Continental Energy Sector Issues

A report prepared for the
The National Round Table on the Environment and the Economy

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The Canadian Energy Research Institute (CERI) is a co-operative research organisation established by government, academia, and industry in 1975. Our mission is to produce relevant, independent, objective economic research and education in energy and environmental issues to benefit business, government, and the public. Related important objectives include an ongoing review of energy issues to inform the development of policy and nurturing expertise in analysing energy matters.

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PREFACE

World population is projected to increase by some three billion people from its current level of six billion by the middle of the 21st century. Since almost all of the increase will be concentrated in developing countries, thirsty for energy, energy demand will grow even faster. Although modern economies are critically dependent on a reliable and affordable supply of energy, roughly two billion people currently do not have access to electricity in daily living. The developing world is not likely to accept limitations on either the form or quantity of energy it uses prior to reaching some acceptable standard of living commensurate with other countries. That means the international demand for reliable energy supplies will increase over the foreseeable future.

This has implications for North America because we are already net importers of crude oil and will soon be net importers of natural gas as well. Growing energy demands, in the face of stagnant or declining supplies will inevitably lead to higher and more volatile energy prices. While that economic response will contribute to stabilising energy markets, it's possible more can be done to resolve specific issues, and thereby ease the transition to some future environment of energy.

This study attempts to provide a framework for identifying the issues that are emerging in North America. Those issues relate to:

- the size and geographic diversity of the resource base;
- the nature of demand and supply for specific fuels;
- the regulatory framework that conditions development;
- the scope for alternate sources of energy;
- the difficult and unique environment surrounding electricity restructuring; and
- the potential for improved energy efficiency.

The study is intended to identify the issues most pertinent to the North American continent. Resolving the issues will require dedicated effort of those involved in all stages of the energy system (finding, producing, delivering, and consuming).

1. Introduction

North America is an important region for energy — producing about 25 percent of global energy supply and consuming about 30 percent of the world's commercial energy. In North America there is concern with an assortment of energy issues, including availability of local energy resources and security of supply, extent of remaining reserves, adequacy of infrastructure for delivering energy to markets, the continuing growth in the demand for energy and the associated environmental repercussions. In addition there are many other local issues that affect particular energy sectors and specific geographic regions.

The objective of this report is to provide an overview of the major issues facing the North American energy sector. That overview must include some implications of these issues with respect to the interface between the energy sector, the environment, and the Canadian economy. The report reflects an extensive review of recent academic and trade publications, government documents and energy studies In addition, an informal survey of selected Canadian Energy Research Institute (CERI) members from government, industry, finance, and education was carried out to confirm the relevance of the list of issues identified.

In reviewing North American energy issues, three main themes emerge:

- Growing Demand and Security of Supply;
- High and Volatile Energy Prices; and
- Achieving Sustainability.

We consider these broad themes in the next three sections.

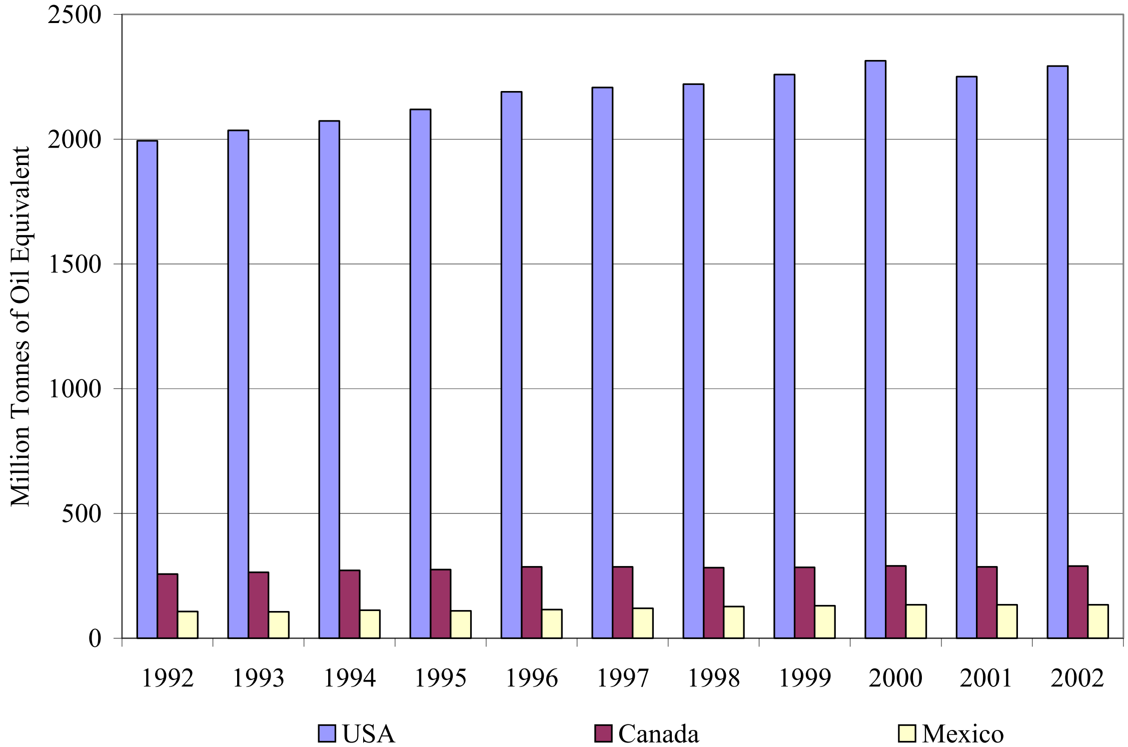
1.1. Growing Demand and Security of Supply

Despite its vast reserves of energy, North America is an energy-importing region. As a result of political instability in countries that export to North America (especially in the Middle East), there is concern in North America (particularly in the U.S.) over its dependence on unstable supply sources and possible supply disruptions.

In general, energy demand is driven by three major growth factors: population, size of the economy and technological advancement. North American primary energy consumption increased by an average of 1 percent from 1992-2002.[1] As clearly shown in Figure 1.1, the United States is the major contributor to energy demand.

[1] Primary energy consumption includes oil, natural gas, hydroelectricity, nuclear and coal

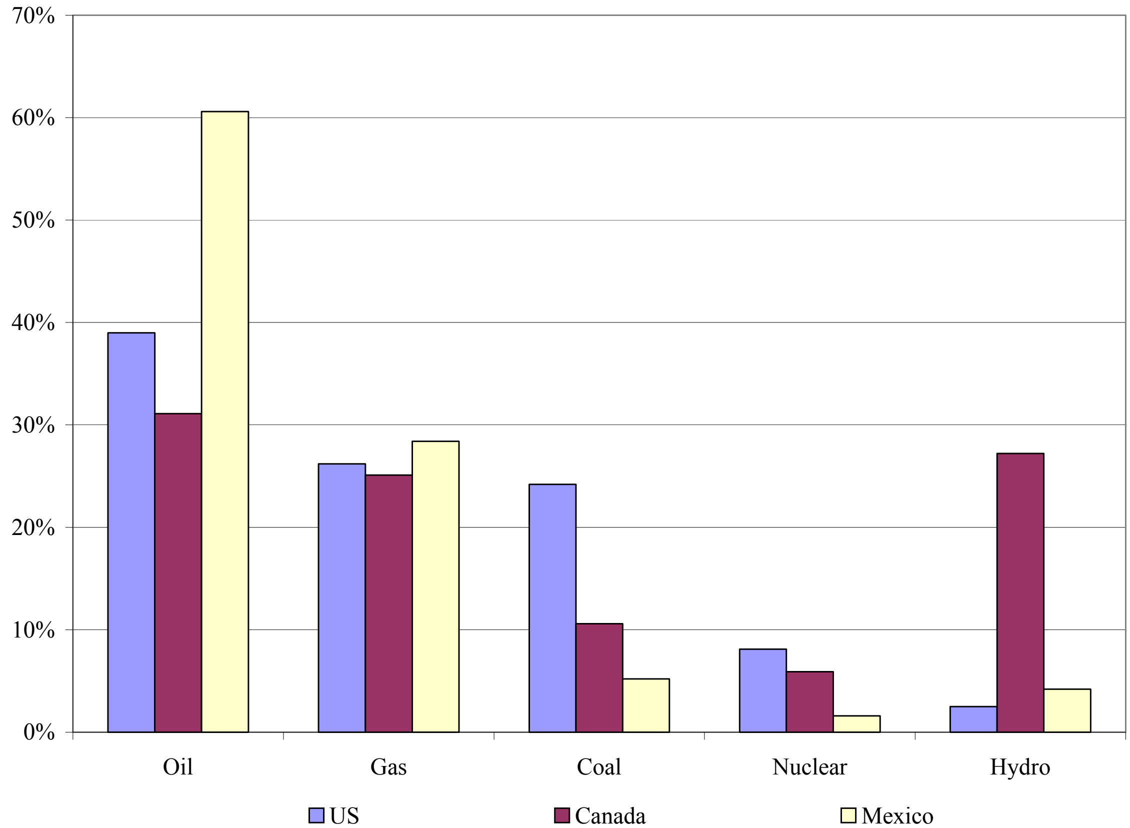
Figure 1.1:North American Primary Consumption (1992-2002)



Source: BP Statistical Review of World Energy 2003.

There are distinct differences in the primary energy mix between Canada, Mexico and U.S. The U.S. relies on fossil-based fuels for almost 90 percent of its primary energy needs (39, 26, 24 percent for oil, gas and coal, respectively). While the contribution of nuclear power has remained fairly stable at around 7 percent between 1990 and 1997, its share has increased to more than 8 percent by 2002. This one percentage share increase masks the fact that while the country's total energy consumption increased at an annual average rate of 0.8 percent between 1997 and 2002, that for nuclear increased at a much higher average of 4.4 percent per year over the same period.

Figure 1.2: Primary Energy Consumption by Fuel – 2002



Source: BP Statistical Review of World Energy, June 2003.

In Canada, hydro power plays a more important role than in U.S. or Mexico. Some 27 percent of Canada's energy requirement is met by hydro power (in contrast to 3 percent and 4 percent for U.S. and Mexico, respectively). Despite having abundant coal reserves (reserves/production ratio of 97 years),[2] coal contributes only 11 percent of Canada's total energy consumption, less than half of that of the U.S. Natural gas represents about 25 percent of Canada's overall energy mix. This proportion is similar to that in the U.S. and Mexico. As a consequence of the high hydro usage, Canada relies on fossil-based fuels for only 67 percent of its total energy needs. Canada has arguably the most diverse energy mix of the three countries.

Of the three NAFTA partners, Mexico is by far the most dependent on oil and gas. Almost 90 percent of its primary energy consumption is based on oil and gas compared to 65 percent for the U.S. and only 56 percent for Canada. The trend since the mid-60s shows a decline in the share of energy from natural gas (a decrease of 3 percent) and hydro (a decrease of 4 percent) with increases in energy from oil, nuclear and coal.

In Table 1.1 we consider gross domestic product (GDP) and energy use in total and on a per capita basis. Energy consumption is normally closely linked to economic prosperity

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[2] Source: BP Statistical Review of World Energy 2003.

(one measure of which is GDP). While the U.S. clearly leads in terms of GDP per capita, Canada has the highest per capita energy consumption. The reasons for this include differences in weather, a relatively small population dispersed over a large geography and an energy intensive resource base. GDP annual growth rate projections between 2000 and 2010 are: Canada (2.5 percent), Mexico (4.0 percent), and the United States (2.9 percent)[3]. The forecasted increase in population and economic growth is projected to cause an annual energy consumption increase of 1.7 percent for North America.[4]

Table 1.1: GDP and Energy Consumption – 2002

	Population million	**GDP** U.S.$billion	**Energy use** Mtoe	**GDP per capita** U.S.$	**Energy use per capita** toe
U.S.	288.4	10,400	2,293	36,100	8.0
Canada	31.4	718	289	22,800	9.2
Mexico	100.9	637	134	6,300	1.6
North America	**420.7**	**11,755**	**2,716**	**27,900**	**6.5**

Source: World Bank.

A significant proportion of U.S. energy consumption is currently met by imports, approximately 26 percent of the total, expected to increase to 36 percent by 2025.[5] North American energy markets are becoming increasingly integrated. Both Mexico and Canada are net exporters of energy to the U.S. Most of Mexico's oil exports go to the U.S. Canada exports about half of its natural gas and crude oil production to the U.S, as well as significant amounts of electric power.[6] The U.S. also exports coal to Canada and smaller quantities of gas and refined petroleum products to Mexico. With growing world energy demand, North America also faces challenges in securing supplies outside of North America. We consider energy trade flows, within and outside North America, in more detail in section 2 and 3 of this report.

1.2. High and Volatile Energy Prices

Crude oil prices rose from under $20 per barrel in the late 1990s to about $35 per barrel in early 2003[7] and have since returned to levels above $30 per barrel in early 2004. These movements were caused by several factors including the Iraq conflict, the situation in Venezuela, and possibly the falling U.S. dollar. In Figure 1.3 below we show the average monthly OPEC reference crude price from 2000 to present.

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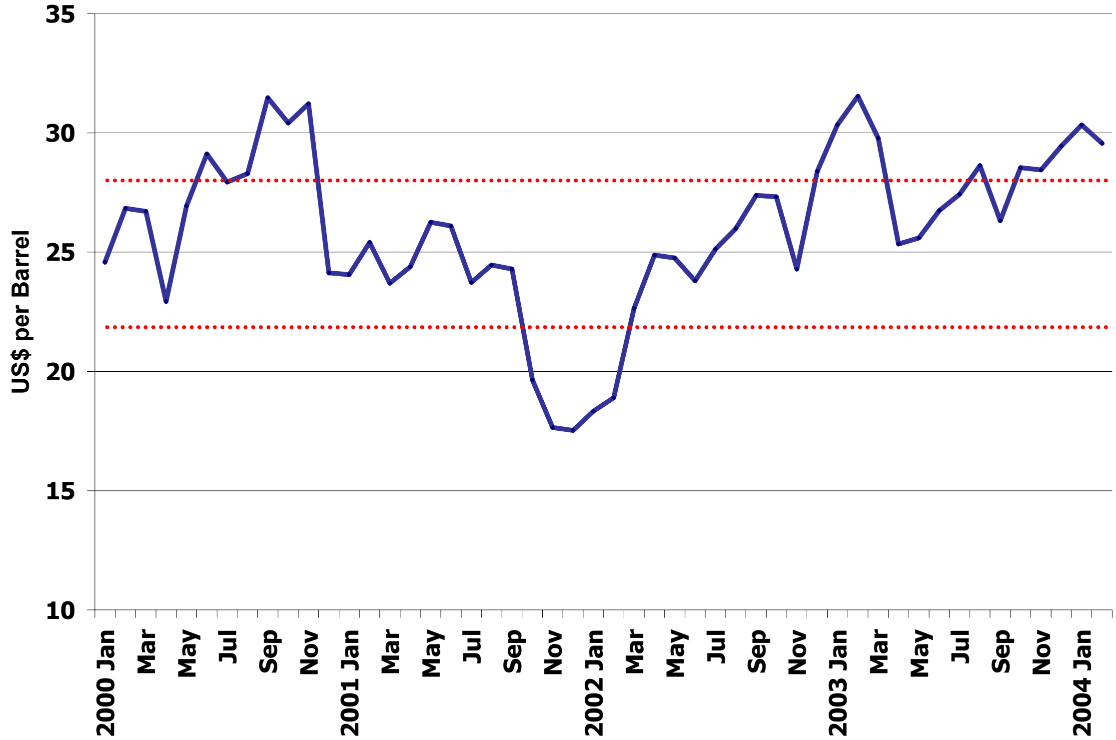
[3] North American Energy Working Group, The Energy Picture; June 2002.
[4] IEA Outlook 2003.
[5] EIA: Annual Energy Outlook 2004 with Projections to 2025.
[6] U.S. and Canadian electric systems are increasingly integrated with flows of power moving from country to country depending on time of day and the capacity of the hydro system.
[7] EIA: Annual Energy Outlook 2004 with Projections to 2025.

Figure 1.3: OPEC Reference Crude Basket Price – Monthly Average (US$ per barrel)



Source: Organization of Petroleum Producing Countries (OPEC), Monthly Oil Market Report. The dotted red lines illustrate OPEC's current desired price range for its basket of crude oils (US$ 22 –28).

Natural gas prices have also increased and are now more volatile than in the past. Wholesale natural gas prices have been consistently higher in the 1990s, averaging $5.45/MMBtu in 2003.[8] The increased presence of gas-fired electricity generation has led to greater volatility of gas prices and a closer correspondence between gas and electricity prices.

Higher prices and increased volatility in fuel prices has affected investment. High prices have made some investment opportunities more profitable. Increased volatility has made the rewards of investment less certain. For example, the possibility of sustained high natural gas prices enhances the economics of exploration and production while at the same time discouraging consumption in commercial uses. Higher and volatile prices have also impacted on residential consumers and in some case have prompted political intervention.[9] The higher prices of natural gas provide potential incentives to seek alternate sources of fuel, conservation, and greater energy efficiency.

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[8] EIA: Annual Energy Outlook 2004 with Projections to 2025.
[9] For example, price caps on residential electricity rates in Ontario and gas rebates in Alberta.

For some energy intensive industries, high gas prices have resulted in pressure to relocate outside North America. This is particular issue for the petrochemical industry that use a large quantity of natural gas as a feedstock.

1.3. Achieving Sustainability

Energy is an integral part of the economy in North America and in the rest of the world. The availability of energy reflects on a nations security and potential for economic growth. However, energy use has local and global implications for climate change as well as air, soil and water pollution. A major challenge for North American is in achieving sustainable energy use that minimises environmental impacts and is compatible with continued economic prosperity. This challenge has implications for the future mix of fuels, the role for various technologies (such as renewable sources) and on the competing demands for land use.

1.4. Organisation of this report

With these three themes in mind the rest of the report is structured into four sections:

- Oil and Natural Gas Issues
- Other Resource Issues
- Electricity Issues
- Energy Efficiency/Conservation Issues

2. Oil and Natural Gas Issues

2.1. Outlook for Oil and Gas Consumption

North America is the world's largest consumer of oil, accounting for more than 30 percent of total demand in 2002.[10] Oil consumption in the transportation sector currently represents 66 percent of North America's total oil demand,[11] comprising gasoline, jet fuel and diesel, the lighter components of the crude barrel. That share is expected to continue to increase as oil use declines in other end-use sectors. In the U.S., the transportation sector accounts for one-third of the country's total energy consumption and produces one-third of its carbon dioxide (CO_2) emissions. The U.S. transportation sector is 97 percent dependent on petroleum.

Demand growth in North America is focussed on lighter-end gasoline and diesel. This poses a challenge to refineries to invest in upgrading/conversion facilities so as to maximize their flexibility to process a diverse (and least-cost) crude slate while satisfying demand for a lighter cut of the barrel.

Mexico's long-term energy demand will be driven principally by economic growth. The Energy Information Administration (EIA) projects a strong 5.2 percent per year GDP growth to 2025[12] aided by its proximity to the U.S. economy and its participation in NAFTA. Consequently, it leads the U.S. and Canada in oil, gas and coal demand growth.

Table 2.1 summarises the EIA's long term forecast of GDP and energy demand growth for U.S., Canada and Mexico.

Table 2.1: GDP, Oil Consumption and Gas Consumption Growth (Average Annual Percent Growth: 2001 – 2025)

	GDP	Total Energy	Oil	Gas	Coal	Nuclear	Hydro
U.S.	3.0	1.5	1.7	1.8	1.3	0.2	2.0
Canada	2.7	1.3	1.0	2.3	0.2	0.6	1.1
Mexico	5.2	4.0	3.2	6.1	3.3	0.8	1.5
North America	**3.1**	**1.7**	**1.8**	**2.2**	**1.3**	**0.3**	**1.7**

Source: EIA International Energy Outlook 2003, May 2003.

Natural gas is expected to be the fastest growing component of primary energy consumption. The EIA expects North America to have the largest increment in natural gas use among the industrialised regions between 2001 and 2025. Most of the increase in natural gas consumption is expected to come from electric generation, but the most recent EIA forecasts have reduced the expectations of growth in gas-fired generation as rising

[10] Source: BP Statistical Review of World Energy 2003.
[11] EIA: International Energy Outlook 2003, May 2003.
[12] The Energy Working Group projects 4 percent growth from 2000 to 2010 (see Section 1.1 above).

gas prices make coal-technologies more competitive.[13] Some of the expected increase in gas demand is likely to come from cogeneration (the joint production of heat and electricity). The increase in cogeneration for industrial use is important since it restricts the possibilities for fuel switching and maintains a high level of gas demand even when prices are high.

Rapid growth in natural gas use is also projected for Mexico at 6.1 percent per annum to 2025. The industrial and electric utility sectors are expected to account for most of the growth. Some increase in residential and commercial sector use is also expected as a result of the 1995 privatisation of the distribution sector, which has brought gas service to a number of cities for the first time.

2.2. Resource Base and Supply Issues

2.2.1. Conventional Crude Oil

Conventional crude oil reserves in Canada's Western Canada Sedimentary Basin (WCSB) are in decline. At the end of 2002, proven reserves of Canada amounted to 6.9 billion barrels as of the end of 2002, representing 9 years of production at current rates.[14] In the near term, conventional oil output is expected to increase by more than 200 thousand barrels per day. The main source of this increase will be from Hibernia that could produce more than 155 thousand barrels per day at its peak sometime in the next several years. Thereafter, conventional oil is expected to resume its historical decline.

Reserves/production ratios of 10.8 and 10.1 years for the U.S. and Mexico, respectively, are only marginally higher than that for Canada. U.S. output is expected to increase only moderately given a higher price outlook, technological advances, and lower costs for deepwater exploration and production in the Gulf of Mexico.

Mexico produced about 3.6 million barrels per day of crude in 2002. The expectation is that it will adopt policies to encourage the efficient development of its resource base, with production peaking at about 4.2 million barrels per day by the end of the decade, and remaining at near that level until 2025.

2.2.2. Canadian Oil Sands

Canada's bitumen resources from oil sands represent one of the world's largest hydrocarbon deposits. The Alberta Energy and Utilities Board (EUB) estimates remaining established reserves of crude bitumen in Alberta to be 174.4 billion barrels as

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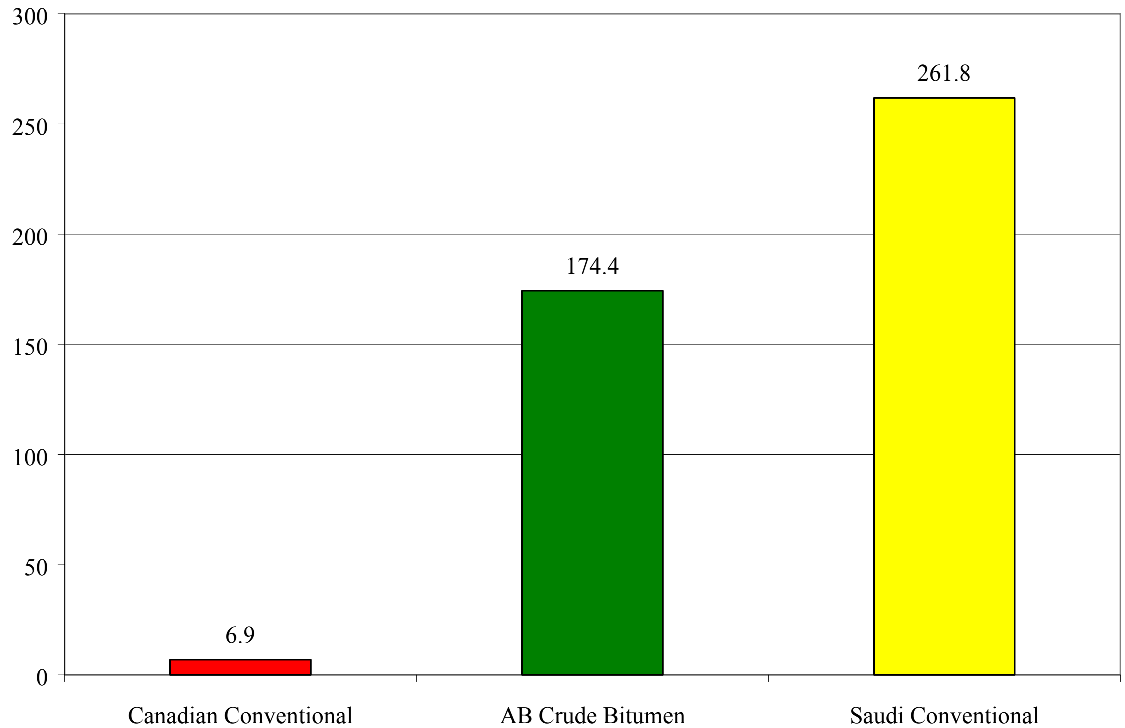
[13] The EIA's *Annual Energy Outlook 2004* forecasts the natural gas share of electricity generation will increase form 18 percent in 2002 to 22 in 2025, down significantly form the previous years estimate of 29 percent by 2025.

[14] Source: BP Statistical Review of World Energy 2003.

of end-2002. These reserves were recognised by the Oil and Gas Journal in late 2003, placing Canada second to only Saudi Arabia on a global scale (see Figure 2.1).

Figure 2.1: Canadian vs. Saudi Reserves
(billion barrels)



Sources: (1) Statistical Series 2003-98, Alberta's Reserves 2002 and Supply/Demand Outlook 2003-2012, Alberta Energy and Utilities Board (EUB); and
(2) BP Statistical Review of World Energy 2003.

In its latest assessment of oil sands supply outlook[15], CERI concluded that most oil sands projects will be economically attractive at the equivalent West Texas Intermediate (WTI) at Cushing oil price[16] of US$25 per barrel. Although oil prices over the last three years have shown some robustness averaging around US$28/b for WTI, many long-term price forecasts suggest a mid-range sustainable figure of about US$25 per barrel, although some upward revision appears imminent.[17]

At the reference price of U.S.$25 per barrel (WTI @ Cushing), CERI projects production (crude bitumen and synthetic crude oil) to realistically increase from 739 thousand barrels per day in 2002 to 2.8 million barrels per day by 2017. Production could be as high as

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[15] CERI Study No. 108, Oil Sands Supply Outlook: Potential Supply and Costs of Crude Bitumen and Synthetic Crude Oil in Canada 2003-2017, March 2004.

[16] WTI is a grade of crude oil that has its main delivery point in Cushing, OK. The spot price for WTI delivered Cushing is the ultimate settlement price for the NYMEX (q.v.) oil futures contract.

[17] Recently, with the weakening of the U.S. dollar relative to other currencies, constraints on non-OPEC supply, and the fact that OPEC has allowed prices to rise well above its US$22 to 28/b price band for the OPEC basket of crude oils, some forecasting agencies are now expecting higher prices.

3.5 billion by 2017 if not constrained by factors such as the availability of skilled labour and the ability of the Alberta economy to absorb the huge investments involved.

The oil sands industry faces a number of development issues and potential constraints.[18]

- Gas use in The Canadian Oil Sands Industry;
- Environmental and Water Management Issues;
- Capital Costs and Labour Shortages; and
- Gas Over Bitumen.

Gas use in The Canadian Oil Sands Industry

Oil sands operations require significant energy inputs, in particular natural gas for steam generation and hydrogen production. Assuming that all of the oil sands projects currently proposed move forward, it is estimated that demand for gas by the oil sands industry could reach 1 billion cubic feet per day as early as 2005. This increase in consumption is equivalent to the production expected to be available from the Mackenzie Delta and some northern frontier regions that could be available from approximately 2009 should the proposed pipeline be approved.

The oil sands industry is actively seeking to improve energy efficiencies. However, if alternate energy sources are not found to replace natural gas, incremental gas consumption by the industry could have a significant impact on the balance of natural gas/supply and demand resulting in upward pressure on prices.

In addition to seeking efficiency improvements in energy use, the oil sands industry is increasingly looking at alternatives to natural gas as an external source of energy and as a means to satisfy its hydrogen requirements. One option is coal, of which there are abundant reserves in Alberta. Although coal gasification represents a proven technology, it would result in increased greenhouse gas emissions and has yet to become cost-effective. Another option being explored is the use or combustion of the heavy ends of the bitumen barrel; however, it suffers many of the same challenges as coal. A third alternative would be to use nuclear generation as both a source of energy (for both heat and/or electric power) and possibly hydrogen. However, the option of nuclear power involves some technical and political complications that would have to be overcome.

Environmental and Water Management Issues

Oil sands development has considerable environmental impact, whether in situ, surface mining/extraction or, to a somewhat lesser extent, upgrading. Surface disturbance is extensive; water consumption is significant; air and water emissions are substantial. Current technologies result in large greenhouse gas emissions. The industry is working hard to mitigate these impacts but concern about environmental impact remains.

Although a detailed assessment of the economic costs of Kyoto compliance has yet to be made, independent surveys of several oil sands operators have concluded that costs will

[18] Appendix A provides a brief overview of oil sands operation.

range between 5-30 Canadian cents per barrel of bitumen produced. Other sources have claimed that costs could be as high as C$3 per barrel.[19]

Water is also an integral part of oil sands operations.[20] Typically water requirements range between 0.2 to 3 m^3 of water for each m^3 of bitumen produced. Water use remains an issue in the oil sands. New recovery technologies have the potential to reduce water use substantially.[21]

Capital Costs and Labour Shortages

The industry has recently experienced substantial capital cost overruns, particularly on large integrated mining, extraction and upgrading developments. Given the sensitivity of project economics to cost overruns, completing projects on budget and on time presents a challenge to future oil sands development.

The high level of development and construction activities has resulted in an acute shortage of skilled labour in the Fort McMurray area. The consequent use of a less-than-qualified workforce has been blamed for the loss in productivity. The efficient assembly, deployment and supervision of work crews are issues that need to be addressed by industry, labour unions and government.

Infrastructure Constraints

The economics of additional cogeneration from oil sands developments are impacted by the electricity transmission infrastructure in Alberta. This in turn has an impact on the economics of bitumen recovery. The current transmission capacity from Fort McMurray is limited, effectively preventing the export of power to other areas of Alberta. Limited interconnection with B.C. and Saskatchewan also constrain potential out of province exports.

Additional crude oil export capacity from Alberta will be necessary by as early as 2006-7. Export capabilities out of the oil sands and Alberta have implications for the U.S. market, refining availability and the choice between exporting bitumen or local upgrading to synthetic crude.

Gas Over Bitumen

A long-standing issue for the in situ oil sands industry is related to the production of natural gas that is associated with crude bitumen reserves. This issue is not expected to ultimately impede in situ development; however, finding a solution is proving difficult and has consumed substantial industry, regulatory and government resources.

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[19] "Kyoto ratification to have limited effect on Alberta oil sands," *Alexander's Gas & Oil Connections*, Volume 8, Issue 23, November 27, 2003.

[20] Water is used for muskeg drainage, overburden and formation dewatering, water flow diversion for mining operations, to makeup water for steam generation in CSS and SAGD operations and to provide water for hydrotransport.

[21] For example, VAPEX (Vapor Extraction) that uses solvents to reduce bitumen viscosity in situ, THAI (Toe-to-Heel Air Injection) that uses air injection and subsurface combustion to increase mobility in the reservoir, and various thermal/solvent hybrids, have the potential to reduce water consumption significantly.

2.2.3. Natural Gas

U.S. proven gas reserves increased by 6 trillion cubic feet between 2001 and 2002. However, with production of 52.1 billion cubic feet per day (or 19 trillion cubic feet per year), the reserves increase represents less than half a year of domestic production and reserves/production ratio stood at 9.6 years as of end 2002. At 60 trillion cubic feet, Canadian reserves increased by less than 1 trillion cubic feet in 2002 (giving a reserves/production ratio of 9.3 years). In Mexico, Petroleos Mexicanos revised its estimate of national oil and gas reserves downward in September 2002 to comply with U.S. Securities and Exchange Commission filing guidelines. Consequently, Mexico's estimated reserves dropped by nearly 21 trillion cubic feet (or 70 percent).

The EIA forecasts U.S. production to grow. However it will not keep pace with domestic consumption. Consequently, imports from Canada are expected to increase supplemented by LNG shipments.

2.2.4. Natural Gas Issues

Conventional production in the WCSB is slowing and some believe is in decline now while others suggest declining production will begin by 2009 (see Figure 2.2). Much of the WCSB gas development in recent years has taken place in the shallow, lower quality areas. This has resulted in a dramatic increase in well drilling activity without a corresponding increase in production. Although the deeper, higher quality gas regions of the WCSB could still produce some prolific wells, the basin is relatively mature and these deeper, larger pools are becoming harder and more expensive to find.

Outside of the WCSB, the Mackenzie Delta and other northern frontier areas are expected to begin producing around 2009. Of course, this is dependent upon whether infrastructure to take gas out of the region proceeds. Gas from the north should help stem the decline in total Canadian production and boost Canadian gas supply after 2009.

Developments on Canada's East Coast offshore and in B.C. (both in the north-east of the province and, longer term, on the West Coast offshore) hold some promise. However, some recent developments have been disappointing. Production from the Ladyfern field in north-eastern B.C., was heralded as Canada's largest find in 15 years, peaked at 700 million cubic feet per day in 2002 and is declining rapidly. Current production is about 300 million cubic feet per day, and many expect the field to be depleted by the end of 2004. Another initially promising development was in the Scotia Shelf Deep Panuke field. Encana, initially optimistic about the Deep Panuke field, requested in early 2003, that the regulatory process for developing the field be placed on hold while it reassesses the economics of development.

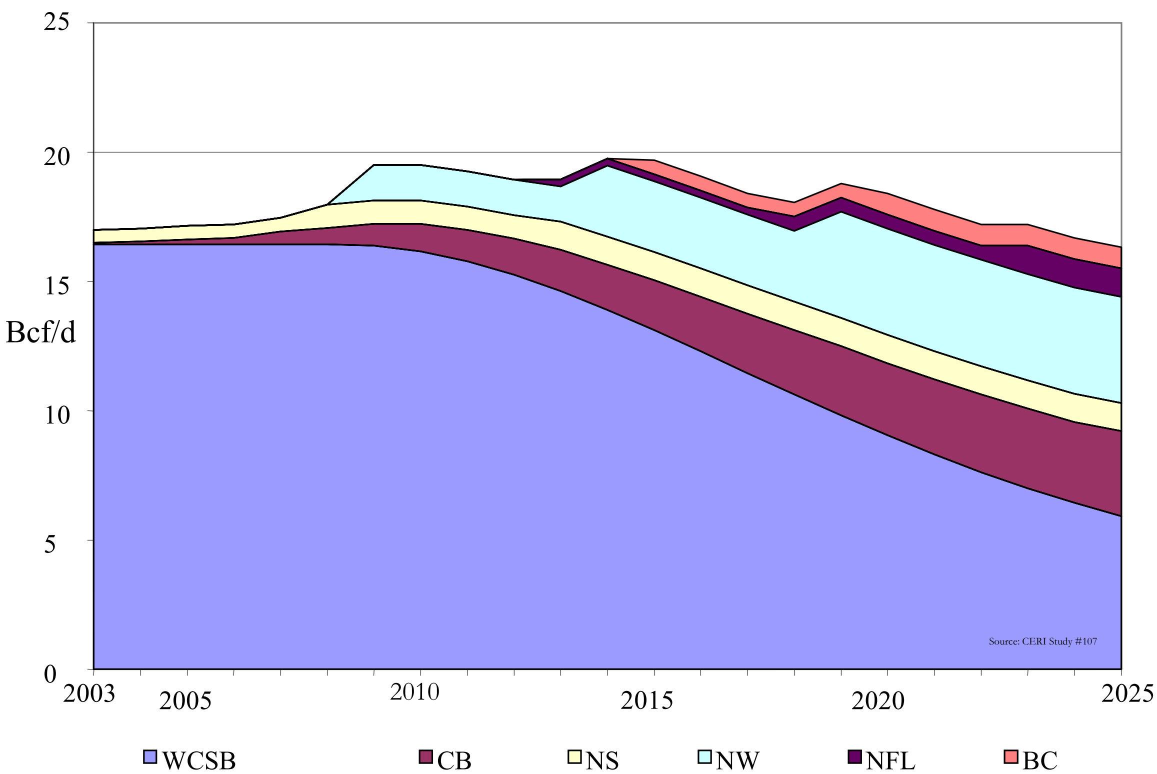
The upward trend in natural gas prices has revived interest in the supply potential of natural gas from Canada's High Arctic. Drilling in the 70s and 80s in the Sverdrup Basin identified 16 trillion cubic feet of discovered reserves. Concepts for development in the

80s were abandoned when natural gas prices fell in the latter half of the decade and remained low throughout the 90s.

Additional gas supply could be available from coalbed methane (CBM) deposits in Western Canada. CBM deposits exist mainly in Alberta, with some in British Columbia. The amount of gas available in the coal seams depends on numerous factors including rank, quality, composition, thickness, depth, and permeability. CBM development is still in its infancy in Alberta, but preliminary estimates suggest that the size of the resource is between 70 and 215 trillion cubic feet (Tcf), or between 2 and 6 trillion m^3.[22]

In summary, other sources of gas in Canada include production from Canada's offshore East Coast, the north and CBM. Supply from CBM, the East Coast offshore and Mackenzie Delta will make up for some of the decline in WCSB conventional gas. However, even with all of these expected additional sources, gas supply in Canada is expected to flatten by 2009 and begin declining by 2016.

Figure 2.2: Canadian Natural Gas Supply, 2003 - 2026



Source: CERI Study No. 107, Potential Supply and Costs of Natural Gas in Canada, June 2003.

2.3. Supply/Demand Balance and Petroleum Trade

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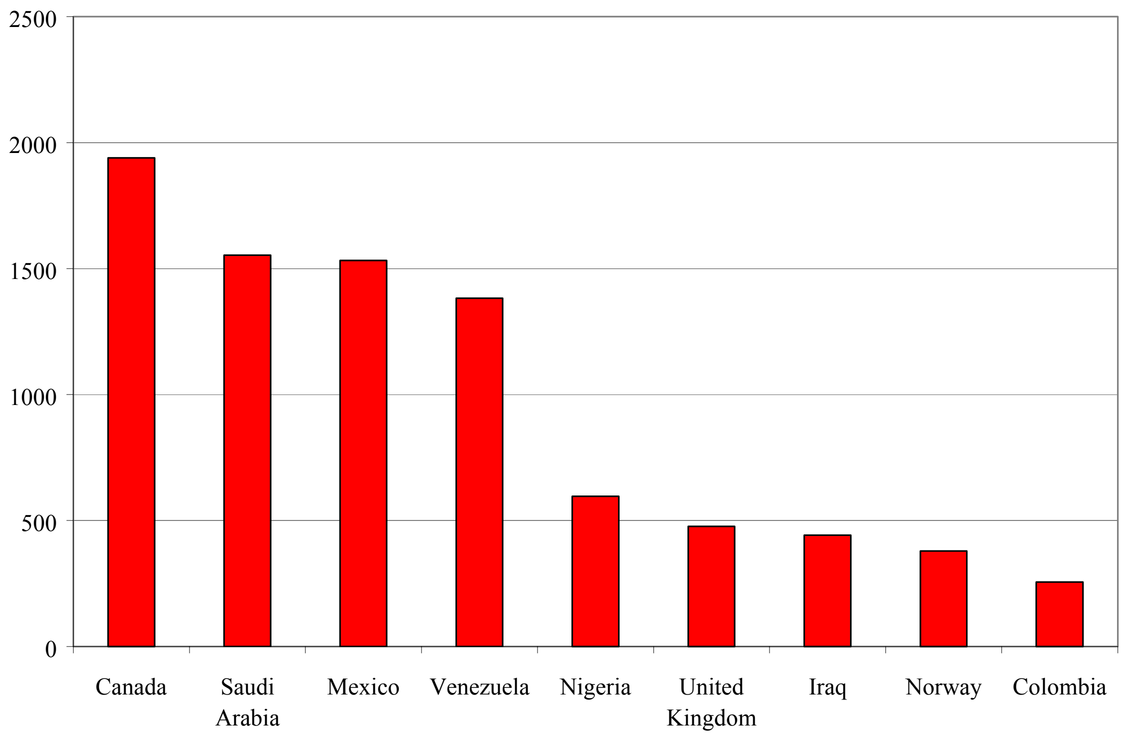
[22]Paul Mortensen, Matthew Foss, Brian Bowers and Peter Miles, *Potential Supply and Costs of Natural Gas in Canada*, CERI Study No. 107 (Calgary, Alberta: Canadian Energy Research Institute, June 2003).

2.3.1. Oil

In 2002, net oil imports by the U.S. represented some 58 percent of its domestic oil consumption. In the same year, it imported a total of 11.4 million barrels per day[23] of oil of which some 40 percent were from OPEC members, and almost one-fifth was from the Persian Gulf nations. Canada's exports amounted to 1.9 million barrels per day, the largest of any country exporting to the U.S. In Figure 2.3 we list the major imports to the U.S. by country of origin.

Figure 2.3: Major U.S. Oil Imports by Country of Origin (million barrels per day)[24]



Source: Energy Information Administration (EIA), Historical Data, Table 5.4, *Petroleum Imports by Country of Origin, 1960-2001*.
Note: The shows the nine countries, which account for 8.6 out of a total of 11.4 million barrels per day of oil imported into the U.S.

In its 2003 energy outlook,[25] the EIA projects that by 2025, net petroleum imports by the U.S. will increase to 68 percent of consumption. Volumes from the Persian Gulf nations are expected to more than double highlighting the country's dependence on a politically volatile region for much of its oil supplies. The EIA also forecasts that imports of oil

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[23] United States, Energy Information Administration (EIA), Historical Data, Table 5.4, *Petroleum Imports by Country of Origin, 1960-2002*.
[24] We show the nine major countries exporting oil to the U.S. These countries account for 8.6 out of a total of 11.4 million barrels per day of oil imported into the U.S.
[25] United States, Energy Information Administration, *International Energy Outlook 2003*, May 2003.

derived from Canada's oil sands will increase to almost 1 million barrels per day by 2025.

In Canada, downstream refiners have to compete for crude with their U.S. counterparts, particularly those in the Mid-West region around the Chicago/Wood River/Patoka area. With hardware configurations that have the flexibility to process a diverse crude slate, and supply options that include crude imports from the U.S. Gulf Coast, U.S. PADD II refiners generally have some advantage over Canadian refiners. As well, oil sands development implies a need for potentially incremental refinery capacity. Therefore, there is an issue with respect to where any new refinery capacity should be located and the appropriate configuration of any new capacity.

2.3.2. Natural Gas

In the U.S., growing natural gas production is not expected to keep pace with rising consumption. Consequently, imports are expected to increase. In 2002, the U.S. imported 4.1 trillion cubic feet of gas (3.9 and 0.2 by pipeline and through LNG shipments, respectively) to satisfy 18 percent of its domestic consumption of 23.6 trillion cubic feet. It is significant to note that in its latest forecast [26] of U.S. gas imports, the EIA dramatically reduced pipeline shipments from Canada citing the following reasons:[27]

- Lower forecasts of Canadian gas production by the National Energy Board;
- Increasing gas use by Alberta's oil sands industry;
- Higher projections of domestic Canadian gas demand; and
- Recent disappointments in Canadian drilling results, including smaller discoveries with lower initial production rates and faster decline rates.

Total net imports by the U.S. are projected to increase from 4.1 trillion cubic feet in 2002 to 5.5 trillion cubic feet in 2010 and some 7.2 trillion cubic feet by 2025 (21 and 23 percent of domestic consumption, respectively). Nearly all of the increase in net imports is expected to consist of Liquefied Natural Gas (LNG), from various African, Asian, and South American sources. Imports are expected to increase from 228 billion cubic feet in 2002 to 2.2 trillion cubic feet in 2010, and 4.8 trillion cubic feet (or 66 percent of net imports) by 2025. U.S interest in LNG has been strengthened as a result of sustained high natural gas prices and declining costs throughout the LNG supply chain (production, liquefaction, transportation and regasification).

LNG is becoming an increasingly important energy source for many other countries including the U.S. As the world market for LNG continues to expand, natural gas is expected to become more of a global commodity. To highlight its shift in thinking, the

[26] United States, Energy Information Administration, *Annual Energy Outlook 2004*, January 2003.
[27] The EIA's report also noted that the decline in Canadian imports could be mitigated by the construction of a pipeline to move MacKenzie Delta gas into Alberta. However, it concluded that "such a dramatic increase [consumption by the oil sands industry] could divert significant amounts of gas from the U.S. import market".

EIA reduced its 2025 forecast of gas imports from Canada from 5.3 trillion cubic in its 2003 report to only 2.5 trillion cubic feet in its 2004 update, a reduction of 2.8 trillion cubic feet that is almost entirely made up by a commensurate increase in LNG imports. There are currently many proposals for expansion of existing, and addition of new, LNG terminals in the U.S., Canada and Mexico. Many of these facilities may not come to fruition, not all facilities appear to be needed and many may not receive the required regulatory approval.[28]

2.4. Regulatory and Land Access Issues

There are two forms of regulation that affect the energy sector: regulation of markets; and direct regulation of development activities. Market regulation has been used mainly in situations where competitive forces are deemed inadequate. For example, the distribution of natural gas or electricity has been viewed as a natural monopoly, requiring oversight through regulatory means. This form of regulation is dealt with in the discussion of electricity markets below and will not be discussed further here. Direct regulation of development relates to safety, environmental, resource conservation, and access issues, both offshore and onshore, and differs across jurisdictions. This latter form of regulation is well developed in Canada, and there are numerous issues that, if resolved, might increase the effectiveness of resource development. Regulation necessarily slows development to some extent, presumably gaining offsetting benefits through meeting the objectives of the regulation. However, when regulatory practice impedes development more than necessary to meet its stated objectives, there may be a case for reform.

In Canada, the provinces own the resources within their borders. The ownership of offshore resources in Canada is more complicated, with the distinction between provincial and federal being the subject of legal rulings and interpretations.[29] Environmental authority is shared in some areas, exclusive to the provinces in others. Northern development may be more complex because some environmental authority has been allocated to a number of groups as well as to the National Energy Board. The sharing of authority may lead to inefficiencies from the point of view of applicants and thereby give rise to some potential for increasing efficiency through common practices or other arrangements that facilitate co-operative assessment. Within provinces, resource development authority is sometimes separate from environmental authority. This adds a need for facilitating processes within provinces as well as between provinces and the Federal government.

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[28] LNG imports to the U.S. come from Trinidad & Tobago, Oman, Qatar, Algeria, Nigeria, Brunei and Malaysia. There are 142 LNG facilities in the United States, Canada and Mexico.

[29] For example, in British Columbia a Supreme Court ruling found resources between Vancouver Island and the mainland where the jurisdiction of the province. However, while the province has claimed so right to an 'Inland Marine Zone' the legal status of ownership of resources along much of the coastline remains unclear.

2.4.1. Existing Developments

While a complete review of the regulatory interactions and potential for enhancement is not possible here, there are some issues that have been identified as warranting further attention:

- Jurisdictional overlap and the need to effectively co-ordinate federal and provincial regulatory activities as well as intra-provincial agency oversight is an important area that could improve overall efficiency. Fully integrated systems with information sharing and co-ordinated decision-making processes could yield a significant improvement in efficiency of overall regulation; and
- The need to streamline specific regulatory processes, such as those related to east coast offshore development has been argued. The Table 2.2 below compares cycle times of the four east coast offshore projects with those of selected countries. While there may be reasons for the longer approval periods observed in the Canadian offshore developments, the table suggests some review is warranted.

Table 2.2: Regulatory Process Cycle Times

Country	Median Duration (Months)
Australia	14
Norway	13
United Kingdom	9
U.S. (Gulf of Mexico)	10
Canada:	
Hibernia	13
Terra Nova	17
Sable	18
Wild Rose	21

Source: *Submission to Atlantic Energy Roundtable II*, from Regulatory Issues Steering Committee & Industrial Opportunities Task Force, October 31, 2003.

2.4.2. New Development

Some large new areas of development pose both challenges and opportunities since they require the development of new regulatory arrangements. The primary example of this is the Mackenzie Valley Development, but emerging interest in offshore British Colombia potential is also worth noting.

<u>Mackenzie Valley Pipeline</u>

The Mackenzie Valley Pipeline project involves several activities and applications to the regulatory system. These include development of the three natural gas fields that will provide base support for the project, Taglu, Parsons Lake, and Niglintgak; an NGL gathering system from the fields to processing plants in the Inuvik area; an NGL pipeline from the Inuvik area to Norman Wells; and a natural gas pipeline to run from the Inuvik area to the existing system in northern Alberta. The daily production rate from the three fields is expected to be .8 to 1 bcf of natural gas and 12,000 to 15,600 barrels of NGLs.

The extent and complexity of the applications would itself pose a challenge to efficient regulation but in addition there are several distinct approving agencies that have to be coordinated including:

- The Inuvialat Game Council;
- the Mackenzie Valley Environmental Impact Review Board;
- The Mackenzie Valley Land and Water Board;
- The NWT Water Board;
- The Canadian Environmental Assessment Agency; and,
- The National Energy Board.

These parties have developed an approach to co-ordination and the Federal government has appointed The Northern Gas Project Secretariat to ensure the public has efficient access to information on an ongoing basis. The steps involved to date have required time and effort and undoubtedly contribute to the costs of the project in a significant way. However, the process is also helping to forge a consensus on critical issues and may lead to a broadly accepted project within a reasonable time frame.

The work that has gone into the Mackenzie Valley regulatory co-ordination effort may prove useful if and when greater development of Arctic resources is contemplated.

West Coast Offshore Development

In 1972, the Government of Canada imposed a moratorium on crude oil tanker traffic through Dixon Entrance, Hecate Strait, and Queen Charlotte Sound due to concerns over the potential environmental impacts. A later federal order prohibited oil and gas drilling activities for an indefinite period. British Columbia extended the moratorium in 1982 with its own ban that included the Strait of Georgia between Vancouver Island and the mainland and Juan de Fuca Strait between the southern tip of Vancouver Island and the U.S. mainland.

In March 2003, Natural Resources Canada (NRCan) announced that it was initiating a process to review the moratorium. The Federal Government is looking to complete the overall review process in 2004. Lifting the federal and provincial moratoriums would open the potentially prolific Queen Charlotte Basin to offshore oil and gas exploration and development.

The First Nations issues have been particularly difficult, resulting in both physical and legal confrontations. There has been a concerted three-way effort by government, industry and aboriginal leaders to establish a clearer regulatory path that gives industry greater certainty over land access and the First Nations a share of the economic benefits without undermining their treaty rights.

In April 2002, the provincial government created the Economic Measures Fund to promote Native participation in northeastern British Columbia's oil and gas industry as part of the process to foster partnerships between the Treaty 8 First Nations and industry. A further boost to the process is a Canadian Association of Petroleum Producers-Treaty 8 forum to facilitate discussions involving First Nations, the industry and government.

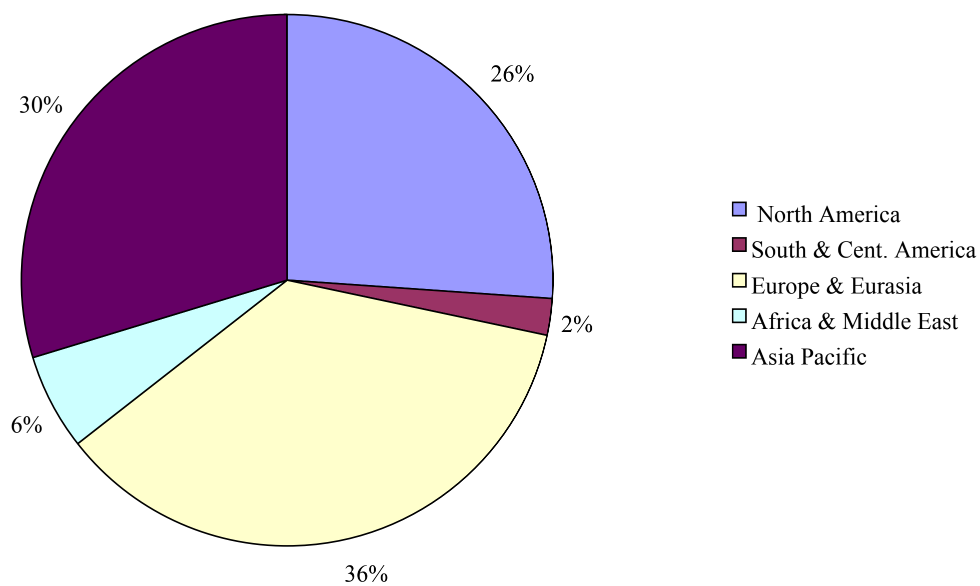
Earlier this year, a federally-appointed panel of scientists released a comprehensive scientific report giving its blessing to offshore petroleum exploration provided there are environmental safeguards. Since then, the BC Government has formed the BC Offshore Oil and Gas Team to devise policies for oil and gas drilling near the Queen Charlotte Islands in anticipation of the lifting of the federal moratorium. Industry observers report that while the drilling bans could be removed as early as 2005, it could be several years of seismic testing and studies before drilling resumes in the Queen Charlotte Basin.

3. Other Resource Issues

3.1. Coal

Coal contributes 64 percent of the world proven reserve of fossil fuels and global coal reserves represent 204 years of production at current rates.[30] North America has over 26 percent of the world coal reserves.

Figure 3.1: World Coal Reserves



Source: EIA Reserves Database[31]

The main barriers to coal relate to environmental concerns regarding emissions. Advanced coal technologies have already been developed that are capable of almost entirely eliminating criteria pollutants from coal-fired power generation, namely particulates, oxides of nitrogen and sulphur dioxide. Coal-fired power generation is becoming increasingly efficient resulting in less coal being used per unit of electricity generated. Thermal efficiencies of coal-fired power plants have reached 40 percent with the prospect of further improvement to 50 percent and better. Achieving this target would lead to a reduction in GHG emissions by 10 to 20 percent compared to the best conventional plants today.

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[30] Canada and U.S. have reserves/production (R/P) ratios of 97 and 252, respectively.
Source: BP Statistical Review of World Energy June, 2003.

[31] http://www.eia.doe.gov/emeu/iea/table82.html

Extensive research is being undertaken to develop ultra-low emissions technology. While such technology is not yet commercial, it may be a viable option in the longer term. One major new technology stream is the gasification of coal in integrated combined cycle (IGCC) systems. Already, some 1,800 MW of this type of plant is operational world-wide.[32] Near-zero emissions are possible if such systems are combined with carbon capture and storage technology. Numerous governments including the U.S. have initiated research and work programs to improve understanding of large-scale carbon capture and sequestration with the aim of lowering costs. Already, the technology to store CO_2 in underground depleted oil and gas reservoirs is proven through commercial applications involving enhanced oil recovery.

3.2. Nuclear

Nuclear energy is an important component of Canada's electricity generating fuel mix. Nuclear's share of generation accounts for upwards of 16 percent of total generation in Canada. Some provinces do not rely on nuclear generation at all while others such as Ontario use nuclear fuel for as much as 41 percent of their generation (Statistics Canada, first 10 months of 2003).[33] Nuclear generation is equally important in the United States, where its share of generation was over 20 percent in 2002 (International Atomic Energy Agency 2004). The share of generation from nuclear fuel varies by state with, where similar to Canada, some states have no nuclear generation to other such as New Hampshire which have upwards of 57 percent of their generation resulting from nuclear fuel.

Canada is also the worlds largest producer of uranium, accounting for over one third of the annual world production. The economic benefit from mining and production of uranium was approximately $583 million in 2001.[34] The value of electricity produced by nuclear energy estimated to be between $2,700 and $3,700 million in 2001 (Statistics Canada), of which close to $200 million was exported. Total export revenue from electricity, uranium, reactor fuel, isotopes, heavy water, and Atomic Energy Canada Limited services were close to $1.2 billion dollars during the early part of the 2000s. Employment generated in positions directly related to the nuclear industry was over 20,000 in 2002.

The use of nuclear energy for generating electricity is one way of moderating the production of greenhouse gases and acid rain associated with the burning of fossil fuels.

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[32] International Energy Agency, Clean Coal Centre, 2003.

[33] A March 18, 2004 report from the Ontario Power Generation (OPG) Review Committee notes that nuclear energy, through the use of refurbishment and new capacity, is most likely the most viable solution to solving Ontario's looming supply crunch. Supply is forecasted to fall between 6,000 and 7,000 MW short by 2007 unless decisive action is taken in the near future. With a desire to decrease coal dependence in the future and with shrinking opportunities for new hydro projects, the refurbishment of Pickering A Unit 1 would act to solve some of the problem (upon completion of Unit 1, an evaluation should be conducted at which time consideration could be given to the refurbishment of Unit's 2 and 3.

[34] CERI (2002).

Table 3.1 shows the estimated reduction in certain gases consequent to the use of nuclear energy as fuel for electricity generation in 1996.

Table 3.1: Emissions Avoided from the Use of Nuclear Energy in 1996

Emission Type	Actual Electricity Sector Emissions (tonnes)	Emissions Avoided by Nuclear Plants (tonnes)	Emissions Reduction in the Electricity Sector (percent)
CO_2	91,552,000	81,900,000	47
NO_X	205,000	222,200	52
VOC	1,774	1,497	46
CH_4	757	526	41
SO_2	497,000	491,200	49

Source: Natural Resources Canada

Nuclear energy is not without potential negative environmental externalities. Concerns exist over the use of spent nuclear fuel from reactors. Nuclear waste is radioactive with some elements remaining hazardous thousands of years into the future. Federal guidelines with respect to nuclear waste are under revision with a target of late 2005 for implementation. These guidelines should resolve issues related to storage technique and location. This will still leave perceptions about safety of the reactors themselves. While it is likely that issues of spent fuel storage and safety can be satisfactorily resolved, they remain a concern of the public.[35]

These safety and environmental concerns contribute to a negative public perception of nuclear energy in some countries.[36] As well, the high capital costs of nuclear energy and some experience over the past decade with cost overruns associated with refurbishment of nuclear facilities has contributed to the negative perception of some members of the public. While cost overruns have been caused by numerous factors, including some related to decision-making of governments, and although more recent examples of new construction on time and on budget are available, some negative perceptions remain. Thus, in spite of a widespread recognition that nuclear energy is a low emitter of greenhouse gases, the negative perceptions related to waste management, safety, and efficiency continue to challenge the industry and affect the potential for new nuclear plants.

[35] Perhaps the most difficult perceptions to deal with are associated with the possibility of terrorist activities. While nuclear plants are now being built to demanding specifications that essentially preclude operating them at levels that pose serious threat, such as happened at Chernobyl, public perception will be difficult to alter.

[36] Interesting to note, an OECD report on public perception of nuclear energy, shows that perception is irrelevant to the nuclear policy of the country (OECD undated, p.109).

3.3. Hydro

North America is a world leader in the production of hydroelectricity, with the IEA reporting a total of 159 gigawatts of installed hydropower as of January 2001.[37] Canada has the largest percentage of its electricity generation mix from hydro at 60 percent, followed by Mexico and the U.S. at 20 percent and 7 percent respectively.

Hydroelectric power is attractive because of its high efficiency, long life, low operating costs, and low emissions. Although electricity generated from water plant is relatively emission free, significant amounts of methane are produced from the decomposition of plants in the flood areas. In addition to methane, hydropower can have significant environmental effects such as fish injury and impact on downstream water quality. By diverting water out of the water bodies for power, dams remove water needed for healthy in-stream ecosystems thereby disrupting the natural river flows. Dams also slow down the flow of the river. Many fish species, such as salmon, depend on steady flows to flush them down river early in their life and guide them upstream years later to spawn. Slow reservoir pools disorient migrating fish and significantly increase the duration of their migration.[38] In addition, bacteria present in decaying vegetation can also change mercury, present in rocks underlying a reservoir, into a form that is soluble in water. The mercury accumulates in the bodies of fish and poses a health hazard to those who depend on these fish for food.[39] These environmental effects along with local siting are issues that need to be addressed for large-scale hydro developments.

In Canada, the majority of hydroelectricity is produced in the five provinces of Quebec, British Columbia, Ontario, Manitoba, Ontario and Newfoundland & Labrador. (See Figure 3.2). The La Grande complex in Quebec is the largest hydroelectric development in the world, with a capacity of over 15,000 MW. Canada is expected to expand its hydroelectricity capacity with several projects under consideration in Quebec, Northwest Territories and Newfoundland. There are also several potential development sites in Manitoba. Environmental concerns also place a limit on the potential for further hydro development.

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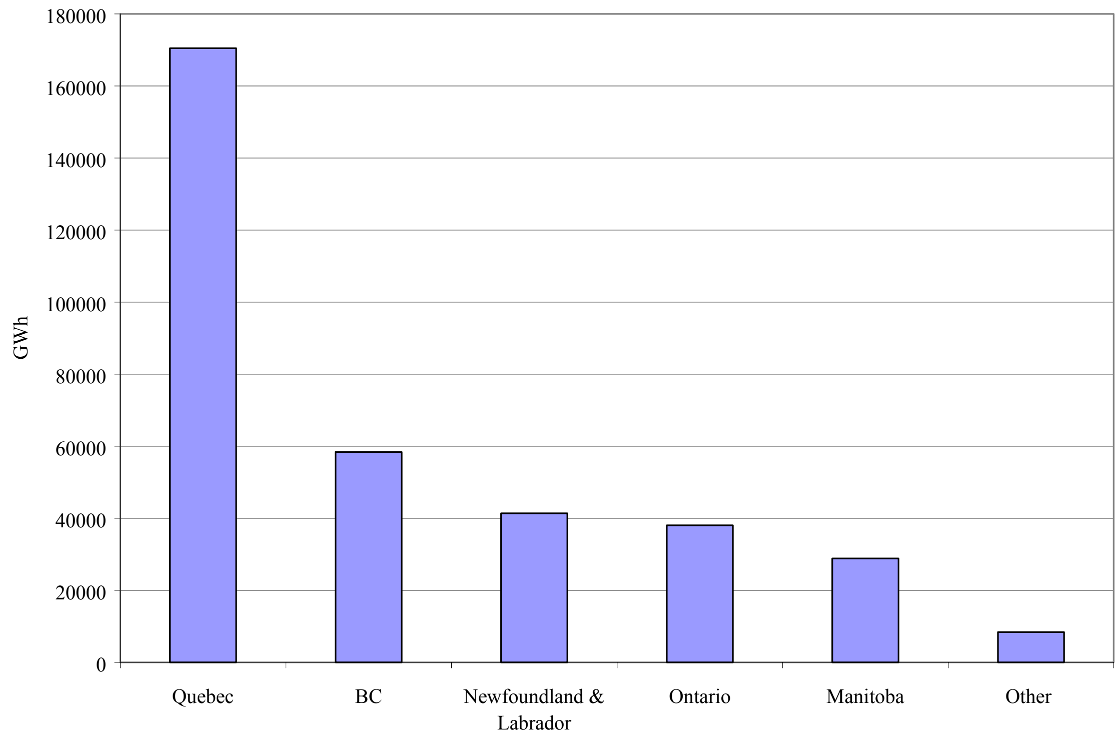
[37] EIA. International Outlook 2003. pg. 116.

[38] International Energy Agency Implementing Agreement For Hydropower Technologies and Programs Annex III: Hydropower and the Environment: Present Context and Guidelines for Future Action. Volume I: May 2000. Pg. 9-12.

[39] Worldbank website, ww.worldbank.org/html/fpd/em/hydro/tp.stm

Figure 3.2: Hydroelectric Generation in Canada (2002)



Source: Statistics Canada 57-001.

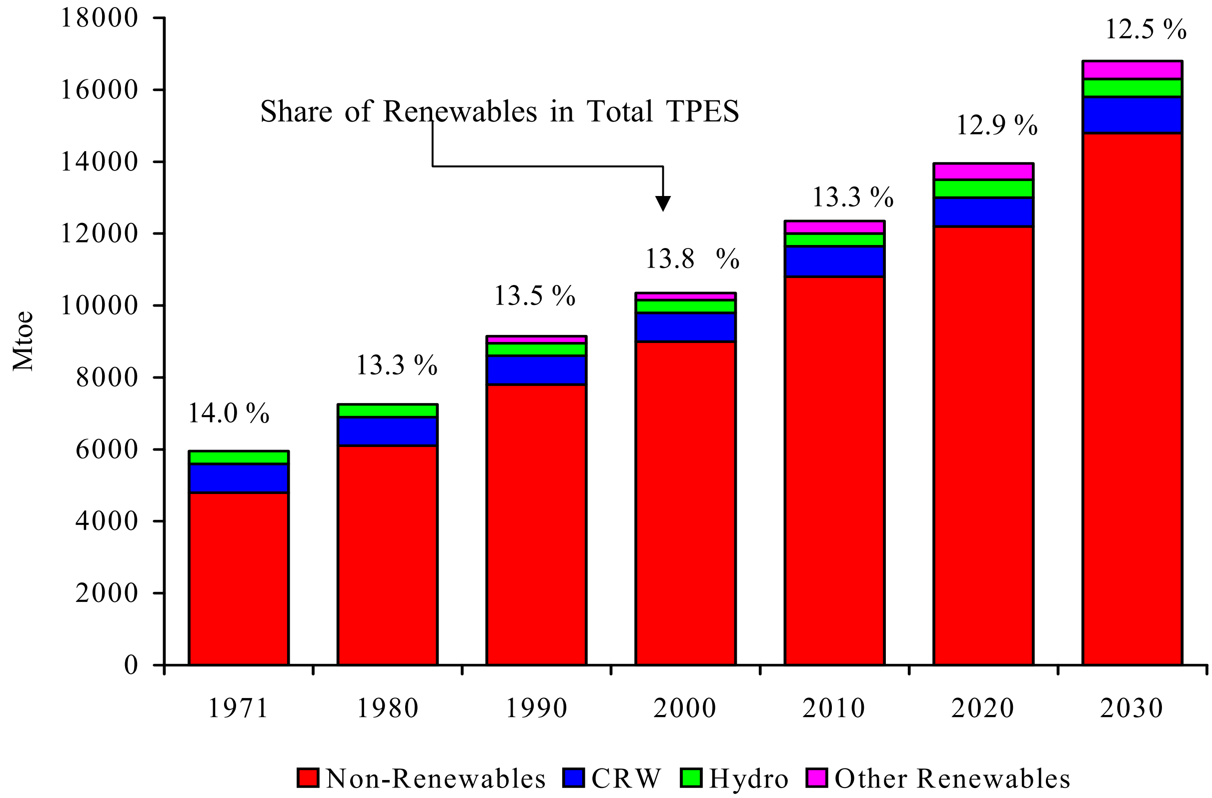
Most of the potential hydroelectricity sites in the United States have already been developed and due to regulatory restrictions hydroelectric generation is not forecasted to increase past 2005.[40] Mexico has plans to construct new hydro capacity with the El Cajon 750-megawatt hydroelectric project on Mexico's west coast slated for completion in 2007.

3.4. Renewables

Renewables play an important role in the world's total primary energy supply, contributing just under 14 percent in 2000 with combustible renewables and waste (CWR) continuing to be the dominant renewable in the future (see Figure 3.3.).

[40] EIA. International Outlook 2003 pg. 116.

Figure 3.3: 2000 Fuel Share of World Total Primary Energy Supply (TPES)



Source: IEA, *Renewables in Global Energy Supply*. November 2002, p.4.

Renewables supplied approximately 6 percent of total domestic gross energy demand in the U.S. in 2002, with majority of renewable energy being from hydroelectricity (45 percent) with the remaining 55 percent mainly from solar, wind and geothermal. Most of the renewable energy was used for electricity production.

Although growing, non-hydroelectric renewables still supply only a small portion of U.S. energy needs. According to the EIA forecast, generation from non-hydroelectric renewables are expected to more than double in the next twenty years increasing from 81 billion kilowatt hours in 2000 to 189 billion kilowatthours in 2025. The main areas of growth are biomass cogeneration, geothermal and wind energy.

Mexico's renewable supply comes mainly from hydroelectricity followed by geothermal energy. In fact Mexico is the third largest producer of geothermal electricity in the world following the United States and the Philippines. To date, wind power does not contribute greatly to the generation mix, with only two significant wind projects with a generation capacity of approximately 2100 kilowatts of the total Mexican generation capacity of 38.9 million kilowatts. Significantly, the Mexico government set goals to increase wind capacity to 2 million kilowatts by 2006 and solar energy to 13,000 kilowatts by 2009. [41]

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[41] EIA Country Briefs.

Renewables account for 17 percent of Canada's primary energy supply, with the majority of the renewable energy mix contributed from hydroelectricity[42], at 11 percent followed by biomass[43]. Wind energy is expected to grow substantially, partly as a result of the Federal Government's Wind Power Production Incentive program.

Renewable energy sources have the potential to play an even greater role in the world energy supply with technical developments and policies that encourage the growth of the renewable market.

Table 3.2: Global Renewable Resource Energy Base (Exajoules a Year)

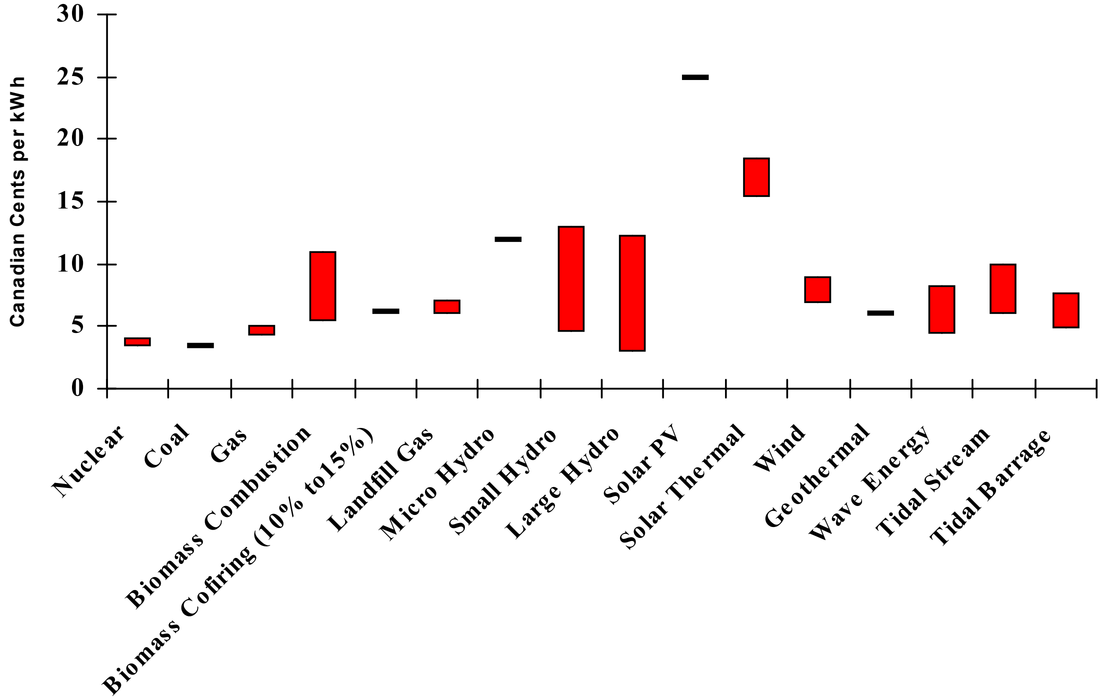
Resource	Current Use	Technical Potential
Hydropower	10.0	50
Biomass energy	50.0	>250
Solar Energy	0.2	>1600
Wind Energy	0.2	600
Geothermal Energy	2.0	5,000
Ocean Energy	-	-
Total	62.4	>7,500

Source: Johannson (2004).[44]

Renewable energy sources are not expected to be economically competitive with fossil fuels in the mid-term without significant support from government policies.[45]. In Figure 3.4 we show a comparison of generation costs for different technologies. Renewable technologies are generally characterised by relatively high capital costs and low operation and maintenance costs.

[42] This refers to all hydroelectricity production.
[43]NRCAN. Renewable Energy in Canada: Status Report 2002.
[44] Johansson, Thomas. The Potentials of Renewable Energy, 2004.
[45] IEA, World Energy Outlook, 2003.

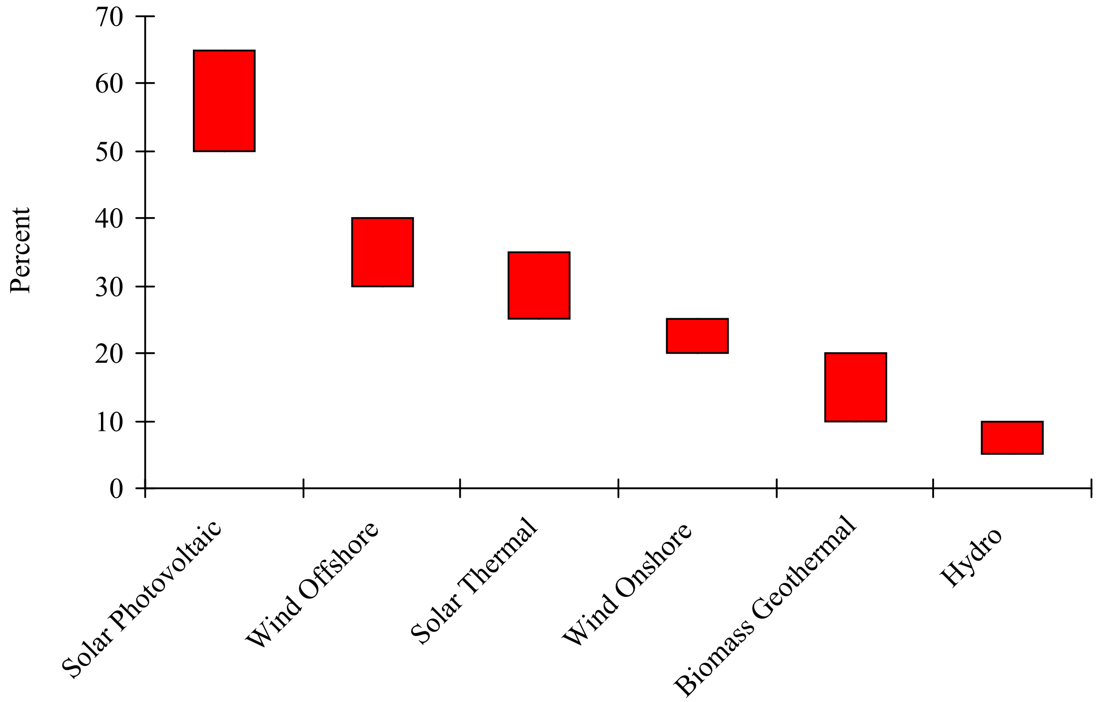
Figure 3.4: Comparison of Generation Prices of Different Energy Sources



Source: Pollution Probe, Promoting Green Power in Canada, 2002.

As renewables' costs come down and technologies advance, they will become more important. IEA forecast the cost reduction most significant for solar. In Figure 3.5 we show the range of estimated cost reductions for different technologies.

Figure 3.5: Reductions in Capital Costs of Renewable Energy Technologies 2000-2030



Source: IEA World Energy Outlook, 2002.

The increasing use of renewable energy sources has important implications for the environment and the economy. Policies promoting the development and use of renewable energy sources and technologies can make a significant difference. The future use of renewable energy resources will depend impart on achieving a balance between economics and controlling environmental impacts of non-renewable resources such as greenhouse gas emissions. The current and future availability of cheap fossil fuels will continue to be a barrier to the expansion of the role of renewable energy.

3.5. Hydrogen

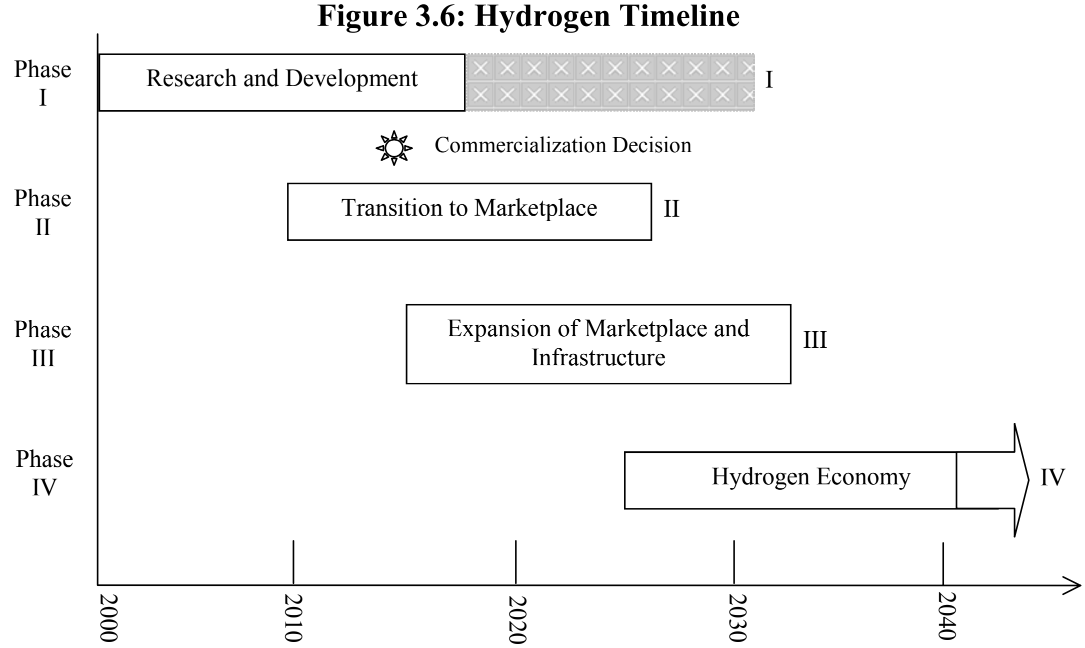
Hydrogen is a potential energy option for the long term in providing a clean and sustainable supply of energy. Hydrogen in the form of fuel cells also has implications for future transportation (see Section 5.3.3 for more discussion). There remain a number of major technical, economic, and political hurdles that need to be overcome.

One of the main barriers for developing a hydrogen economy is a low cost option for producing hydrogen. Currently, most hydrogen is produced from natural gas. Although natural gas will likely provide the earliest affordable feedstock for hydrogen, high natural gas costs are a deterrent. If hydrogen is going to become a realistic option, it needs investment to develop the technology and drive down the costs. To bring down costs, research is underway to develop innovative "breakthrough" technologies for extracting fuel-grade hydrogen from natural gas and coal, as well as producing hydrogen through the use of nuclear energy technology.

A move to reliance on hydrogen also requires advancement be made in the infrastructure for hydrogen energy. At the forefront are required advancements in hydrogen storage and transportation techniques. Many countries are participating in the research with the United States leading the way (the U.S. government spends about $300 million annually on hydrogen and fuel cell research). Other countries actively pursuing research include Canada, Japan, the UK, China, Russia and France.

Figure 3.6 below provides a representation of a possible time line for the adoption of a hydrogen economy in the United States (U.S. Department of Energy Hydrogen Posture Plan 2004). This figure indicates that we are far from recognizing the widespread use of hydrogen as an energy source. Phase I highlights the importance of continued research and development into hyrogen based technology. Phase's II and III include the tranition from research to the implementation of hydrogen as viable fuel source. Phase II would include small scale use in the transportation sector, using existing natural gas and electricity infrastructure. Phase III is the beginning of the development of infrastructure primarily designed with hydrogen in mind. This would include infrastructure for storage and transportation over wide areas. Phase IV is the final realization of the hydrogen economy. In this phase, infrastruture would span the United States and hydrogen would be available as a fuel source in all regions. Phase IV, will not likely be a reality until close to 2030.

Figure 3.6: Hydrogen Timeline



Source: United States Department of Energy Hydrogen Posture Plan (2004).

4. Electricity Issues

After almost 100 years of regulated electricity supply, deregulation and restructuring of the electricity industry, including the introduction of markets, are still fairly new phenomena. Soon after the first electric companies started to operate during the last decade of the 19th century, aggressive competition gave way to the geographic division of the electricity market into regional monopolies and absence of any competition. Until the latter part of the 20th century, the traditional structure of electricity markets was a *vertically integrated monopoly* responsible for generation, transmission and distribution. Under this structure customers have no choice about the supplier of power. Consumers were compensated for the lack of choice by regulated promotional electricity tariffs in the form of declining block rates and by decreasing average bills due to ever decreasing costs associated with economies of scale.

The first practical steps to reintroduce some measure of consumer choice and competition took place in the early 1970s following more frequent requests by regulated electric utilities for rate increases. Economies of scale seemed to come close to being exhausted and mismanagement led to a few bankruptcies. The energy crisis of the 1970s promoted legislation that introduced non-tradition electricity generators, in the form of subsidised qualified facilities, and marginal cost based rates. The rates and alternate sources of energy made consumer choice a possibility.

The last decade has seen a major change in the North American electrical industry. Many areas have restructured allowing a shift of ownership in assets form public to private hands. In the U.S., the share of installed capacity provided by competitive suppliers has increased from about 10 percent in 1997 to about 35 percent in 2003[46]. Present trends indicate that this industry will be significantly restructured over the next decade. [47] Most have adopted a functional separation of activities into different companies (usually in generation, transmission and distribution). In many markets, restructuring has involved the establishment of wholesale competitive markets (known as 'power pools'). Some markets have continued restructuring allowing customers to purchase supplies from competitive retailers.

Despite the rapid pace of electricity restructuring it remains a central energy issue. Not all restructuring has proved successful, as evidenced by the high profile problems experienced in California. Problems with restructuring have caused some states and provinces to postpone plans (in some cases indefinitely). Where restructuring has successfully avoided the problems experienced in California some uncertainty remains with respect to the 'best' market design.

For those provinces and states that have not restructured as far as establishing competitive wholesale markets the main issue remains whether this move would be

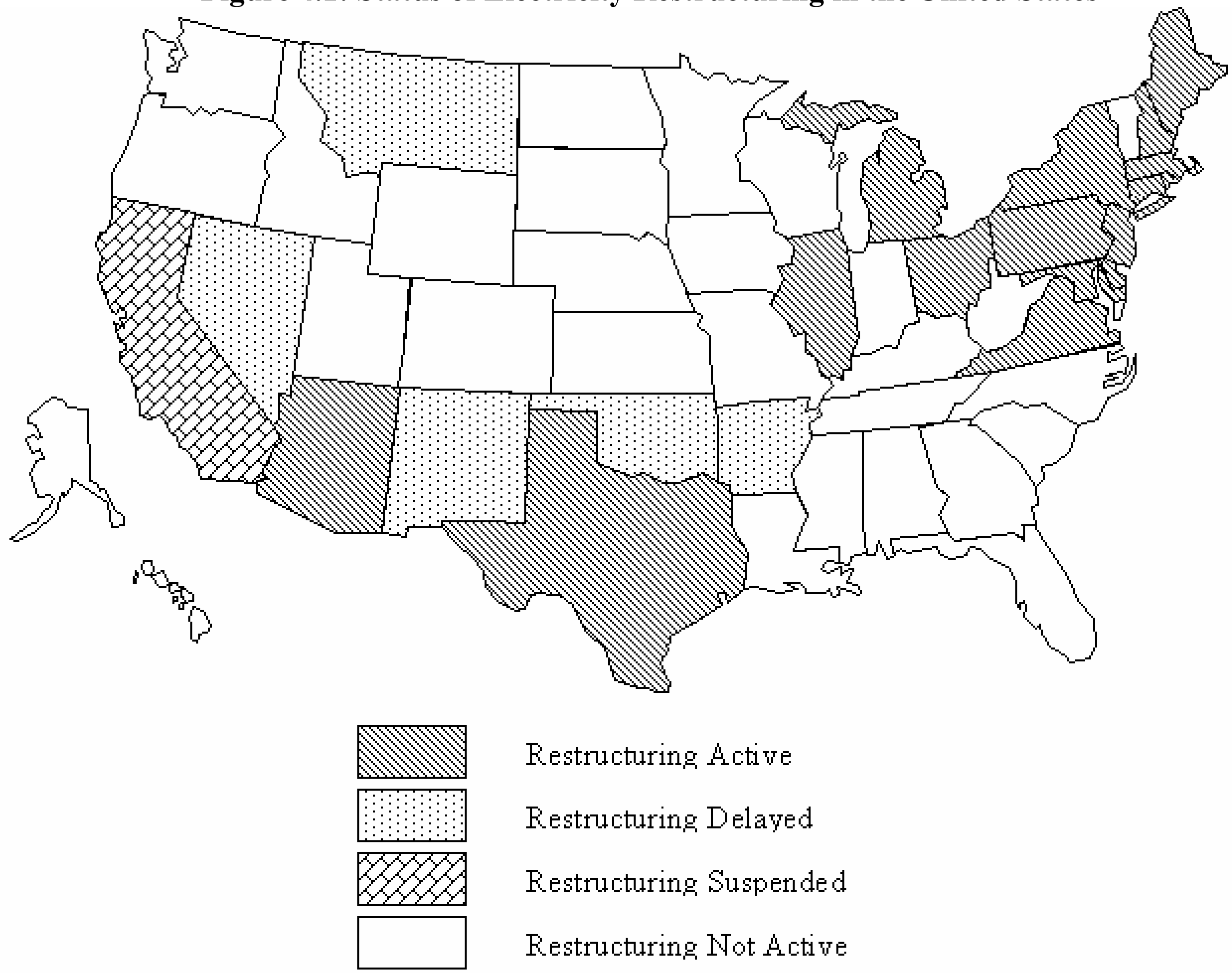
[46] United States Department of Energy Office of Electric Transmission and Distribution. "Grid 2030" — A National Vision for Electricity's Second 100 Years. July 2003.
[47] Edwards, pg 11.

desirable. If a traditional monopoly structure is maintained how best can potential problems of over-capitalisation and the lack of market signals for need for new investment best be overcome. A summary of electricity market restructuring in the U.S. and Canada is given in Figures 4.1 and 4.2 below.

Some of the main issues in electricity restructuring include:

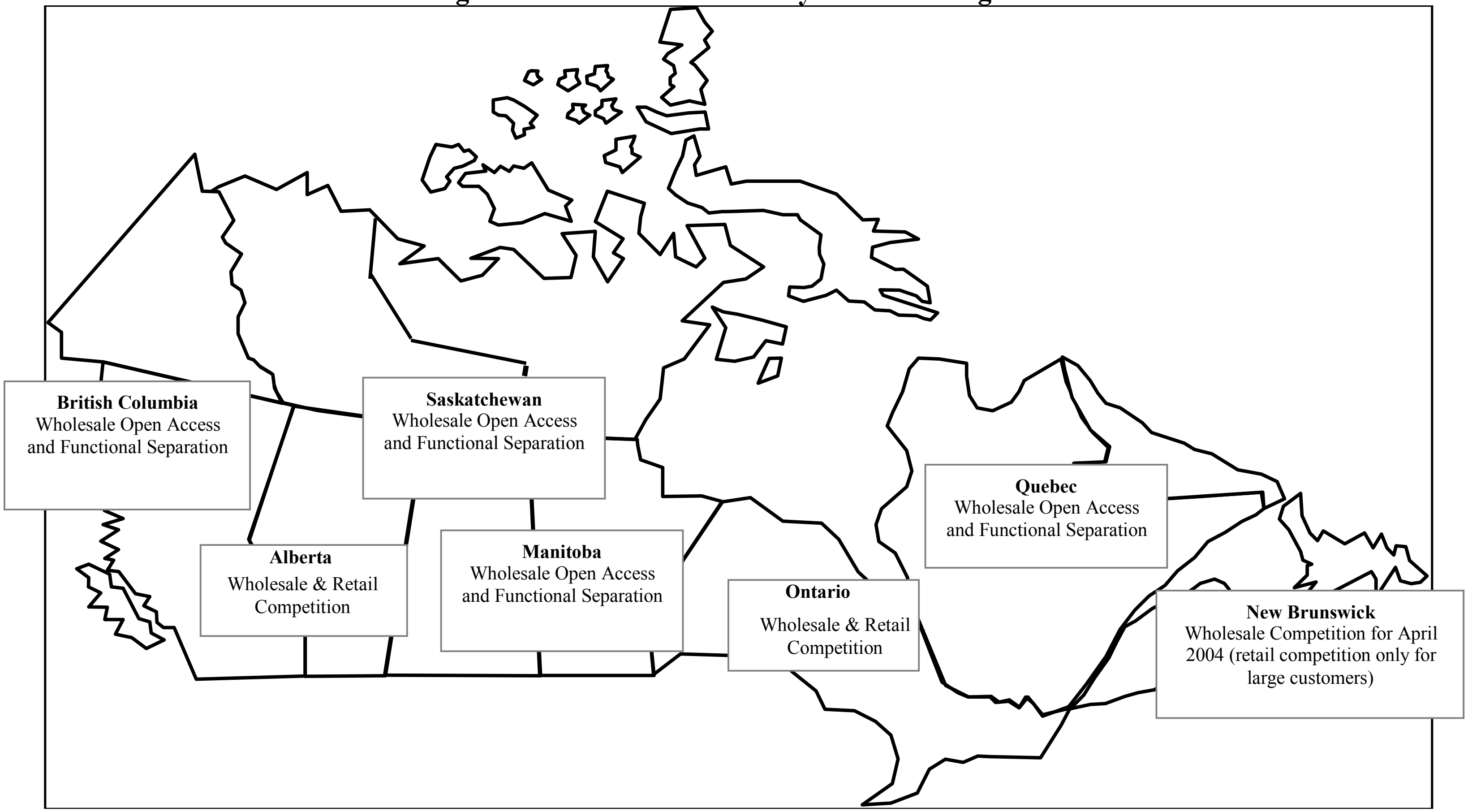
How to ensure *reliability* of the system is maintained?
Is *price volatility* a problem?
How to deal with abuses of *market power?*
Are there benefits from *full retail competition?*
Should restructuring markets adopt a *standard market design?*
What are the *options for markets not adopting a competitive wholesale market?*

Figure 4.1: Status of Electricity Restructuring in the United States



Source: EIA (http://www.eia.doe.gov/cneaf/electricity/chg_str/regmap.html).

Figure 4.2: Status of Electricity Restructuring in Canada



Source: Based on Canadian Electricity Association, http://www.canelect.ca/english/electricity_in_canada_structure_competition_1.html

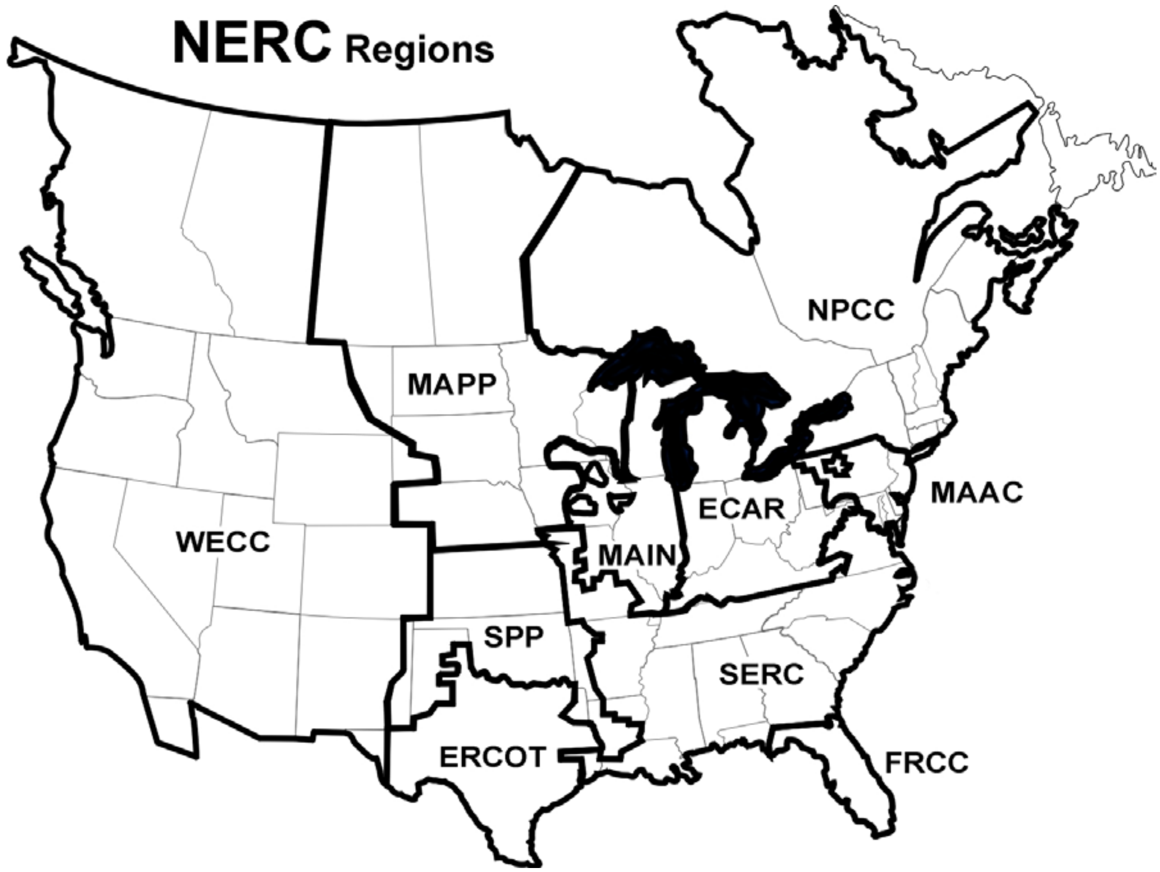
4.1. Reliability

Reliability is a critical characteristic of modern electric systems. System reliability issues came to the forefront on August 14, 2003 with a large blackout in Ontario and eight eastern U.S. states. While there is an obvious cost associated with the disruptions caused by blackouts, there is an equally obvious trade-off between investing in system reliability and the cost of electricity.

In Canada, the U.S. and a portion of Baja California, voluntary reliability standards are determined at the regional level by reliability councils.[48] In Figure 4.3 we show the North American regional reliability councils. The reliability councils can also be grouped into interconnected areas with WECC forming the Western Interconnection, ERCOT forming the ERCOT interconnection and the remaining councils forming the Eastern Interconnection. The ten reliability councils also form the membership of the North American Electricity Reliability Council (NERC). Under proposed legislation NERC may be granted mandatory powers for enforcing reliability standards.

[48] Outside NERC regions, between the U.S. and Mexico there are some problems in ensuring the compatibility between interconnections.

Figure 4.3 Reliability Council Regions



Source: http://www.nerc.com/regional/nercmapbw.jpg

System reliability issues came to the forefront on August 14, 2003 with a large blackout in Ontario and eight eastern U.S. states. While there is an obvious cost associated with the disruptions caused by blackouts, there is an equally obvious trade-off between investing in system reliability and the cost of electricity.

Reliability can be thought of in terms of two components, short-term *security* (the ability of the electric system to withstand unexpected events) and long-term *adequacy* (the ability of the electric system to meet expected demand). Security and adequacy can also be thought of as relating either to generating capacity or the transmission network.

Generation

In the move to competitive markets, typically private investors fund new generation. In nearly all markets there is concern over whether restructured markets provide adequate signals of when new generation may be needed. These concerns include:

- Does uncertainty over future regulation deter investment?
- Do price caps prevent prices from adequately reflecting scarcity?

Supply of new generating capacity is causing particular concern in Ontario. This is in part due to retirement of existing generation, as well as demand growth.

Transmission[49]

The North American electricity transmission system is comprised of about 204,000 miles of high voltage lines (158,000 miles located in the U.S.). Much of this system is now aging and a number of bottlenecks are causing problems for reliability and for increased electricity trade.

A major obstacle to new transmission in North America is obtaining planning and approval. Reasons for this include multiple layers of government review, public opposition to new lines and cross-jurisdictional issues (transmission lines may impact on more than one province or state. Transmission planning can also lead to environmental concerns over land use and the impact of electrical and magnetic fields. Careful transmission planning can also alleviate some problems of local air quality by allowing siting of new generation away from population centres or other sensitive areas.

Even in restructured markets transmission remains under monopoly provision. A key issue is to resolve how best new transmission be planned, regulated and funded. A related question is how should congestion on the transmission network be reflected in prices.

4.2. Price Volatility

Under the traditional regulated structure, prices for almost all customers were fixed for long periods of time. This situation provided some certainty for consumers but prices did not reflect scarcity (i.e., prices were not high when capacity was limited) and therefore did not encourage consumers to conserve. With the advent of competitive electricity markets the price of energy is able to reflects its scarcity (prices are high when capacity is in short supply, and low in situations of excess capacity). Such a situation encourages efficient use of energy (conservation) and also indicates whether new resources are needed (high prices can be seen as signal to investors that profitable opportunities exist).

However, there may also be concerns that high prices do not reflect genuine scarcity but are caused by problems in the market design (such as indicating an abuse of market power, see Section 4.3). Fluctuating and possible volatile prices, whatever the cause, may be inconsistent with customers and politicians expectations should they view electricity provision as a ‘right’. In some markets this has resulted in political intervention and great uncertainty over continued restructuring.

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[49] For further discussion on transmission issues in North America, see Gale, R.W. and O’Driscoll, M. (2001), *The Case for New Electricity Transmission and Siting New Transmission Lines,* Edison Electric Institute.

Some jurisdictions in Canada have enacted 'Heritage Contracts' in order to shield residents from variations in the wholesale price for electricity. Hydro Québec Production is currently mandated to supply 165 TWh annually to the Québec market through a heritage pool at a price of $0.0279/kWh (Hydro Québec Annual Report 2002). Beyond the 165 TWh, it is free to sell power to Hydro Québec Distribution or to other markets at competitive market prices. BC Hydro's Energy Implementation Plan (April 2003) proposed a new rate for residential customers (under a Heritage contract) and a stepped rate for industrial customers. A British Columbia Utilities Commissions (BCUC) report dated October 17, 2003 has supported both these proposals and also recommended the consideration of time of use rates for industrial customers.[50]

4.3. Market Power

In a deregulated market it may be possible for generators to exercise market power by physically withholding available capacity or raising the price at which capacity is made available. In order for this to be profitable a withholding generator must still have sufficient capacity in the market such that the profit forgone from withholding is outweighed by the increased profit of the remaining capacity.

Allegations of abuse of market power may be difficult to prove. The reason for this could be that it is difficult to identify market power spikes (market power may be easiest to exercise when capacity is tight) or the threat of ex-post investigation and action by regulatory authorities has been sufficient to dissuade abuse of market power. Suspicions of market power abuse and gaming in contributing to the Californian electricity crisis have led to The Federal Energy Regulatory Commission (FERC) investigations and 'show cause' orders (orders to submit specific information on actions during the crisis).[51] FERC's success in reaching settlements with some companies accused of gaming is seen by the FERC chairman 'as a warning to all energy companies that attempts to manipulate energy markets will have consequences'.[52]

It is also possible that available capacity may not be made available to the market for reasons other than an abuse of market power. Some generators plant may not be competitive at current market prices suggesting it be retired or mothballed until market conditions change. For other generators, the market design may not provide sufficient opportunity to offer into the market. For example, if prices an hour or day ahead are not forecast with a reasonable degree of accuracy, some generators may be unable to respond in timely manner even though they would have made power available at the market price.

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[50] British Columbia Hydro and Power Authority and an inquiry into a Heritage contract for British Columbia Hydro and Power Authority's Existing Generation Resources and Regarding Stepped Rates and Transmission Access. Report and Recommendations, October 17, 2003.

[51] Press Release June 25, 2003, *Commission issues sweeping show cause orders to companies alleged to have gamed western energy markets*; Hearings set to explain actions, address remedies

[52] Press Release October 2, 2003, FERC approves settlement with reliant in California cases; proceeds could total $50 million.

The scope for the abuse of market power is limited in many deregulated markets (including Alberta and Ontario) by the presence of a wholesale price cap (a level above which prices are not allowed to rise). However, the presence of a price cap may have adverse effects on other parts of the market (including incentives for the provision of new capacity). There may also be less intrusive ways of tackling market power (for example, divestiture of assets among many generators).

4.4. Full Retail Competition

Full Retail competition in electricity describes a further stage in the restructuring process.[53] Under such a system, all customers, from industrial to residential, can choose from whom they purchase electricity. The advantages of retail competition stem from increased customer choice. Customer choice may provide an incentive for distribution companies and retailers to offer a level of customer service better suited to customer needs. Increased customer choice between competing retailers is also the mechanism that may see that benefits of lower prices resulting from wholesale competition resulting in lower prices at the retail level. Consequently, the existence of a smooth functioning competitive wholesale market and transparent spot prices are preconditions for potential benefits of competition to retail customers. Retail competition is also as important in exposing all customers to price signals. If these price signals reflect the true cost of provision this would promote an efficient level of conservation, efficient demand response and provide efficient signals for new investment.

Retail competition among larger industrial users appears to have been relatively successful with large numbers of retailers and choice for customers. Retail competition for smaller users (including residential customers) has been much more problematic. In many jurisdictions, including Alberta, ‘switching’ (the number of customers leaving an incumbent supplier for a competitive supplier) has been very low.[54] This reflects the fact that for smaller users, the savings are not large and not obvious. Individuals have to understand the market fairly well and then be able to identify benefits in order to decide to switch. This is a pervasive problem in opening up the retail market, although there has been some success in a few jurisdictions.

4.5. Standard Market Design

Not all markets that have restructured have done so in a uniform way. This has created some problems for interconnected markets with different rules and disagreement about the best design. FERC has proposed a ‘Standard Market Design’ (SMD) to overcome

[53] Prior to the introduction of full retail competition, many markets have adopted an intermediate step of allowing competition in the supply of large industrial customers.

[54] Switching rates have been higher in other jurisdictions (such as Texas) where regulated rate options have been set with some ‘headroom’ to allow lower competitive offers to be attractive to customers. It is not clear whether such measures are sufficient to establish a vibrant competitive market.

some of these problems. They propose a SMD to provide 'rules and incentives for new investment, and to promote current stability and lower costs.[55]

SMD presents a framework for wholesale markets that is intended to address problems encountered in restructured markets (such as market power, capacity adequacy, how to manage and cost congestion of transmission networks and provide a level playing field for load, generators and technologies). Although, the proposal for SMD in the U.S. has not be enacted, regulatory moves towards standardisation also have important implications for the structure of markets in Canada (and to lesser extent Mexico).

4.6. Other Issues

Other issues faced by the electricity industry include:

- The extent to which increased energy efficiency and demand-side response represents an economic alternative to new generation capacity.
- Given high natural gas prices and concern over emissions, what will be the 'fuel of choice' in constructing new electric generation?
- Even in restructured markets transmission remains under monopoly provision. How best should transmission be planned, regulated and funded?

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[55] FERC, *SMD Questions and Answers*, assessed at http://www.ferc.gov/industries/electric/indus-act/smd/nopr/q-a.pdf on March 17, 2004.

5. Energy Efficiency

The energy crisis of the 1970s triggered policy initiatives that included energy conservation and alternate energy sources. Legislation in the U.S. supported research and development, training and subsidies for qualified facilities, such as small power plants that use renewables.[56] However, the main response at that time was to enhance options to supply the needed energy.

Conservation and energy efficiency is once again gaining prominence. This time the catalysts include higher and more volatile energy prices, constraints on new supply and large infrastructure bottlenecks that cause electricity blackouts such as those in Californian in 2001 and the summer of 2003 in Ontario and mid-western U.S.. Moreover, an increasing concern with environmental integrity has provided support for the demand-side approach.

It is possible to distinguish, conservation and efficiency as:

- **Conservation:** is a demand response to address energy shortages by altering normal activities. However, institutional, economic, and social barriers may delay or inhibit the realisation of the energy saving potential from conservation[57]; and

- **Energy efficiency**: can be defined as continuing normal activity and relying on technology to increase efficiency thereby reducing demand while producing the same output (e.g., efficient lighting).

In the above definition, energy efficiency refers to technical efficiency. It is also commonly used interchangeably with conservation to more broadly refer to all changes that result in decreasing the amount of energy used to produce one unit of economic activity including technological, behavioural and economic changes. For the purpose of this report, we use the term 'energy efficiency' to broadly refer to efficiency and conservation issues.

5.1. Investing in Energy Efficiency

The impacts of energy efficient improvements on demand are based on several assumptions regarding equipment costs, rate of market penetration, consumer uptake and potential policy measures. Reducing energy consumption or choosing energy efficient equipment that reduces the cost of energy contributes to the competitiveness of companies, the strength of the economy and benefits the environment. *Investment*, *market structure* and *environmental policies* influence the role of energy efficiency.

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[56] For example the 1976 Public Utility Regulatory Policy Act (PURPA).

[57] Conservation is also commonly used in discussions of supply, for example, ensuring optimal recovery from hydrocarbon reservoirs. However, in this study, we refer mainly to demand-side applications.

- The benefits improvements in energy efficiency can bring to the environment and the economy are difficult to measure. Benefits from efficiency must be quantified to determine how much is available and at what cost from competing schemes (and also in comparison with increasing supply). Consequently the evaluation of energy efficiency programs still remains an issue. While the process of assessing the cost effectiveness of an energy efficiency improvement is a standard exercise in project evaluation, the difficulties in measuring the benefits of improved efficiency complicate the analysis.

5.2. Electricity: Energy Efficiency and Demand-side Management

In many electricity markets requirements for generation and transmission are determined by peak demands. If consumers can be persuaded to consume less during peak times some generation and transmission investments may not be required. Mechanisms to do this are sometimes described as demand-side or demand response mechanisms.

Early demand-side programs tended to focus on energy efficiency (including information programs, rebates and installation of energy efficient devices) and incentives for off-peak usage (time of use rates) or lower rates with interruptible supply. The perceived success of demand-side programs in the 1990s was mixed, at least partially due to the difficulty in verifying the cost and benefits associated with particular programs. A major barrier to achieving greater demand response has been the limited exposure many customers have to prices that vary over time and thus prices that are able to reflect the scarcity of supply.

More recent attention on the demand–side in electricity has focussed on real time pricing and demand-side bidding. In some markets these have been successfully employed for larger customers. Other options include direct control programs, whereby equipment such as air conditioners can be switched off (or cycled) during times of peak demand. Some regulatory issues remain to be resolved in the deployment of new metering, monitoring and control technologies.

The potential benefits of energy efficiency programs in electricity may be quite large. Estimates by the American Council for an Energy Efficient Economy (ACEEE) indicate energy efficiency savings in the U.S. 'could negate about 40 percent of the growth in peak demand predicted over the next decade.'[58]

5.3. Role of Energy Efficiency in Meeting Environmental Targets

Increasing energy efficiency has the potential to reduce energy shortages, lowers reliance on energy imports, mitigate the impact of high energy prices, reduces pollution, leads to investment in new technologies and lowers energy intensity. The combination of these effects may also be beneficial to general economic performance. Energy efficiency can

[58] Nadel, S., Gordon, F. and Neme, C., (2000) *Using targeted energy efficiency programs to reduce peak electrical demand and address electric system reliability problems*.

weaken the link between economic growth and energy demand, delaying the need for new capacity. Conservation also has a role to play in providing a near-term solution to the supply-demand imbalance, dampening prices and the impact of the supply shortfall.

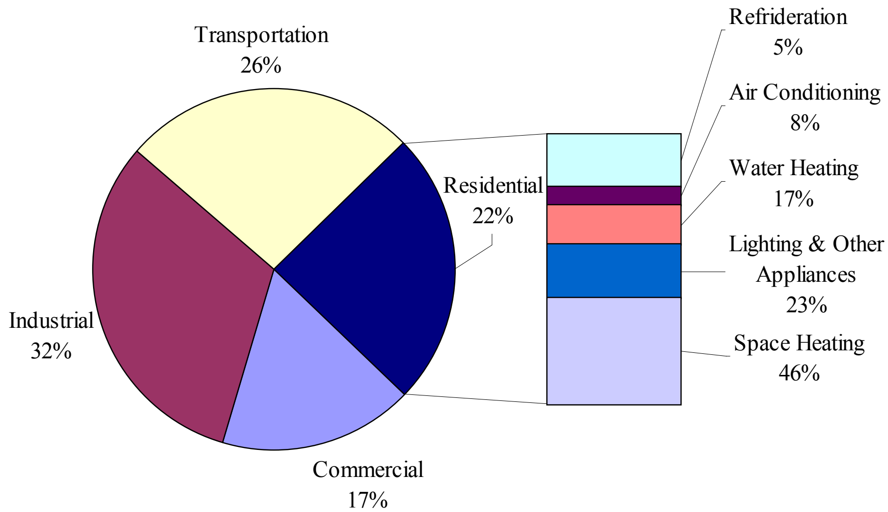
Although energy efficiency and conservation are perceived as essential elements in environmental and energy policy goals there is wide discrepancy on what the targets should be and how to achieve them. In the 1970s energy policies were aimed at providing sufficient energy for economic growth and ensuring energy security. In the 1980s and 1990s partly driven by cross boundary issues relating to acid rain and climate change issues, energy policies began to consider energy efficiency as a means of both meeting energy needs and addressing global environmental concerns. The dual role of energy policy has made both implementation and measurement more complex.

To achieve the existing emission targets set out in agreements such as Kyoto, energy policies in North America are addressing the efficiency with which fuels and electricity are used. This is clearly outlined in the Bush Administration's U.S. energy policy. Policy measures targeting the supply side in the U.S. consist of technology development programs and fiscal measures such as emission taxes. Policies targeted at demand-side energy efficiency include energy performance standards, technology procurement programs, and utility demand-side management (DSM).

5.3.1. Efficient Energy Use in the Home

The residential sector is a major contributor to North America's energy consumption.
In 2003, the residential sector accounted for over 21 percent of energy consumed. As illustrated by Figure 5.1, the majority of energy consumed was for space heating.

Figure 5.1: U.S. 2001 Energy Consumption per Sector



Source: EIA.[59]

Individuals and families produce 23 percent of Canada's GHG emissions just from day-to-day activities. Consequently, improving the efficiency with which energy is used in homes could make a significant contribution to achieving current energy policy goals.

Standards and labels have proven successful policy tools for increasing the end-use efficiency by accelerating the infiltration of energy-efficient technology into the marketplace. Standards function to drive manufactures to produce more efficient models. Labels function to educate the consumers as to the benefits of purchasing energy efficient models.

An example of a successful labeling program is the 'Energy Star' labeling program in the U.S., Canada, and under consideration in Mexico. The Energy Star label identifies for purchasers energy-using products that meet specified efficiency criteria (>10 percent above the minimum standard). The label also provides a basis for publicity campaigns, supports purchasing programs, and helps markets energy efficient models.

Even when choices of energy efficient products and economically justifiable (the increased initial cost is outweighed by the reduction in the cost of energy consumption) consumers may unwilling or unable to make the required investment. Uncertainty of future energy prices may make the benefits of energy efficient products difficult to estimate. Budget constraints may also lead to a preference for products with a low initial

[59] EIA: http://www.eia.doe.gov/emeu/aer/pdf/pages/sec2_4.pdf

cost. Other consumers may make decisions over relatively short time horizons (1 to 2 years)[60].

Improvements in the energy efficiency of appliances usually occur in combination with increased numbers and/or larger appliances. For example, the number of refrigerators per Canadian household has increased 4 percent since 1990 and the average size from 15.6 to 17.0 cubic feet.[61] Such offsetting effects complicate the measurement of potential benefits of energy efficiency programs.

Other common residential programs include:

- **Education/information –** improved information for customers on reducing consumption. This could also take the form of an energy audit; and

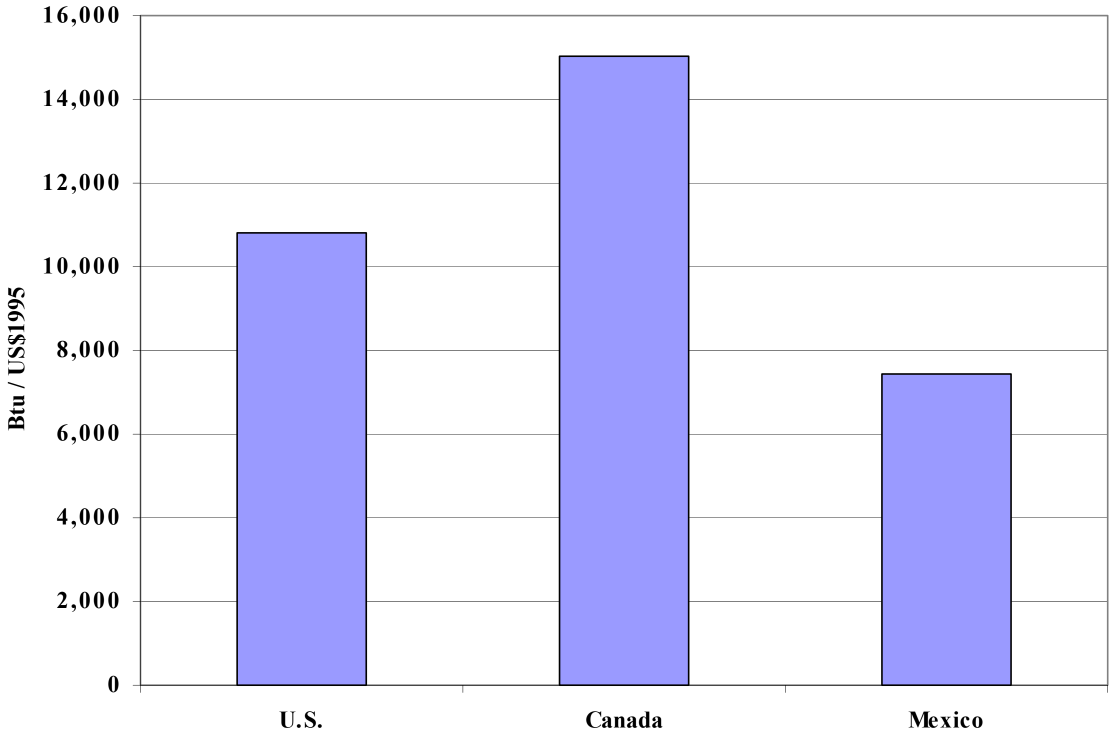
- **Grants/ rebates to encourage efficient energy use –** for example, providing a subsidy for additional insulation, the replacement of aging gas furnaces, or for domestic generation (e.g., solar panels for water heating)

5.3.2. Efficient Energy use in Industry

One method of measuring energy efficiency is via energy intensity. Energy intensity can be defined as the amount of energy it takes to produce a dollar of gross domestic product. Canada has the highest energy intensity of the three countries as shown in Figure 5.2. The high Canadian energy intensity is related to the development of Canada's rich resource base. If Canada is going to achieve sustainability a balance must be obtained between economic growth and environmental concerns. For the last several years North America's energy intensity has been slowly declining which is a trend expected to continue through 2025.[62] The majority of the decline in energy intensity is attributable to energy efficiency improvements and the remainder is due to structural changes and fuel switching.

[60] In some cases this is rational. For example, a high efficiency furnace that requires 5 years to recover its increased capital cost through operating savings might not be chosen by a family considering moving in the next year or two. In other cases, the choice simply reflects incomplete understanding of the benefit-cost relationships involved.
[61] Energy Efficiency Trends in Canada, 1990 to 2001, June 2003, Natural Resources Canada. p.11.
[62] EIA Annual Outlook 2004.

Figure 5.2: North American Energy Intensity 2001



Source: EIA[63]

Natural Resources Canada has invested millions in the promotion of energy efficiency and renewable energy programs to help address climate change. The majority is invested in energy efficiency programs (leadership, information, voluntary actions, regulation, and research and development). In 1991, NRCan initiated a comprehensive Efficiency and Alternative Energy Program that targeting residential, commercial, industrial, and transportation end-use sectors. Some initiatives include:

- Development of a comprehensive combustion and environmental emissions research facility in Ottawa;
- Development of standards under the Energy Efficiency Act;
- The C-2000 Program for commercial buildings supports state-of-the-art building construction. The first building completed under this program uses 50 per cent less operating energy and 28 per cent less water than a conventional building.
- The Federal Buildings Initiative (FBI) and Energy Innovators Initiative (EII) provide organizations with a full package of products and services to help plan, finance, and implement comprehensive energy-efficiency improvements. The package includes how-to guides, technical fact sheets, a list of qualified energy service companies, and project financing options;

[63] EIA Country Briefs for Canada (January 2004) and Mexico (March 2004).

- NRCan and the National Research Council developed Canada's first comprehensive energy efficiency codes, the Model National Energy Code for Buildings and Houses, to establish acceptable levels of energy efficiency.

One of the most successful programs at achieving energy efficiency in Canadian Industry is The Canadian Industry Program for Energy Conservation (CIPEC). CIPEC is a government-industry partnership that provides services to help Canada's industrial sectors develop energy efficiency goals and action plans. CIPEC is a network of 43 trade associations that represent more than 5000 companies and more than 95 percent of secondary industrial energy demand in Canada. General Motors Canada Limited (GMCL) is just example of how CIPEC is working with industry to improve energy efficiency. Over the last ten years GMCL has reduced its company-wide GHG emissions by 37 percent since 1990, in the process reducing its energy use by 479 million kWh.

5.3.3. Efficient Energy use in the Transportation Sector

The internal combustion engine (ICE) with its reliance on petroleum-based fuels is expected to maintain its domination in the transportation sector. Continuing advancements in ICE design coupled with on-board engine management systems are expected to result in some improvements fuel efficiency and emissions control.

The possibility of more widespread use of gasoline-electric and diesel-electric hybrid vehicles could yield a 15 to 20 percent reduction in liquid fuel consumption. Although hybrid vehicles have been in the personal-use markets in North America for more than 3 years, sales have been slow. Barriers to increasing sales include perception of lower performance (excepting fuel efficiency and emissions) and the higher initial price. However, more automobile manufacturers including the 'Big-Three' in North America (GM, Ford and Daimler-Chrysler) have announced plans to introduce hybrid vehicles.

Battery-powered electric vehicles (EVs) offer the possibility of quiet and pollution-free operation. They are also currently the only vehicles to meet California's Zero Emission Vehicle requirement. However, there may be emissions "upstream" depending on the fuel that is used to generate electricity. EVs continue to face issues with respect to range and re-charging convenience. Although recent advances in battery and electric motor technologies have made EVs more practical, they are not expected to be a major player unless significant improvements are made to battery technologies that provide higher energy densities at lower costs.

Fuel cell vehicles (FCVs) have the potential to revolutionise on-road transportation but are not expected to reach the mass market until late in the next decade. While EVs use electricity from an external source (and store it in a battery), FCVs create their own electricity. On-board fuel cells create electricity through a chemical process using hydrogen fuel and oxygen from the air. FCVs can be fueled with pure hydrogen stored onboard in high-pressure tanks, or they can be fueled with hydrogen-rich fuels, such as methanol, natural gas, or even gasoline; but these fuels must first be converted into hydrogen gas by onboard reforming.

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APPENDIX A: Acronyms

Acronyms

ACEEE	American Counscil for an Energy Efficient Economy
AGA	American Gas Association
Bcf	Billion cubic feet
BCUC	British Columbia Utilities Commission
Btu	British Thermal Unit
CBM	Coalbed Methane
CGA	Canadian Gas Association
CIPEC	The Canadian Industry Program for Energy Conservation
CSS	Cyclic Steam Stimulation
CERI	Canadian Energy Research Institute
DSM	Demand-side Management
ECAR	East Central Area Reliability Coordination Agreement
EIA	Energy Information Agency
EOR	Enhanced Oil Recovery
ERCOT	Electric Reliability Council of Texas
EUB	Energy and Utilities Board
EV	Electric Vehicles
FCV	Fuel Cell Vehicles
FERC	Federal Energy Regulatory Commission
FRCC	Florida Reliability Coordinating Council
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GJ	Gigajoule
GMCL	General Motors Canada Limited
GRI	Gas Research Institute
ICE	Internal Combustion Engine
IEA	International Energy Agency
IGCC	Integrated Combined Cycle
IPP	Independent Power Producer
kWH	Kilowatt Hour
LDC	Local Distribution Company
LNG	Liquefied Natural Gas
MAAC	Mid-Atlantic Area Council
MAIN	Mid-America Interconnected Network
MAPP	Mid-continent Area Power Pool
MCE	Maximum Cash Exposure
NAFTA	North America Free Trade Agreement
NEB	National Energy Board
NEP	National Energy Program
NERC	North American Electric Reliability Council
NGPA	Natural Gas Policy Act of 1978

NYMEX	New York Mercantile Exchange.
NPC	National Petroleum Council
NPCC	Northeast Power Coordinating Council
NRCAN	Natural Resources Canada
NUG	Non-Utility Generators
NGV	Natural Gas Vehicles
NPV	Net Present Value
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
OPG	Ontario Power Generation
PADD	Petroleum Administration for Defense Districts
PUC	Public Utility Commission
ROR	Rate of Return
SAGD	Steam Assisted Gravity Drainage
SERC	Southeastern Electric Reliability Council
SMD	Standard Market Design
SPP	Southwest Power Pool
Tcf	Trillion cubic feet
THAI	Toe-to-Heel Air Injection
TWH	Terawatthours
U.S.	United States of America
VAPEX	Vapor Extraction
WCSB	Western Canada Sedimentary Basin
WECC	Western Electricity Coordinating Council
WTI	West Texas Intermediate

APPENDIX B: Glossary of Key Terms

AECL - Atomic Energy of Canada Limited: A nuclear technology and engineering company that designs and develops the CANDU nuclear power reactor, as well as other advanced energy products and services.

Anthracite: A hard, black lustrous coal, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of volatile matter.

API: An American Petroleum Institute measure of specific gravity

Ash: Impurities consisting of silica, iron, alumina, and other non-combustible matter that are contained in coal. Ash increases the weight of coal, adds to the cost of handling, affects the burning characteristics of the coal , and lowers its calorific value. The disposal of ash from coal-fired generating plants after combustion is costly.

Baseload Capacity: The generating equipment normally operated to serve electricity demand on an around-the-clock basis.

Baseload Plant (or Unit): A generating plant or unit that is normally operated to take all or part of the minimum load of a power system, and which, consequently produces electricity at an essentially constant rate and runs continuously.

Baseload: The minimum amount of electric power delivered or required at a steady rate over a given period of time.

Bituminous Coal: The most common coal. It is dense and black (often with well-defined bands of bright and dull material). Its moisture content usually is less than 20 percent.

Bitumen: Petroleum that exists in the semisolid or solid phase in natural deposits – it is the molasses-like substance which can compromise anywhere from 1 to 18 percent of the oil sand

Boiler: A device for generating steam for power, processing or heating purposes, or for producing hot water for heating purposes or hot water supply. Heat from an external combustion source is transmitted to a fluid contained within the tubes in the boiler shell. This fluid is delivered to an end-use at a desired pressure, temperature and quality.

British Thermal Unit: The standard unit of energy used in the United States. It equals 0.9478 kilojoules.

Calorific Value (Heat Content): The sum of latent heat and sensible heat contained in a combustible substance, above the heat contained at a specified temperature and pressure; expressed as Joules per unit of volume or weight.

CANDU: Canadian Deuterium Uranium Reactor. A standardized design for nuclear generating stations developed in Canada. All nuclear generating units in Canada use the CANDU design.

Capability: The maximum load, in kilowatts or megawatts, that a generating unit, generating plant, or other electrical equipment can carry under specified conditions for a given period of time without exceeding approved limits of temperature and stress.

Capacity Factor: The ratio of the electrical energy produced by a generating unit for a given period of time to the electrical energy that could have been produced at continuous full-power operation during the same period.

Capacity: The maximum power capability of a generating unit in kilowatts or megawatts.

Capital Expenditures: The amount of capital used during a particular period to acquire or improve long-term assets such as a generating unit or plant or piece of equipment.

Carrying Costs: Allowance for funds used during construction (AFUDC) of a generating unit or plant. These are incurred from the time of investment begins to the time the unit or plant goes into commercial operation.

Coal: A black or brownish-black solid combustible substance formed by the partial decomposition of vegetable matter without access to air. The rank of coal, which includes anthracite, bituminous coal, sub-bituminous coal and lignite, is based on fixed carbon, volatile matter and calorific value.

Coalbed methane: Methane is generated during coal formation and is contained in the coal microstructure. Typical recovery entails pumping water out of the coal to allow the gas to escape. Methane is the principal component of natural gas. Coalbed methane can be added to natural gas pipelines without any special treatment.

Cogeneration: The simultaneous generation of electricity and another form of useful thermal energy (e.g. heat or steam) from a single energy source (e.g. natural gas, biomass) used for industrial, commercial, heating or cooling purposes.

Coking: A process used to break down heavy oil molecules into lighter ones by removing the carbon that remains as a coke residue

Combined Cycle Block: A set electricity generating equipment that consists of one or more gas (combustion) turbines producing electricity and a heat recovery steam generator HRSG (or boiler), feeding a steam turbine-generator producing additional electricity. A portion of the required energy input to the HRSG is provided by the heat of the exhaust gas from the gas turbine(s).

Construction Period: The time, usually expressed in years, required to build a long-term asset such as an electricity generating unit or plant. It is also the period over which carrying costs (or AFUDC) are incurred.

Conventional Crude Oil: Petroleum found in liquid form, flowing naturally or capable of being pumped without further processing or dilution

Conventional Generation: Electricity that is produced at a generating unit or plant where the prime movers are driven by a contained nuclear reaction or by the gases or steam produced by burning fossil fuels.

Conservation: Steps taken to cause less energy to be used than would otherwise be the case. These steps may involve improved efficiency, avoidance of waste, reduced consumption, etc. They may involve installing equipment (such as a computer to ensure efficient energy use), modifying equipment (such as making a boiler more efficient), adding insulation, changing behavior patterns, etc.

Cost of Debt: The interest rate associated with borrowing money for investment.

Cost of Spent Fuel Storage and/or Disposal: The cost of storing and/or disposing of nuclear fuel that has been used in a nuclear reactor to the point where it can no longer produce economic power.

Cost: The amount paid to acquire resources, such as plant and equipment, fuel, and labour and other services.

Cost of Capital: The rate of return that a firm could earn from investments, other than a generating facility in question, with equivalent risks. It can also can be stated as the *opportunity cost* of the funds used due to the investment decision.

Crude Oil: A mixture of hydrocarbons that exists in liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Depending upon the characteristics of the crude stream, it may also include:

- Small amounts of hydrocarbons that exist in gaseous phase in natural underground reservoirs but are liquid at atmospheric pressure after being recovered from oil well (casinghead) gas in lease separators and are subsequently commingled with the crude stream without being separately measured. Lease condensate recovered as a liquid from natural gas wells in lease or field separation facilities and later mixed into the crude stream is also included;

- Small amounts of nonhydrocarbons produced with the oil, such as sulfur and various metals;

- Drip gases, and liquid hydrocarbons produced from tar sands, gilsonite, and oil shale.

- Liquids produced at natural gas processing plants are excluded. Crude oil is refined to produce a wide array of petroleum products, including heating oils; gasoline, diesel and jet fuels; lubricants; asphalt; ethane, propane, and butane; and many other products used for their energy or chemical content.

Debt/Equity Ratio: A measure of the risk of the firm's capital structure in terms of amounts of debt contributed by creditors and the amount of equity contributed by owners (shareholders). It expresses the protection provided by owners to the creditors. A low debt/equity ratio implies an ability to borrow. While using debt implies risk (required interest payments must be paid), it also offers the potential for increased returns to the firm's owners. When debt is used successfully (operating earnings exceed interest charges), the returns to shareholders are magnified through financial leverage.

Decommissioning Cost: The cost of the retirement of a nuclear unit or plant, including decontamination and/or dismantlement.

Decommissioning: The act of taking a generating unit or plant out of service permanently. In the case of a nuclear plant this includes safely closing, and possibly dismantling (or otherwise disposing of), the existing facilities at the end of their service life.

Deep Panuke Field: is a gas field that is trapped over carbonate reef south-east of Halifax, Nova Scotia. The field is anticipated to be online by 2005.

Demand-side Management (DSM): The planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand. It refers to only energy and load-shape modifying activities that are undertaken in response to utility-administered programs. It does not refer to energy and load-shaped changes arising from the normal operation of the marketplace or from government-mandated energy-efficiency standards. Demand-Side Management covers the complete range of load-shape objectives, including strategic conservation and load management, as well as strategic load growth.

Density: The heaviness of crude oil, indicating the proportion of large, carbon-rich molecules, generally measured in kilograms per cubic metre (kg/m3) or degrees on the American Petroleum Institute (API) gravity scale; in Western Canada oil up to 900kg/m3 is considered light to medium crude – oil above this density is deemed as heavy oil or bitumen

Depreciation or Amortization: The depreciation, depletion or charge-off to expense of intangible and tangible assets over a period of time.

Discounted Cash Flow: A calculation of the present value of a projected annual cash flow based on an assumed annual discounting rate, or rate of interest.

Economic Life: The time period of commercial operation of an asset that is assumed for the purpose of economic and/or financial evaluation of the asset.

Efficiency: The efficiency of a generating unit in converting the thermal energy contained in a fuel source to electrical energy. It is expressed as a percentage and equals 3.6 divided by the heat rate of the unit (in GJ/MWh).

Electrical Energy: The quantity of electricity produced over a period of time. The commonly used units of electrical energy are the kilowatt-hour (kWh), megawatt-hour (MWh) and gigawatt-hour (GWh).

Electric vehicle: A motor vehicle powered by an electric motor that draws current from rechargeable storage batteries, fuel cells, photovoltaic arrays, or other sources of electric current.

Electrical Power: The rate of delivery of electrical energy and the most frequently used measure of capacity. The typical basic units of electrical power are the kilowatt (kW) and megawatt (MW).

Emission Cap: An upper limit placed on the emissions (usually airborne) from a polluting facility or from a group of such all facilities within a defined region.

Emissions: Anthropogenic releases of gases to the atmosphere. In the context of global climate change, they consist of radiatively important greenhouse gases (e.g., the release of carbon dioxide during fuel combustion).

Emissions Cost: The cost associated with the release or discharge of a substance into the environment; generally refers to the cost associated with the release of gases or particulates into the air.

End User: A firm or individual that purchases products for its own consumption and not for resale (i.e., an ultimate consumer).

Energy: The capability for doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks.

Energy Consumption: The amount of energy consumed in the form in which it is acquired by the user. The term excludes electrical generation and distribution losses.

Energy Demand: The requirement for energy as an input to provide products and/or services.

Energy Efficiency: Refers to reducing the energy used by specific end-use devices and systems, typically without affecting the services provided. Examples include high-efficiency appliances, efficient lighting programs, high-efficiency heating, ventilating and air conditioning (HVAC) systems or control modifications, efficient building design, advanced electric motor drives, and heat recovery systems.

Energy Intensity: The amount of energy it takes to produce a dollar of gross domestic product.

Equity: The sum of capital from a firm's retained earnings and the issuance of stocks.

Extraction: The process of separating the bitumen from the oil sands

Expenditure: The incurrence of a liability to obtain an asset or service.

External Costs: Costs that individuals, firms and society as a whole bear, that are not paid or compensated for directly in monetary terms, are said to be external costs.

External Benefits: Benefits that individuals, firms and society as a whole acquire, that they do not pay for directly in monetary terms, are said to be external benefits.

Externalities: Benefits or costs generated as a by-product of an economic activity, that do not accrue to the parties directly involved in the activity. Environmental externalities are benefits or costs that manifest themselves through changes in the physical or biological environment.

Facility: An existing or planned location or site at which prime movers, electric generators, and/or equipment for converting mechanical, chemical, and/or nuclear energy into electric energy are, or will be, situated. A facility may contain generating units of either the same or different prime mover types.

Fixed Operating Cost: The fixed portion of the cost associated with the annual operation and maintenance of a generating unit or plant. It is independent of the electrical energy produced. It is expressed in dollars per kilowatt per annum ($/kW.a).

Flue Gas: Gas resulting from the combustion of fuel, the calorific value of which has been substantially spent and discarded to the flue.

Flue Gas Desulphurization Unit (Scrubber): Equipment used to remove sulphur oxides from the combustion gases of a boiler plant before discharge to the atmosphere. Chemicals (e.g., lime) are used as the scrubbing media.

Flue Gas Particulate Collectors: Equipment used to remove fly ash from the combustion gases of a boiler plant before discharge to the atmosphere. Particulate collectors include electrostatic precipitators, fabric filters (baghouses), mechanical collectors (cyclones) and wet scrubbers.

Fly Ash: Particle matter remaining after the combustion of coal, in which the particle diameter is less than 1×10^{-4} metre. It is substantially removed from the flue gas using particulate collectors such as electrostatic precipitators and fabric filters.

Forced Outage: The shutdown of a generating unit for emergency reasons, or a condition in which a generating unit is unavailable to supply electrical load due to unanticipated breakdown.

Fossil Fuel: Any naturally occurring organic fuel, such as coal, oil and natural gas.

Fossil-fuel Unit: A generating unit using coal, oil, gas or another fossil fuel as its source of energy.

Fuel cell: A device capable of generating an electrical current by converting the chemical energy of a fuel (e.g., hydrogen) directly into electrical energy. Fuel cells differ from conventional electrical cells in that the active materials such as fuel and oxygen are not contained within the cell but are supplied from outside. It does not contain an intermediate heat cycle, as do most other electrical generation techniques.

Fuel Cost: That portion of the total variable cost of operating a generating plant or unit that is associated with the purchase and delivery of fuel used in the production of steam or driving another prime mover for the generation of electricity. It is usually expressed in dollars per megawatt-hour ($/MWh).

Fuel Price: It is the price of fuel used in a generating unit, at the point of purchase. It is expressed here in dollars per gigajoule ($/GJ). In some cases, it is derived from the price of fuel expressed in dollars per unit of weight or volume (e.g. $/tonne of coal) and the corresponding calorific value (e.g. GJ/tonne).

Fuel: Any substance that can be burned to produce heat. It is also a material that can be fissioned in a nuclear reaction to produce heat.

Fuel Switching: the substitution of one type of fuel for another, especially the use of a more environmentally friendly fuel as a source of energy in place of a less environmentally friendly one

Gas (or Combustion) Turbine: A generating unit in which the prime mover is a gas turbine. A gas turbine consists typically of an axial-flow air compressor, one or more combustion chambers, where liquid or gaseous fuel is burned and the hot gases are passed to a turbine where the hot gases expand to drive a generator to produce electricity.

Gas Oil : The higher boiling point component of crude oil

Generating Unit: Any combination of physically connected reactor(s), boiler(s), combustion turbine(s) or other prime mover(s), generator(s) and auxiliary equipment operated together to produce electricity.

Generating Plant: A facility containing one or more generating units.

Generation: The process of producing electrical energy by transforming other forms of energy.

Generation Mix: Term for the diversity of generating units used to produce electricity. For example, a region's generation mix might include 35 percent hydroelectricity, 35 percent nuclear and 30 percent coal-fired energy.

Generator: A machine that converts mechanical energy into electrical energy.

Gigajoule (GJ): One billion Joules.

Gigawatt (GW): One billion Watts.

Gigawatt-hour (GWh): One billion watt-hours.

Global Warming: The theoretical escalation of global temperatures caused by the increase of greenhouse gas concentrations in the lower atmosphere.

Greenhouse Effect: The increasing mean global surface temperature of the earth caused by gases in the atmosphere (including carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbon). The greenhouse effect allows solar radiation to penetrate but absorbs the infrared radiation returning to space.

Greenhouse Gases: A collection of gaseous substances, primarily consisting of carbon dioxide, methane and nitrogen oxides which have been shown to warm the earth's atmosphere by trapping solar radiation. Greenhouse gases also include chlorofluorocarbons (CFCs), a group of chemicals used primarily in cooling systems and which are now either outlawed or severely restricted by most industrialized nations.

Gross Domestic Product (GDP): Total economic output in a given country.

Gross Generation: The electrical energy production a generating plant or unit before subtracting station service, expressed in megawatt-hours (MWh) or gigawatt-hours (GWh).

Grid: The layout of an electrical transmission and/or distribution system.

Gypsum: A mineral used as a soil amendment in consolidated tails technology

Heat Content: (see Calorific Value).

Heat Rate: A measure of the efficiency of energy conversion of a generating unit or plant. It is the ratio of the heat content of the fuel used (expressed in kJ or Btu) in the unit or plant per kWh of net electrical energy produced.

Heavy Oil: Dense, viscous oil, with a high proportion of bitumen, which is difficult to extract with conventional techniques and is more costly to refine.

Hibernia: The Hibernia field, which was discovered in 1979, is located (pdf - 265kb) about 315 kilometres east southeast of St. John's, Newfoundland in 80 metres of water. A fixed production platform, consisting of a Gravity Base Structure (GBS) and Topsides drilling and production facilities, has been installed to produce the field.

Hydrocarbons: A large class of liquid, solid or gaseous organic compounds, containing only carbon and hydrogen, which are the basis of almost all petroleum products

Hydroelectric Power: Electricity produced by falling water that turns a turbine generator. Also referred to as HYDRO.

Hydrogen: A colorless, odorless, highly flammable gaseous element. It is the lightest of all gases and the most abundant element in the universe, occurring chiefly in combination with oxygen in water and also in acids, bases, alcohols, petroleum, and other hydrocarbons.

Hydrotransport: Oil sand from the mine operation is mixed with hot water and caustic and the oil sand slurry is then transported by pipeline to the extraction plant where it feeds directly into the Primary Separation Vessel

Hydrophilic: Describes a substance that attracts, dissolves in, or absorbs water.

Income Tax Rate: A government levy on individuals as personal income tax and on the earnings of corporations as corporate income tax.

Inflation Rate: The annual rate at which the general level of prices for goods and services rises.

In situ: In its original place; in position; in situ recovery refers to various methods used to recover deeply buried bitumen deposits, including steam injection, solvent injection and firefloods

Installed Capacity: The capacity measured at the output terminals of all the generating units in a plant, before deducting power requirements for station service.

Integrated gasification-combined cycle technology: Coal, water, and oxygen are fed to gasifier, which produces syngas. This medium-Btu gas is cleaned (particulates and sulfur compounds removed) and is fed to a gas turbine. The hot exhaust of the gas turbine and heat recovered from the gasification process are routed through a heat-recovery routed through a heat-recovery generator to produce steam, which drives a steam turbine to produce electricity.

Intermediate Load: The range of power system loads between baseload and peak load.

Intermittent Power Source: A generator, such as a wind turbine, whose output may vary considerably over short periods due to the variability and unpredictability of its external energy source.

Joule: The international unit of energy. It is the energy produced by the power of one Watt operating for one second. At 100 percent efficiency, there are 3.6 megajoules in a kilowatt-hour (or 3.6 gigajoules in a megawatt-hour).

kilowatt (kW): A standard unit used to measure electric power, equal to one thousand Watts. A kilowatt can be visualized as the total amount of power required to light ten 100-watt bulbs.

kilowatt-hour (kWh): A standard unit for measuring electrical energy.

Kyoto Protocol: The Kyoto Protocol is a proposed amendment to an international treaty on global warming -- the United Nations Framework Convention on Climate Change (UNFCCC). Countries which ratify this protocol will commit to reduce their emissions of carbon dioxide and other greenhouse gases, which are linked to global warming.

Least-cost Dispatch: The scheduling of power production as demand for electricity varies, according to the lowest cost generation sources available to the operator of a power system, given transmission limits and other constraints.

Levelised Cost: The present value of the total cost of developing and operating a generating plant or unit over its economic life, converted to equal dollars per megawatt-hours of generation ($/MWh).

Light Fuel Oil: Lighter fuel oils distilled off during the refining process. Virtually all petroleum products used in internal combustion and gas turbines is light fuel oil.

Lignite: A brownish-black coal of low rank with high inherent moisture and volatile matter content

Liquefied Natural Gas (LNG): Natural gas (primarily methane) that has been liquefied by reducing its temperature to -260 degrees Fahrenheit at atmospheric pressure.

Load: The amount of electricity demand at any specific point or points on a power system. The amount originates at the energy-using equipment of consumers.

Load Factor: The ratio of the average electricity demand over a designated period of time to the peak demand occurring during the same period.

Load Following: An ancillary service that adjusts generation to meet the hour-to-hour and daily load variations between generators and demands.

Long – run Marginal Cost (LRMC): The total cost of developing and operating facilities including both total fixed and total variable costs. Here, it is the same as Levelised Cost.

Megawatt (MW): One million Watts.

Megawatt-hour (MWh): One million Watt-hours.

Muskeg : A water soaked layer of decaying plant material, one to three metres thick, found on top of the overburden

Nameplate Capacity: The full-load continuous rating of a generator, prime mover, or other electric power production equipment, under specific conditions as designated by the manufacturer. Installed nameplate rating is usually indicated on a nameplate physically attached to the piece of equipment.

Natural Gas: A naturally occurring mixture of hydrocarbon and non-hydrocarbon gases found in porous geological formations beneath the earth's surface, often in association with petroleum. The principal constituent is methane. It is used as a fuel in boilers and gas turbines for electricity generation.

Net Capability: The maximum ability of a generating unit or plant, under specified conditions, to meet electricity demand. It is the capability of the generating equipment minus station service. It is usually expressed in megawatts (MW).

Net Generation: Gross generation of a generating unit or plant minus station service, expressed in megawatt-hours (MWh) or gigawatt-hours (GWh).

Net Present Value (NPV): A method used to evaluate an investment, whereby the *present value* of all revenues less the *present value* all expenditures, including capital cost, fixed and variable operating costs, and fuel costs, associated with the investment, are calculated using a given discount rate. The investment is acceptable if the NPV is positive.

Nominal Dollars: Value of currency expressed as dollars of the day, i.e., not inflation adjusted. Also referred to as “current” dollars.

Nuclear electric power (nuclear power): Electricity generated by the use of the thermal energy released from the fission of nuclear fuel in a reactor.

Nuclear Fuel: Fissionable materials that have been enriched to such a composition that, when placed in a nuclear reactor, will support a self-sustaining fission chain reaction, producing heat in a controlled manner for process use.

Nuclear Power Plant: A generating plant in which heat produced in a nuclear reactor by the fissioning of nuclear fuel is used to drive a steam turbine.

Nuclear Reactor: A device in which a fission chain reaction can be initiated, maintained and controlled. Nuclear reactors are used in the power industry to produce steam used for the generation of electricity.

Oil Sand: Sand containing bitumen.

Overburden: Layer of rocky, clay like material that lies under muskeg.

Overnight Capital Cost: The total capital expenditures required to develop a generating plant or unit, before adding carrying charges.

Peak Load Plant (or Unit): A generating plant (or unit) that normally operates intermittently during the hours of highest (peak) daily, weekly or seasonal power system loads.

Peaking Capacity: Capacity of generating equipment normally reserved for operation during peak load periods.

Petroleum : A naturally occurring mixture composed predominantly of hydrocarbons in the gaseous, liquid, or solid phase

Petroleum Administration for Defense District (PADD): A geographic aggregation of the 50 States and the District of Columbia into five Districts, with PADD I further split into three subdistricts. The PADDs include the States listed below:

PADD I (East Coast):

PADD IA (New England): Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

PADD IB (Central Atlantic): Delaware, District of Columbia, Maryland, New Jersey, New York, and Pennsylvania.

PADD IC (Lower Atlantic): Florida, Georgia, North Carolina, South Carolina, Virginia, and West Virginia.

PADD II (Midwest): Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin.

PADD III (Gulf Coast): Alabama, Arkansas, Louisiana, Mississippi, New Mexico, and Texas.

PADD IV (Rocky Mountain): Colorado, Idaho, Montana, Utah, and Wyoming.

PADD V (West Coast): Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington.

Planned Outage: The shutdown of a generating unit, transmission line, or other facility, for inspection or maintenance, in accordance with an advance schedule.

Power: The rate at which energy is produced. Electrical energy is usually measured in Watts.

Power System: All the physically interconnected facilities of an electrical utility, or a number of interconnected utilities. A power system includes all the generation, transmission, distribution, transformation, and protective components necessary to provide service to consumers.

Present Value: The value of a revenue acquired or an expenditure incurred in the future, expressed in terms of its current value, taking into consideration the time value of money. Present value equals future value divided by one plus interest rate all raised to the power of the number of years into the future. Here, the interest rate used represents the return on investment.

Price: The amount of money or consideration-in-kind for which a good or service is bought, sold, or offered for sale.

Primary Energy: Energy embodied in natural resources (e.g. coal, crude oil, sunlight, uranium) that has not undergone any anthropogenic conversion or transformation.

Prime Mover: The engine, turbine, water wheel or similar machine that drives an electric generator.

Profit: The income remaining after all business expenses are paid.

Proved energy reserves: Estimated quantities of energy sources that analysis of geologic and engineering data demonstrates with reasonable certainty are recoverable under existing economic and operating conditions. The location, quantity, and grade of the energy source are usually considered to be well established in such reserves.

Radioactive waste: Materials left over from making nuclear energy. Radioactive waste can destroy living organisms if it is not stored safely.

Rate of Return: The gain or loss for a security in a particular period, consisting of income plus capital gains relative to investment, usually quoted as a percentage. The real rate of return is the annual return realized on that investment, adjusted for changes in price due to inflation.

Real Dollars: Value of a currency expressed in inflation-adjusted terms and referenced to a base year. Also known as "constant" dollars.

Refinery: An installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and oxygenates.

Renewable Energy: Any sources or resources of energy that constantly renew themselves through natural processes, can be renewed artificially, or that are regarded as practically inexhaustible. These include solar, wind, geothermal, hydro and wood resources. Although particular geothermal formations can be depleted, the natural heat in the earth is a virtually inexhaustible reserve of potential energy. Renewable resources also include some experimental or less-developed sources such as tidal power, sea currents and ocean thermal gradients.

Residuum: A residual product from the processor distillation of hydrocarbons

Return on Equity (ROE): Measures the overall efficiency of the firm in managing its total investments in assets and in generating a return to stockholders. It is the primary measure of how well management is running the company.

Return on Investment (ROI): ROI can be calculated in various ways. The most common method is Net Income as a percentage of Net Book Value (total assets minus intangible assets and liabilities).

Revenue: The total amount of money received by a firm from sales of its products and/or services, gains from the sales or exchange of assets, interest and dividends earned on investments, and other increases in the owner's equity except those arising from capital adjustments.

Separate Work Unit (SWU): A standard measure of uranium enrichment services.

Scrubber: See Flue Gas Desulphurization Unit.

Security of Supply: Policy that considers the risk of dependence on fuel sources located in remote and unstable regions of the world and the benefits of domestic and diverse fuel sources.

Short-run Marginal Cost (SRMC): Variable cost of production that do not carry long-term or capital implications. Here it equals variable operating cost plus fuel cost. It is the same as total variable cost.

Spent Fuel: Nuclear fuel removed from a reactor following irradiation, which is no longer usable in its current form because of depletion of fissile material, poison build-up or radiation damage.

Station Service: The electric energy used in the operation of a generating plant or unit. This energy is subtracted from the gross generation to obtain net generation.

Steam-Assisted Gravity Drainage (SAGD): A recovery technique for extraction of heavy oil or bitumen that involves drilling a pair of horizontal wells one above the other; one well is used for steam injection and the other for production

Steam-electric Unit: A plant in which the prime mover is a steam turbine. The steam used to drive the turbine is generated in a boiler where fossil fuels are burned, or by heat produced in a nuclear reactor by the fissioning of nuclear fuel.

Sub-bituminous Coal: Sub-bituminous coal, or black lignite, is dull black and generally contains 20 to 30 percent moisture.

Sunk Cost: A cost that was incurred in the past and cannot be altered by any current or future decision.

Sustainability: Indicator selected with the aim to provide information on the essence of sustainable development; it may refer to systemic characteristics such as carrying capacities of the environment, or it may refer to interrelations between economy, society and the environment.

Synthetic Crude Oil : A mixture of hydrocarbons, similar to crude oil, derived by upgrading bitumen from oil sands

Tailings : A combination of water, sand, silt and fine clay particles that are a byproduct of removing the bitumen from the oil sand.

Thermal Efficiency: The percentage of total energy content of a fuel that is converted to useful output. The ratio of useful work (or energy output) to total work (or energy input).

Toe-to-Heal Air Injection (THAI): a process that uses air injection an subsurface combustion to increase mobility in the reservoir.

Total Fixed Cost: Expenses that are incurred to provide facilities and organization that are kept in readiness to do business without regard to actual volumes of production and sales. Here, total fixed costs comprise the capital charges and fixed operating costs of a generating plant or unit. They are incurred regardless of the amount of electrical energy produced. They are expressed in dollars per kilowatt per annum ($/kW.a).

Total Variable Costs: Expenses incurred in the operation of a generating plant or unit that depend on the amount of electrical energy produced. Here, total variable costs comprise variable operating costs plus fuel costs. They are expressed in dollars per megawatt-hour ($/MWh).

Turbine: A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse or reaction, or a mixture of the two.

Unit (or Plant) Availability: The number of hours a generating unit is available to produce power (regardless of the amount of power) in a given period, compared to the number of hours in the period.

Upgrading : The process of converting heavy oil or bitumen into synthetic crude oil

Uranium (U): A heavy, naturally radioactive, metallic element (atomic number 92). Its two principally occurring isotopes are uranium-235 and uranium-238. Uranium-235 is indispensable to the nuclear industry because it is the only isotope existing in nature, to any appreciable extent, that is fissionable by thermal neutrons. Uranium-238 is also important because it absorbs neutrons to produce a radioactive isotope that subsequently decays to the isotope plutonium-239, which also is fissionable by thermal neutrons.

Vapor Extraction: the use of solvents to reduce bitumen viscosity in situ.

Variable Operating Cost: The variable portion of the cost associated with the operation and maintenance of a generating unit or plant. It is dependent on the amount of electrical energy produced. It is expressed in dollars per kilowatt per annum ($/MWh).

Viscosity: The resistance to flow or "stickiness" of a fluid

Volatility: In financial matters, volatility of returns is the measurement used to define risk. The greater the volatility, the higher the risk.

Watt: The standard unit of electrical power. One Watt is equal to one Joule per second. It also equals one Ampere flowing under a pressure of one Volt at unit power factor.

Watt-hour (W.h): The standard unit of electrical energy. It is equal to one Watt of power operating steadily for one hour.

West Texas Intermediate (WTI): is a grade of crude oil that has its main delivery point in Cushing, OK. The spot price for WTI delivered Cushing is the ultimate settlement price for the NYMEX oil futures contract.

Wholesale Power Market: The purchase and sale of electricity from generators to resellers (who sell to retail customers) along with the ancillary services needed to maintain security of service and power quality at the transmission level.

Wholesale Price: The price of energy supplied electric utilities and other power producers.

Wind Generator: A generator that obtains its power from wind turning a wind turbine.

Sources for the Glossary:

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APPENDIX C: Overview of the Oilsands Operation

C.1 Composition

Oil sands are hydrophilic; each grain of sand is covered by a film of water, which is then surrounded by a slick of heavy oil (bitumen). The sands are bonded firmly together. The bitumen content in deposits varies from 1 percent - 18 percent (>12 percent bitumen content is considered rich, and less than 6 percent is poor). It takes approximately 2 tonnes of mined oil sand to produce one barrel of synthetic crude oil.

C.2 Methods of Processing Oil Sands

1. Surface Mining

The Athabasca deposit is the only oil sand deposit with reserves shallow enough to be surface mined. The process of surface mining begins by clearing trees, draining and storing the overburden[64] and then removing this top layer of earth to expose the ore body.

2. In Situ

Approximately 80 percent of Canada's oil sands lie deep below the surface and cannot be recovered by open pit (surface) mining techniques, so *in situ* processes are used to get at some of the deposits. Two major in situ techniques, Cyclic Steam Stimulation (CSS) and Steam Assisted Gravity Drainage (SAGD), are used commercially in Alberta's oil sands.

Cyclic Steam Stimulation (CSS)

CSS injects high-pressure, high temperature (about 350°C) steam into oil sand deposits. The pressure of the steam fractures the oil sand, while the heat of the steam melts the bitumen. As the steam soaks into the deposit, the heated bitumen flows to a producing well and is pumped to the surface. This process can be repeated several times in a formation, and it can take between 120 days and two years to complete a steam stimulation cycle.

SAGD (Steam Assisted Gravity Drainage)

This involves injecting steam through a series of wells into the oil sand. The pressure and high temperature cause bitumen and water to separate from the sand particles. The hot bitumen migrates towards producing wells, bringing it to the surface, while the sand is left in place

[64] Layer of rocky, clay like material that lies under muskeg