, *Final Report: Survey of Active Solar Thermal Collectors, Industry and Markets in Canada* (2005), Table 8, "Analysis of avoided GHG emissions, using four reference systems, 2004," p. 23.

[60] NRCan (prepared for the IEA), *National Survey Report of PV Power Applications in Canada – 2006* (May 2007), p. 6.

[61] Ontario Power Authority, Ontario's Standard Offer Program Web site, http://www.powerauthority.on.ca/sop/.

[62] NRCan, Photovoltaic Potential and Solar Resource Maps of Canada Web page, https://glfc.cfsnet.nfis.org/mapserver/pv/index_e.php.

[63] NRCan, *An Evaluation of the Potential of Building Integrated Photovoltaics in Canada* (2006), p. 6, http://cetc-varennes.nrcan.gc.ca/fichier.php/codectec/En/2006-047/2006-047_OP-J_411-SOLRES_BIPV.pdf

[64] Science Applications International Corporation, *Survey on Canadian Geoexchange Industry: 2004–2006* (2006), Figure 2, "Total sales, by capacity and number of units," p. 6.

[65] The *National Inventory Report, 1990–2005: Greenhouse Gas Sources and Sinks in Canada* (2007) was prepared by Environment Canada. It says that **carbon dioxide** produced from the combustion or aerobic decomposition of biomass is considered to be sequestered when biomass regenerates, i.e. biomass combustion and aerobic decomposition are carbon-neutral. Other greenhouse gases produced from either the combustion of biomass (**methane and nitrous oxide**) or the anaerobic decomposition of biomass (**methane**) are not sequestered in biomass regeneration.

[66] NRCan, *Energy Use Data Handbook Tables (Canada)* (2007), Tables 5 and 12, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0.

[67] Quebec, Agence de la santé et des services sociaux de Montréal, Qualité de l'air extérieur – Prévenir les problèmes de santé reliés à l'environnement, Web page, www.santepub-mtl.qc.ca/environnement/chauffage/index.html.

[68] Figures comparing 1990 and 2005 are from the following:

Statistics Canada, CANSIM (2007), Table 127-0001, "Electric power statistics monthly (megawatt hour)," vectors v222416, v222422 and v222429.

Statistics Canada, *Quarterly Report on Energy Supply-demand in Canada, 1990* (1991), Cat. No. 57-003-X, Table 15, "Electricity generated from fossil fuels, 1990."

Statistics Canada, *Report on Energy Supply-demand in Canada, 2005* (2007), Cat. No. 57-003-XWE, Table 8-1, "Electricity generated from fossil fuels – Total electricity generated," p. 112, and Table 9, "Primary electricity generation," p. 113.

[69] Total consumption data are from Statistics Canada, CANSIM (2007), Table 128-0003, "Supply and demand of primary and secondary energy in natural units, quarterly," vector v340872 (1990–2001 data), and Table 128-0010, "Supply and demand of primary and secondary energy in natural units, annual," vector v32452656 (2002–2005 data). Growth-rate figures are calculated for year y as follows, where C_y denotes total consumption in year y: $(C_y – C_{y-1})/C_{y-1}$.

[70] Total consumption data by province are from Statistics Canada, CANSIM (2007), Table 128-0010, "Supply and demand of primary and secondary energy in natural units, annual," vectors v32453647, v32453888, v32454172, v32454478, v32454817, v32455359, v32455925, v32456352, v32456679, v32457182, v32457797, v32457943 and v32458083.

[71] Per capita consumption figures were calculated by dividing total consumption data by total population.

For total consumption data by province, see the following:

> Data on hydro, wind and tidal, and nuclear generation are from Statistics Canada, *Electric Power Generation, Transmission and Distribution, 2005* (2007), Cat. No. 57-202-X, Table 2, "Generation of electric energy, 2005," pp. 10–11.
>
> Data on non-nuclear thermal generation are from Statistics Canada, *Report on Energy Supply-demand in Canada, 2005* (2007), Cat. No. 57-003-XIE, Table 8-1, "Electricity generated from fossil fuels – Total electricity generated," p. 112.

Data on total population by province are from Statistics Canada, CANSIM (2007), Table 051-0001, "Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual," vectors v466668, v466983, v467298, v467613, v467928, v468243, v468558, v468873, v469188, v469503, v469818, v470133, v479937 and v480252.

[72] Per capita residential consumption figures were calculated by dividing total residential consumption data by total population.

Total residential consumption data by province are from Statistics Canada, CANSIM (2007), Table 128-0010, "Supply and demand of primary and secondary energy in natural units, annual," vectors v32453658, v32453894, v32454182, v32454486, v32454832, v32455374, v32455937, v32456363, v32456692, v32457195, v32457800, v32457946 and v32458086.

For total population by province, see the following:

Data on hydro, wind and tidal, and nuclear generation are from Statistics Canada, *Electric Power Generation, Transmission and Distribution, 2005* (2007), Cat. No. 57-202-X, Table 2, "Generation of electric energy, 2005," pp. 10–11.

Data on non-nuclear thermal generation are from Statistics Canada, *Report on Energy Supply-demand in Canada, 2005* (2007), Cat. No. 57-003-XIE, Table 8-1, "Electricity generated from fossil fuels – Total electricity generated," p. 112.

Data on baseboard heaters are from Natural Resources Canada, Comprehensive Energy Use Database (2007), www.oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/index.cfm?attr=0, Residential Sector, Table 14, "Total households by building type and energy source," of each province and territory.

[73] Per capita industrial consumption figures were calculated by dividing total industrial consumption data by total population.

Total industrial consumption data by province are from Statistics Canada, CANSIM (2007), Table 128-0010, "Supply and demand of primary and secondary energy in natural units, annual," vectors v32452657, v32453648, v32453889, v32454173, v32454479, v32454818, v32455360, v32455926, v32456353, v32456680, v32457183, v32457798, v32457944 and v32458084.

For total population by province, see the following:

Data on hydro, wind and tidal, and nuclear generation are from Statistics Canada, *Electric Power Generation, Transmission and Distribution, 2005* (2007), Cat. No. 57-202-X, Table 2, "Generation of electric energy, 2005," pp. 10–11.

Data on non-nuclear thermal generation are from Statistics Canada, *Report on Energy Supply-demand in Canada, 2005* (2007), Cat. No. 57-003-XIE, Table 8-1, "Electricity generated from fossil fuels – Total electricity generated," p. 112.

[74] Data on total consumption by sector are from Statistics Canada, CANSIM (2007), Table 128-0010, "Supply and demand of primary and secondary energy in natural units, annual," vectors v32452657, v32452658, v32452660, v32452661, v32452662, v32452663, v32452664, v32452665, v32452666, v32452667, v32452668, v32452671, v32452672, v32452673 and v32452674.

[75] Data are from Hydro-Québec, *Comparison of Electricity Prices in Major North American Cities* (2007), p. 26. Residential electricity rates are in the column entitled "Residential, 1,000 kWh." Large industrial rates are in the column entitled "General, Large Power, 5,000 kW, 3,060,000 kWh, 85%."

[76] Conclusion of NERC's *2007 Long-Term Reliability Assessment 2007–2016*.

[77] Ibid., p. 18.

[78] Canadian Electricity Association, *Addressing Challenges to Electricity Infrastructure Development* (2007), p. 5.

[79] North American Electric Reliability Corporation (2007), *Long-term Reliability Assessment 2007–2016*, p. 10.

[80] A detailed outlook is available in Natural Resources Canada, *Canada's Energy Outlook: The Reference Case 2006* (2006).

[81] Natural Resources Canada (NRCan), National Energy Use Database (NEUD), 1990 to 2005 (2007), Energy Use Data Handbook Tables (Canada), Residential Sector, Table 18, "Residential energy prices and background indicators." **For all statistics on NEUD, visit oee.nrcan.gc.ca/statistics.**

[82] Ibid., Total End-Use Sector, Table 5.

[83] This rapid growth rate could be due in part to data quality and availability issues.

[84] In the commercial/institutional sector, only limited data are available on stocks, sales and unit energy consumption levels related to this equipment. Hence an index has been estimated to capture the impact of these changes over time.

[85] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 1 and Table 7.

[86] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

[87] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Residential Sector, Table 1.

[88] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

[89] A detailed forecast is available in NRCan, *Canada's Energy Outlook: The Reference Case 2006 (*2006).

[90] The secondary energy use described in this section includes the energy demand for pipelines and non-energy use from the industrial sector. It excludes consumption by petroleum refining and oil and gas industries.

[91] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Total End-Use Sector, Table 2.

[92] Ibid., Residential Sector, Table 18.

[93] NRCan, NEUD (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 21.

[94] NRCan, Residential End-Use Model (REUM), Ottawa, February 2007. **For further information, contact NRCan's Energy Technology Programs Sector, Office of Energy Efficiency (OEE), Demand Policy Analysis Division (DPAD), Market Analysis group.**

[95] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Residential Sector, Table 18.

[96] NRCan, NEUD (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 1.
[97] NRCan, REUM, Ottawa, February 2007.

[98] NRCan, NEUD (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 27 and Table 32.

[99] Ibid., Table 18.

[100] Ibid., Table 5.

[101] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Residential Sector, Table 3 (a).

[102] NRCan, NEUD (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 8.

[103] Ibid., Table 27.

[104] Ibid., Table 2.

[105] Ibid., Table 14.

[106] Ibid., Table 37.

[107] Ibid., Table 18.

[108] Ibid., Table 18.

[109] Ibid., Table 1 and Table 33.

[110] Ibid., Table 2.

[111] Ibid., Table 33.

[112] Assumes that CFLs entered the residential lighting market in 2000 and that various bulb types are perfect substitutes. Trends are extrapolated from data collected from NRCan, *2003 Survey of Household Energy Use* (2006).

[113] NRCan, *2003 Survey of Household Energy Use* (2006).

[114] NRCan, NEUD (2007), Comprehensive Energy Use Database, Residential Sector, Canada, Table 1.

[115] A detailed forecast is available in NRCan, *Canada's Energy Outlook: The Reference Case 2006* (2006).

[116] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 1.

[117] Ibid., Table 2.

[118] Ibid., Table 7.

[119] Ibid., Table 1.

[120] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

NRCan, Transportation Energy Use Model (TEUM), 2005. **For further information, contact NRCan's Energy Technology Programs Sector, OEE, DPAD, Market Analysis group.**

[121] NRCan, NEUD (2007), Comprehensive Energy Use Database, Transportation Sector, Canada, Table 7 and Table 11.

[122] Ibid., Table 1.

[123] Ibid., Table 4.

[124] Transport Canada, Canadian Motor Vehicle Traffic Collision Statistics: 2005, www.tc.gc.ca/roadsafety/tp/tp3322/2005/page12.htm.

[125] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Transportation Sector, Table 7.

[126] Ibid., Table 7.

[127] Ibid., Table 4.

[128] Ibid., Table 7.

[129] Ibid., Table 8.

[130] Ibid., Table 11.

[131] Ibid., Table 1.

[132] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

NRCan, TEUM, 2005.

[133] A detailed forecast is available in NRCan, *Canada's Energy Outlook: The Reference Case 2006* (2006).

[134] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

[135] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Commercial/Institutional Sector, Table 5.

[136] Ibid., Table 1.

[137] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Commercial/Institutional Sector, Table 5(a).

[138] NRCan, NEUD (2007), Comprehensive Energy Use Database, Commercial/Institutional Sector, Canada, Table 1.

[139] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

NRCan, TEUM, 2005

[140] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Commercial/Institutional Sector, Table 1 and Table 5.

[141] NRCan is working with Statistics Canada to determine the reasons for this anomaly to improve the quality of the commercial/institutional data reported.

[142] NRCan, NEUD (2007), Comprehensive Energy Use Database, Commercial/Institutional Sector, Canada, Table 25.

[143] Ibid., Table 25 and Table 31.

[144] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Total End-Use Sector, Table 1.

NRCan, TEUM, 2005.

[145] A detailed forecast is available in NRCan, *Canada's Energy Outlook: The Reference Case 2006* (2006).

[146] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Total End-Use Sector, Table 5.

[147] Ibid., Table 2.

[148] Ibid., Table 2.

[149] Ibid., Industrial Sector, Table 2.

[150] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Industrial Sector, Table 7(a).

[151] NRCan, Industrial End-Use Model (IEUM), 2005.

[152] NRCan, NEUD (2007), Energy Use Data Handbook Tables (Canada), Industrial Sector, Table 2.

[153] Ibid., Table 7.

[154] Ibid., Table 2 and Table 5.

[155] NRCan, NEUD (2007), Energy Efficiency Trends Analysis Tables (Canada), Industrial Sector, Table 7(a).

[156] Data are also from NRCan, IEUM, 2005.

[157] A detailed forecast is available in NRCan, *Canada's Energy Outlook: The Reference Case 2006* (2006).

[158]Source: Statistics Canada, CANSIM (2006 data):

Gross Domestic Product (GDP) at basic prices, by special industry aggregates based on the North American Industry Classification System (NAICS) and by province, annual (dollars), Table 379-0026. Total GDP vectors: v41890489+v41890490,v41890498+ v41890499,v41890507+v41890508, v41890516+v41890517,v41890525+ v41890526,v41890534+v41890535, v41890543+v41890544,v41890552+ v41890553,v41890561+v41890562, v41890570+v41890571,v41890579+ v41890580,v41890597+v41890598 and v41890606+v41890607. Energy GDP vectors: v41890497, v41890506, v41890515, v41890524, v41890533, v41890542, v41890551, v41890560, v41890569, v41890578, v41890587, v41890605 and v41890614.

Estimates of population, by economic region, sex and age group for July 1, 2001 Census boundaries, annual (persons), Table 051-0038. Population vectors: v32417544, v32419194, v32419524, v32421504, v32423484, v32429424, v32433384, v32436354, v32438664, v32441634 and v32444604+v32444934+v32445264.

Labour force survey estimates (LFS), supplementary unemployment rates by sex and age group, annual, Table 282-0086. Unemployment vectors: v2170417, v2170633, v2170849, v217065, v2171281, v2171497, v2171713, v2171929, v2172145 and v2172361.

Employment (SEPH), unadjusted for seasonal variation, by type of employee for selected industries classified using the North American Industry Classification System (NAICS), annual (persons), Table 281-0024, and NRCan calculations based on Statistics Canada data. Direct Energy Employment vectors: Quebec – v1715989 and v13922127; Ontario – v1716257, v1716259 and v13922128; Saskatchewan – v1716693 and v1716696; Alberta – v1716836, v13922042, v1716837, v1716839 and v1716840; and British Columbia – v1716840 and v1717031.

[159]Source: Statistics Canada, *Report on Energy Supply-demand in Canada 2005* (2006), Cat. No. 57-003-X,Primary Energy Production, vectors:
Canada: v32446088, v41708883, v32446131, v32446145, v32446183 and v32446209
Newfoundland: v32447127, v32447148, v32447157 and v32447187
Prince Edward Island: v32447529 and v32447564
Nova Scotia: v32447871, v41709336, v32447908, v32447917, v32447932 and v32447957
New Brunswick: v32448334, v41709390, v32448369, v32448381 and v32448423
Quebec: v32448790 and v32448889
Ontario: v32449275, v32449312, v32449324, v32449362 and v32449388
Manitoba: v32449816, v32449851, v32449892 and v32449924
Saskatchewan: v32450284, v41709006, v32450322, v32450334, v32450367 and v32450398
Alberta: v32450717, v41709068, v32450750, v32450761, v32450797 and v32450826
British Columbia: v32451227, v41709136, v32451264, v32451276, v32451312 and v32451341
Territories: v32451718, v32451727, v32451736, v32451749 and v32451774

Electricity Generation: Statistics Canada, *Report on Energy Supply-demand in Canada 2005* (2008), Cat. No. 57-003-XIB, Energy Consumption vectors:
Canada: v32446074, v32446081, v32446082, v32446083 and v32446085
Newfoundland: v32447113, v32447120, v32447121, v32447122 and v32447124
Prince Edward Island: v32447516, v32447522, v32447523, v32447524 and v32447526
Nova Scotia: v32447857, v32447864. v32447865, v32447866 and v32447868
New Brunswick: v32448320, v32448327, v32448328, v32448329 and v32448331
Quebec: v32448776, v32448783, v32448784, v32448785 and v32448787
Ontario: v32449261, v32449268, v32449269, v32449270 and v32449272
Manitoba: v32449802, v32449809, v32449810, v32449811 and v32449813
Saskatchewan: v32450270, v32450277, v32450278, v32450279 and v32450281
Alberta: v32450703, v32450710, v32450711, v32450712 and v32450714
British Columbia: v32451213, v32451220, v32451221, v32451222 and v32451224
Territories: v32451704, v32451711, v32451712, v32451713 and v32451715

Statistics Canada NRCan former *Energy Statistics Handbook*, Cat 57-601, Table 2.9, Demand by fuel.

[160]Source: Statistics Canada, CANSIM (2006), Supply and disposition of crude oil and equivalent, monthly, Table 126-0001, and NRCan calculations based on Statistics Canada data, vectors:
Canada: v17948, v17944, v17945, v17946, v17947, v17949 and v17950
Newfoundland: v17719 and v17718
Nova Scotia: v1408975
Ontario: v17997 and v17996
Manitoba: v18004 and v18003
Saskatchewan: v18024, v18022, v18023 and v18025
Alberta: v18050, v18046, v18047, v18048, v18049, v18051 and v18052
British Columbia: v18079, v18078, v18080 and v18081
Territories: v18099, v18098 and v18101