National Energy Board

Office national de l’énergie

Canada’s Energy Future

SCENARIOS FOR SUPPLY AND DEMAND TO 2025

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Errata Number 1 July 2003

National Energy Board

Canada's Energy Future – Scenarios for Supply and Demand to 2025

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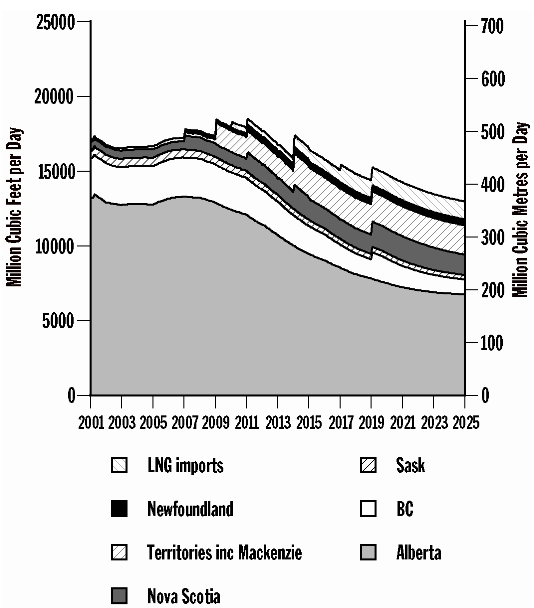
Cover page added

Chapter 5, page 65, Figure 5.22, replace with the following:

Figure 5.22 Deliverability by Region – Supply Push



Appendix 6.2
Appendix 6.3
These revisions can be viewed at www.neb-one.gc.ca .

The Board apologizes for any inconvenience caused by these changes.

Errata n° 1 - Juillet 2003

Office national de l'énergie

L'avenir énergétique au Canada : Scénarios sur l'offre et la demande jusqu'à 2025

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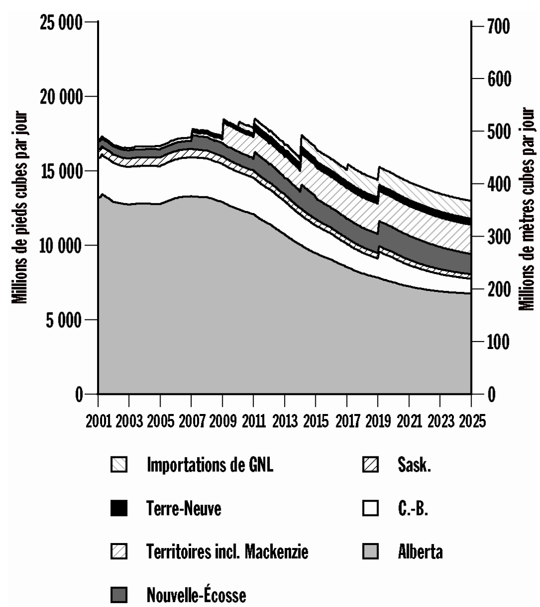
Page couverture intérieure ajoutée

Chapitre 5, page 72, figure 5.22, remplacer par ce qui suit :

Figure 5.22 Productibilité par région – Pression de l'offre



Annexe 6.2
Annexe 6.3
On peut voir ces révisions à www.neb-one.gc.ca .

L'Office regrette tout inconvénient que ces changements pourraient vous causer.

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Foreword

The National Energy Board (NEB or the Board) was created by an Act of Parliament in 1959. The Board's regulatory powers under the *National Energy Board Act* include the authorization of exports of oil, natural gas and electricity; the authorization of the construction of interprovincial and international oil, gas and commodities pipelines and international power lines; the setting of just and reasonable tolls for pipelines under federal jurisdiction; and the regulation of oil and gas activities on Canada lands in the north.

The Board also has a monitoring function, pursuant to which it releases reports from time to time on the outlook for Canada's energy supply and demand.

In a distinct change from previous reports, the NEB has adopted a scenario-based approach to help it better understand the forces impacting Canada's energy environment and to address the uncertainties and issues associated with evolving energy markets. This report, *Canada's Energy Future – Scenarios for Supply and Demand to 2025*, examines two distinct scenarios of Canada's energy future for the public to consider.

The two main objectives of this report are to:

- provide an examination of possible energy futures for Canada; and
- identify the key forces which will shape future energy supply and energy use in Canada.

In developing its report, the Board sought the views of Canadians interested in energy matters by adopting a consultative process involving roundtable discussions and public workshops. The Board held roundtable discussions in June 2002 with selected stakeholders in six Canadian cities. The key objective of these sessions was to provide parties with the opportunity to comment on the Board's analytical approach, particularly the scenario logic and characteristics. Public workshops were also held in January and February 2003 in seven Canadian cities that provided an opportunity to comment on the Board's preliminary analyses and findings.

As noted above, the Board has adopted a scenario-based approach for this report. During the public consultations, some parties expressed a preference for a business as usual, or reference case, rather than the use of scenarios in order to derive energy supply and demand outlooks. How Canada's energy future energy environment unfolds is uncertain. Given this uncertainty, the Board feels it is important to focus discussion and encourage debate around the major forces and uncertainties impacting energy supply and demand and the emerging trends. The scenario based approach provides a useful tool to achieve this goal as well as to examine alternative energy futures.

The Board appreciates the comments and interchange of views received during the consultation process and would like to thank those who contributed their time and expertise. The Board considered all comments and incorporated a good portion of them into its final report.

If a party wishes to rely on material from this report in any regulatory proceeding, it can submit the material as it can submit any public document. In such a case, the material is in effect adopted by the party submitting it and that party could be required to answer questions on it. For clarification, the Board notes that this report is not a recommendation to the Minister of Natural Resources on energy policy matters.

Executive Summary

In this report we have adopted a scenario-based approach in which two different plausible energy futures for Canada are explored in detail: a ***Supply Push*** scenario and a ***Techno-Vert*** scenario. Neither of the scenarios represents a more probable or more desirable energy future. The scenario approach enables us to identify issues, constraints and uncertainties affecting energy supply and energy use in Canada. Scenarios are not forecasts; they are designed to challenge our thinking and to provide a framework for public discussion on emerging issues and trends.

Although there are many forces that will affect future energy use patterns, we considered **the pace of technological progress** and **action on the environment** as the two forces that are the most important and most uncertain. In any conceivable future, it is clear that there will be ongoing technological progress and actions will be taken to improve the way in which we use energy with respect to the environment. However, there is considerable uncertainty as to the scope for technological advancements in areas such as fuel cell vehicles, clean coal technology or advanced nuclear generation, which could radically change our energy use patterns. At the same time, there is equal uncertainty about the scope and range of real actions that might be taken to reduce the overall environmental impact of energy use, including emissions of air pollutants and greenhouse gases.

The ***Supply Push*** scenario represents a world in which technology advances gradually and Canadians take limited action with respect to the environment. The main theme of this scenario is security of continental energy supply and the push to develop known conventional sources of energy.

The ***Techno-Vert*** scenario represents a world in which technology advances rapidly and Canadians take broad action with respect to the environment and the accompanying preference for environmentally-friendly products and cleaner-burning fuels.

In November 2002, the Government of Canada released a plan to address Canada's commitment to the Kyoto Protocol. However, additional elements of implementation would be required in order for the Protocol to be incorporated in the scenario analysis. Therefore, the Protocol was not considered in either scenario.

The focus of this report is on plausible energy futures for Canada. However, Canada's energy economy is closely tied to that of the U.S. Thus, the scenarios necessarily imply that similar developments take place in the U.S. economy and, to a lesser extent, in the world economy.

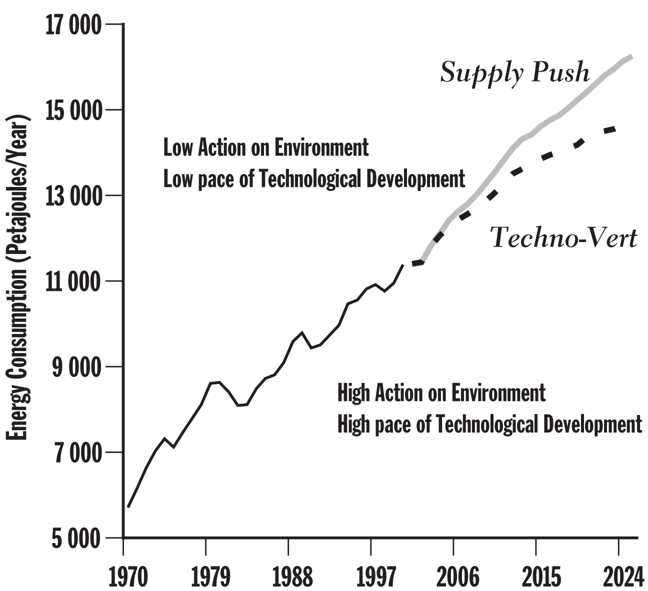
Key Findings

- There are significant obstacles to changing the fuel mix or achieving large gains in energy efficiency due to the structure of the Canadian economy. Energy use patterns change slowly and Canada will continue to satisfy the majority of its energy needs from fossil fuels until 2025 and likely for a considerable period thereafter.
- Natural gas will be in high demand as a premium clean-burning fossil fuel. However, a major uncertainty is the availability of supplies of natural gas. Tight natural gas supply relative to demand implies:

- natural gas prices will continue to be volatile;
- demand-side adjustments could occur in the industrial sector, including more efficient energy use, switching to other fuels and possible relocation of industries; and
- new electric power generation will come from a variety of sources, including coal, wind, large hydro and possibly nuclear.

➢ Oil sands production will increase significantly and will offset the decline in conventional crude oil production and become Canada's major source of oil supply. Exports will increase considerably through 2025.

How Will Canada's Energy Future Unfold?



Key Assumptions

There are a number of underlying drivers that are the same in both scenarios. First, energy demand is determined primarily by economic growth and income levels, and the efficiency of energy use. As economic output increases, there is increased demand for energy to produce a greater range of products and services. This can be partially offset by improved efficiency but the income effect still results in rising demand.

Canada is a large country with a cold northern climate and large distances between population centres: this translates into high demand for energy for transportation and space heating. Energy demand is also affected by the density of population. There is more scope for efficiencies in energy use in densely populated areas where economies can be realized in mass transit, heating of apartment buildings and large commercial centres. However, Canadian cities tend to be relatively spread out with a very high rate of single detached home ownership. In both scenarios, we assume that climate and living patterns remain largely unchanged over the projection period to 2025. Both scenarios contain the same demographic assumptions; i.e. the Canadian population will age over the projection period, and the overall population will grow slowly.

We assume that world oil prices will average a constant real US$22 per barrel in each scenario, which is the low end of OPEC's target price range. This implies that there is adequate oil in the world at that price to meet energy demand and that price will be largely depend on the production policies of the OPEC nations. Due to the high demand for natural gas as a clean-burning fuel, we assume the price of natural gas will grow from 83 percent to 90 percent of the crude oil price in the ***Supply Push*** scenario by 2025. In ***Techno-Vert***, the natural gas price reaches parity with crude oil by 2010. While there will undoubtedly be considerable volatility in both oil and gas prices, we believe that $22 per barrel is a reasonable assumption for oil prices and that gas will not be priced above crude oil, on an equivalent energy basis, for any sustained period of time.

Outlook for Energy Use

In the **residential sector,** space heating accounts for over 50 percent of energy demand, followed by water heating, and electricity for appliances, computers, lighting and home entertainment systems. The Canadian population grows slowly in both scenarios, thereby limiting change in the composition of the housing stock over the projection period. Because it is more practical to implement energy efficient features in new homes than to refit existing homes, the degree to which energy efficiencies can be implemented in this sector is limited.

Due to rising incomes and attendant rising demand for goods and services, energy demand in this sector increases by about 20 percent in the ***Supply Push*** scenario and by about 10 percent in the ***Techno-Vert*** scenario by 2025. Electricity and natural gas account for a greater share of the fuel mix in both sectors, while alternatives such as passive solar power make minor inroads only in the ***Techno-Vert*** scenario. Energy demand could be reduced further if there were a marked shift in living patterns away from large detached homes to multi-family residences and smaller bungalows; however, this is not expected to happen in either scenario.

There is more scope for implementing energy efficiencies in the **commercial sector** due to the average larger size of buildings and the importance owners place on economizing on energy bills. Nonetheless, energy efficiency gains are limited by turnover in the existing stock and also because, similar to the residential sector, it is relatively expensive to retrofit existing buildings. Natural gas and electricity are expected to account for over 90 percent of the fuel mix in this sector, as is the case today.

Energy demand in the **industrial sector** is roughly equal to that in the residential and commercial sectors combined. Industrial energy demand grows only by about 50 percent in the ***Supply Push*** scenario and by 55 percent in the ***Techno-Vert*** scenario, while economic output grows by 90 percent and 120 percent respectively. The pulp and paper and mining sectors are the two largest energy users and energy costs are a very high component of overall costs to these industries. They are highly motivated to implement cost savings and have been leaders in searching out efficiencies. However, further efficiencies are limited by the need to exploit more remotely located resources in the forestry, mining and oil and gas sectors, and by the limited options for alternative fuel sources in these industries.

Road transportation accounts for 80 percent of energy demand in the **transportation sector,** with marine and rail transport accounting for the remainder. Oil dominates energy use in this sector, accounting for close to 100 percent of energy use. Accordingly, there has long been a search for alternatives to oil, with the primary candidates being a hybrid electric vehicle or a vehicle powered by a fuel cell. Both are attractive due to energy efficiencies and the reduction or complete lack of hydrocarbon emissions.

The demand for energy for passenger vehicles depends on the total stock of vehicles, the average fuel economy of the stock and the average number of kilometres travelled per vehicle. Each of these is, in turn, affected by factors such as consumer preference and urban living patterns. In our scenarios, we assume no fundamental changes in urban living patterns and, hence, high demand for personal transport persists.

In the ***Supply Push*** scenario, there is considerable progress made in improving the efficiency of the internal combustion engine and gasoline and diesel continue to supply almost all road transportation fuel needs. In the ***Techno-Vert*** scenario, hybrid electric and fuel cell vehicles become competitive. By 2025, they account for 14 percent and 10 percent of the vehicle stock, respectively. During this period, continuous progress is made in using oil cleanly and efficiently; hence, oil still retains a large market share. Overall, transportation demand for energy grows by 50 percent in the ***Supply Push*** scenario, while in the ***Techno-Vert*** scenario it initially grows, but then falls back, finishing close to initial demand levels.

Energy Production

Canada has enormous reserves of oil in the Alberta oil sands. This resource acts as the major source of growth in domestic oil production, and corresponding growth in oil exports to the U.S. in both scenarios. The assumed price of US $22 per barrel provides adequate returns to support investment in the oil sands and offshore oil development. Production from the oil sands increases five-fold in the ***Supply Push*** scenario and about four-fold in the ***Techno-Vert*** scenario. In both scenarios, light crude production from the Atlantic offshore increases, with slightly higher increases being achieved in ***Techno-Vert*** due to the more successful application of technology to offshore exploration and production engineering. Canada continues to be a net exporter of oil throughout the period, with growth in exports outpacing growth in imports, especially in ***Techno-Vert.*** The result is that net exports of crude oil almost double in ***Supply Push*** and triple in ***Techno-Vert.***

The size of Canada's natural gas resource base is a major uncertainty, particularly for the frontier regions and unconventional natural gas sources, such as coal bed methane. There are signs that the Western Canada Sedimentary Basin is maturing. It will be necessary to develop unconventional and frontier sources to maintain, or potentially increase Canadian production. However, since there has been little development of unconventional gas or frontier gas to date, there is considerable uncertainty about future potential production. In the ***Supply Push*** scenario, natural gas production peaks at about 18 Bcf/d whereas production reaches about 19 Bcf/d in the ***Techno-Vert*** scenario, primarily due to more success in expanding the resource base through successful application of technology.

Electricity generation is expected to grow by about 1.8 percent per year in both scenarios, but the mix of generation will be quite different. Natural gas is a preferred fuel due to its clean burning properties, efficiency, the short lead time required to build gas-fired power plants and significant lower up-front capital investments than are required for coal, large hydro or nuclear. Nonetheless, price volatility will be a concern that will lead generators to consider alternatives.

In the ***Supply Push*** scenario, in addition to gas-fired generation, there is a resurgence of coal-fired plants, particularly in Ontario and the western provinces. Coal continues to be relatively inexpensive and will thus always be an option to consider. In the ***Techno-Vert*** scenario, there is a shift towards "cleaner" generation options such as clean coal technologies, wind power and advanced nuclear reactors. Overall, renewable fuels (wind, biomass and small hydro) account for almost ten percent of the generation mix in 2025 in ***Techno-Vert***, compared to only three percent in the ***Supply Push*** scenario.

Coal is an abundant resource on a world basis and in North America. In Canada, reserves are equivalent to 90 years of current production. Future production will be governed primarily by the use of coal in domestic power generation. As with oil, continuous progress is made in burning coal cleanly and efficiently and, consequently, coal continues to retain a significant market share of twelve percent of total energy demand in ***Supply Push*** and eight percent in ***Techno-Vert***. In the ***Supply Push*** Scenario, coal production rises from 70 million tonnes in 2001 to over 90 million tonnes in 2025 and declines to 63 million tonnes in ***Techno-Vert***.

Key Uncertainties

Examination of our scenarios appears to indicate that Canada's energy future will continue to be based on fossil fuels, at least until 2025. However, there are a number of key questions that remain:

- How will technological development impact economic growth and energy demand?
- How long will it take to achieve significant changes in Canadian energy consumption patterns given the structure of the Canadian economy?
- How soon can new transportation technologies such as hybrid electric and fuel cell vehicles become commercially competitive with traditional gasoline-powered vehicles?
- What concrete actions will be taken to address environmental concerns and what impact will these actions have on our choice of energy sources?
- Will OPEC be able to maintain oil prices within its target band of $22 - $27 per barrel or is it possible that prices will be outside this range for prolonged periods of time?
- What is the impact of future environmental measures on oil sands development?
- How will gas supply from conventional sources including the WCSB, and offshore sources and new sources such as CBM respond to increased demand?

The answers to these questions will have a major impact on Canada's energy future to 2025.

Next Steps

As part of its ongoing assessment of energy markets, the Board will continue to monitor developments in Canadian energy supply and usage patterns and from time to time, will release its findings.

1.0 Introduction

1.1 A New Approach

The Board used a scenario based approach in identifying and examining the major forces and key uncertainties facing Canada's energy environment. Scenarios are not forecasts; they are descriptions of plausible alternative futures. How Canada's energy future environment unfolds is uncertain and highly unpredictable. Given this uncertainty, the Board decided not to develop a consensus view and single line projection for energy supply and demand. The overarching question the scenarios examined is "How might the energy environment in Canada change over the next 25 years?"

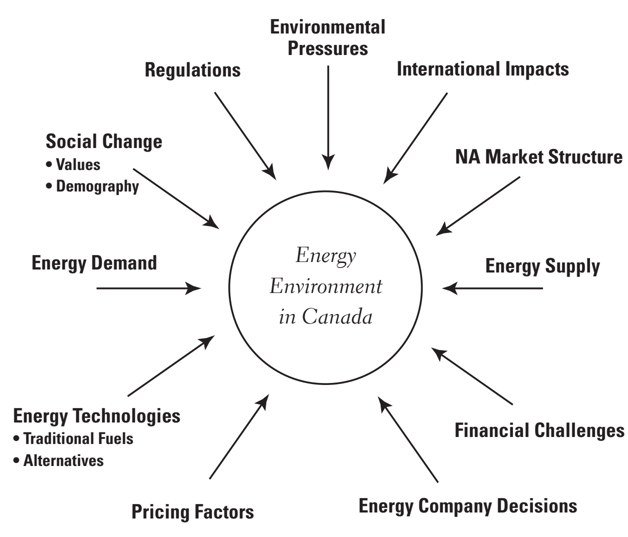
1.2 How to use Scenarios

Scenarios are intended to explore new ground and generate new ideas, challenge conventional views and focus on the most important uncertainties facing the energy industry. It is unlikely that any one scenario will prevail for the entire period. The real value in using scenarios is not to debate whether a scenario will occur but to consider what we would do if it did happen and to determine what actions need to be taken in the near term to address key long term issues.

1.3 Process and Framework

The process for developing a framework for the scenario approach began with the identification of driving forces deemed likely to impact the energy environment over the next 25 years. Many factors that have been driving change in the past are expected to continue to impact and shape the energy environment in the future but new forces must be considered as well (Figure 1.1). After consideration, two key forces were established as the most important and most uncertain: **action on environment** and **pace of technological development.** These key uncertainties provided the analytical framework for developing four distinct scenarios (Figure 1.2). It is important to note that these key uncertainties are independent. For example, action on the environment does not itself yield technological development. The desire to take more action on the environment may lead us to pursue technological advancements but the success is uncertain.

Figure 1.1 Driving Forces



Action on Environment

The nature and level of action that will be taken to enact environmental improvement is a key uncertainty that raises a number of questions. How will public concerns about the environment – air quality, health and global warming, etc.. – evolve and how will these be translated into action? What government, industry and individual actions on the environment will be initiated? Will consumers be willing to pay more for cleaner fuels? Will societal and personal priorities converge? Will governments respond to pressure from citizens for environmental actions by increasing regulatory requirements?

In November 2002, the Government of Canada released a plan to address Canada's commitment to the Kyoto Protocol. However, additional elements of implementation would be required in order for the Protocol to be incorporated in the scenario analysis. Therefore, the Protocol was not considered in either scenario.

Pace of Technological Development

Technological change is inevitable and will affect both the supply and demand of energy. The pace of technological development, however, is uncertain. Will existing technologies improve steadily or will there be major breakthroughs? How quickly can technological improvements or breakthroughs be introduced? Will technological advancements lead to more diverse energy sources and significant energy efficiency improvements? Will clean coal technologies, which reduce CO_2 emissions, become viable?

Figure 1.2 Scenario Framework

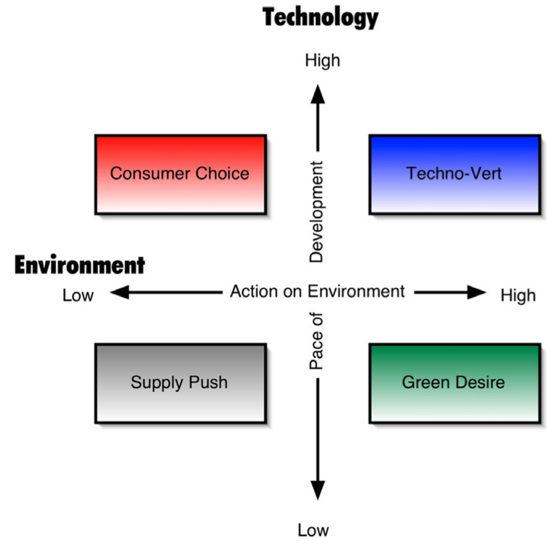


Figure 1.2 illustrates how the key uncertainties provide a logical framework for developing distinctly different scenarios. Each quadrant represents a unique combination of outcomes of the two key uncertainties.

For this report, we chose to focus on two scenarios, ***Supply Push*** and ***Techno-Vert***, because they offer very divergent, but plausible views of the future. We recognize that there are other scenarios that may fall outside the bounds of these two scenarios. However, there would be limited value in attempting to explore a large number of possibilities. The two scenarios we selected identify the major constraints in the possibilities, point us to what is reasonable to expect and identify the key issues and uncertainties.

The Differences between Climate Change and Air Pollution

The greenhouse effect refers to a natural phenomenon whereby certain "greenhouse gases" (GHGs) present in the atmosphere serve to trap energy from the sun. The scientific community has reached a broad consensus that climate change through global warming is occurring, and that certain human activities (e.g. the burning of fossil fuels) contribute to this warming through acceleration of the greenhouse effect. The Kyoto Protocol has targeted a number of greenhouse gases including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Industrial processes are releasing additional volumes of these and other non-naturally occurring gases such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) that have also been targeted for reduction. GHGs are generally not considered to be regulated "air pollutants".

The federal government outlined the means to achieving Canada's climate change objectives and reaching the Kyoto Protocol targets in a report released in November 2002 entitled "*The Climate Change Plan for Canada*" following consultation with provincial and territorial governments, municipalities, industry representatives, and the public. In December 2002 the Government of Canada announced its ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change. The Kyoto Protocol establishes legally binding targets and timeframes for greenhouse gas reductions for those industrialized countries ratifying the agreement. Under the Protocol, Canada has agreed to lower its greenhouse gas emissions to six percent below 1990 levels during the first commitment period (2008-2112).

Air pollution can be broadly defined as the presence in the air of any substance that can affect our health or the health of plants and animals, or that causes damage to property or to the environment. These substances are in large part emitted by human activities but can also have natural origins. A large number of contaminants, such as particulate matter, volatile hydrocarbons and sulphur dioxide contribute to air pollution, and even low levels of concentration can have detrimental effects. It is estimated that each year thousands of people are hospitalized because of respiratory complications resulting from urban smog. While air pollution is more concentrated in urban areas with high traffic flows, air pollution is a concern for all Canadians in that air pollution affects forests, agricultural crops, water, livestock and wildlife in many regions of the country.

The release of pollutants is regulated under federal as well as provincial legislation, and is closely monitored by a number of departments. A number of provinces and the federal government are taking serious and long-term measures to address air quality issues, such as restricting levels of sulphur in gasoline.

2.0 Scenario Overviews

2.1 Supply Push

What is Supply Push?

The ***Supply Push*** (SP) scenario represents a world in which technology advances gradually and Canadians take limited action on the environment. However, major technological breakthroughs on alternative energy sources remain beyond reach and environmental action is focussed on local initiatives. The main theme of the SP scenario is security of continental energy supply and the push to develop known conventional sources of energy. This is necessary because technological breakthroughs to either economically develop unconventional energy or significantly reduce energy consumption do not occur. Without being able to count on any significant technological breakthroughs, investment is focussed on developing conventional fuel sources using proven technologies. Although action on environmental matters is important, the drive to increase domestic energy supply is a higher priority. Energy demand continues to grow in accordance with well-established trends, energy efficiency gradually increases, and new technology is gradually implemented.

What is a possible path to Supply Push?

Higher energy prices over the last few years have elevated public and political awareness of energy matters. At times, growth in energy demand to fuel the economy outpaces growth in energy supply. As a result, North Americans are more concerned about energy security and the ability to meet growing energy consumption. Governments encourage and initiate policies to foster growth in North American energy supply and take other measures to reduce the impact of price volatility. These measures include rebates to consumers to offset high prices, the provision of information to increase public awareness, and voluntary programs to encourage conservation and to improve energy efficiency. However, without an economic motivation to focus policies and fund government programs, consumer behaviour towards energy consumption remains largely unchanged.

Energy Demand – Still an Age of Convenience

A key driver in this scenario is consumer preference for convenience, powerful vehicles and electronic gadgets. In this context, environmental protection is not a high priority for most consumers: there is a lack of broad willingness amongst consumers to pay more for alternative technologies and renewable fuels or for products that provide improved energy efficiencies.

The economy of North America experiences moderate economic growth throughout the projection period. The Canadian economy grows at an annual average rate of 2.2 percent and energy demand continues to grow in North America. However, as the Canadian population ages, economic growth begins a slow decline that lasts throughout the projection period. This contributes to decelerating growth in energy demand to rates much lower than experienced in the 1990s (but a bit higher than the 1980s). Energy efficiency improvements also slow energy demand, but improvements are limited by the costs of retrofitting the existing stock of buildings. Energy use by the industrial sector grows more slowly than the industrial sector itself because a larger proportion of industrial output is derived from less energy intensive industries (such as automotive assembly, transportation equipment and manufacturing of electronic and communications equipment).

Energy demand for road transportation grows more slowly than in the 1990s. The slowing economic growth in the latter part of the projection period results in slower growth for commercial transportation. However, some trends that were established in the 1990s still continue; namely, consumers' preference for larger vehicles and the growing popularity of light duty trucks over cars. In general, car manufacturers continue to rely on the internal combustion engine (ICE) operating on traditional petroleum products because technology for most alternatives remains expensive. Although hybrid electric vehicles are introduced into the new vehicle mix early in the projection period, they account for only about five percent of the new vehicle stock by 2025. Moderate improvements in fuel economy for all classes of vehicles continue through the projection period at rates that are, in general, higher than experienced in the 1990s (with the exception of small cars which improved considerably in the 1990s). In addition, consumers still prefer the convenience and flexibility of personal-use vehicles.

Energy Supply - Emphasis on Conventional Fuels

Natural Gas Supply

Following periodic episodes of tightness in supply and demand and corresponding volatile natural gas prices, the drilling rig fleet in North America operates at a high utilization level to increase production. Increased drilling manages to offset declines in existing wells and maintain total production at a constant level for several years in Canada. Access to lands in Canada and the U.S. for exploration and drilling is increased. A better response in supply is observed in the U.S. due to drilling in large tracks of the prolific Rockies and eastern Gulf of Mexico.

Unconventional natural gas supplies are pursued in Canada to supplement conventional production. Pilot projects to produce coalbed methane (CBM) are pushed ahead in the Western Canada Sedimentary Basin (WCSB) following some successes. Later, producers continue to maintain natural gas production levels from the WCSB with the success of several CBM projects. CBM production continues to increase through the projection period but, eventually, natural gas production from the WCSB commences a gradual decline as growth in CBM production cannot offset increasing declines in conventional supply.

Eventually, North America must increasingly rely on sources of natural gas supply beyond its maturing basins to meet future demand. Producers turn more to the frontier areas. Production is expanded from the Scotian shelf and solution gas from depleting oil pools offshore of Newfoundland is delivered to market as compressed natural gas (CNG). A pipeline from the Mackenzie Delta area is also developed. A pipeline from Alaska follows and it delivers natural gas to the lower 48 states. The Alaskan natural gas is delivered into existing pipeline systems, thereby increasing the utilization of these systems. While a major project, Alaskan natural gas satisfies only a small portion of growing U.S. demand.

The expansion of existing liquefied natural gas (LNG) facilities, along with the construction of new terminals in the Gulf of Mexico, Bahamas and Mexico make a significant contribution to U.S. natural gas supply. LNG has historically been relied upon for peak-shaving; however, it is increasingly considered as a critical component to offset the expected tight gas supply in North America. In addition, other LNG projects have been proposed for North America. One of them is the Canaport LNG project, which would be situated at Saint John, New Brunswick. It has been proposed by Irving Oil Ltd. and would have a send-out capacity of 500 MMcf/d (14.2 million m^3/d). This would be the first LNG terminal in Canada.

By 2025, Canadian conventional natural gas production from the WCSB has declined sharply. Northern and East Coast natural gas, along with expanded CBM and LNG supply, cannot offset lower production from the maturing basins.

Oil Supply

In SP, domestic crude oil production in the U.S. continues its long-term decline trend despite the approval of drilling in previously restricted areas. However, the SP sets the stage for significant expansion of Canadian oil supply.

With enormous deposits of recoverable bitumen, the oil sands regions of Alberta experience expansions of existing facilities and the development of new surface-mining and upgrading operations. A sharp increase in upgraded or synthetic crude from the oil sands is realized. As well, incremental in situ crude bitumen production is added through the expansion of existing projects and by the addition of new steam-assisted-gravity-drainage (SAGD) projects. By 2025, oil sands derived production increases five-fold compared to 2000.

Production of conventional light crude oil in the WCSB also continues its long-term decline. By contrast, production of conventional heavy crude oil continues to trend slightly upward, primarily as a result of improved recovery techniques and concentrated infill drilling in heavy oil pools. Eventually, conventional heavy oil production begins to decline. By 2025, combined conventional light and heavy crude oil account for only ten percent of total Canadian oil production.

Frontier oil production expands, initially from offshore Newfoundland with the onset of production from the White Rose and Hebron fields. Subsequently, an additional Terra Nova-sized field plus several smaller satellite fields commence production on the East Coast offshore. After several years with high rates of production, offshore oil production begins to decline.

By 2025, Canadian oil production has levelled off while U.S. production has been in decline throughout the period. As a result, North American reliance on oil imports steadily increases.

Natural Gas Liquids Supply

Natural gas condensate is the traditional source of diluent used to blend with in situ bitumen and heavy oil to render them transportable in pipelines. At the outset of the SP scenario, natural gas condensate is already in tight supply and synthetic crude oil is increasingly used as a diluent.

The supply of ethane tends to track the decrease in conventional WCSB natural gas supply. However, small increments of supply (related to straddle plant expansion and unconventional ethane supply from oil sands off-gas) enhance production and help to reduce the decline rate. This supply is further supplemented with the commencement of a pipeline from the Mackenzie Delta. Eventually, about the middle of the outlook period, decreasing conventional WCSB natural gas production leads to a shortfall in ethane supply. To improve the utilization of ethylene plants in Alberta, access to incremental ethane from Alaska or unconventional sources or use of alternative feedstocks will be needed.

Liquefied Natural Gas (LNG)

LNG is simply natural gas that has been cooled to a temperature of approximately -260°F (-160°C) at atmospheric pressure, causing it to condense into a liquid state from a gaseous state. This process significantly reduces the physical volume of gas; consequently, large quantities can be transported by ships, offloaded and stored efficiently and economically at receiving terminals. To meet market requirements, the LNG is later re-gasified and delivered into a pipeline system.

The technology for LNG has existed for four decades but recent improvements in the liquefaction process, combined with decreasing shipping costs, have resulted in a 50 percent decline in supply costs over the past twenty years. Industry analysts estimate that LNG is now competitive in some East Coast North American markets at a price of about US$ 3.50 per MMBtu. In addition to the increased competitiveness of LNG, stranded gas reserves amounting to some 4,000 Tcf worldwide are making LNG an attractive gas supply option to meet North American needs.

There are three operating facilities in the U.S. today - the busiest facility is operated by Southern Union at Lake Charles, LA. with the others being Tractebel's facility at Everett, MA. and El Paso Corporation's Elba Island, GA. terminal. Dominion Energy plans to reopen a fourth U.S. terminal at Cove Point, MD. later in 2003. LNG imports in the U.S. have increased more than tenfold since 1995, reaching 228 Bcf (6.5 billion m^3) in 2002. However, this volume is only a quarter of the total send-out capacity of the three operating terminals, which is about 2.5 Bcf/d (71 million m^3/d).

In Atlantic Canada, an economic volume of ethane to support extraction is not attained. As a result, ethane will be left in the gas stream and a petrochemical industry will not likely develop.

Electricity Supply

Electricity generators continue to rely mainly on conventional technologies to meet rising domestic load requirements, while alternative technologies and renewable fuels generally remain uneconomic.

Natural gas-fired generation is developed because of the relatively lower capital investment, the shorter time for construction and higher efficiency. Growth in natural gas-fired generation occurs primarily in Alberta in conjunction with the growing number of oil sands plants and in situ bitumen projects. However, in Canada and the U.S., declining conventional natural gas production combined with a lack of adequate infrastructure in some areas may cause reliability concerns.

Extensive resources of coal across North America make it an attractive option for electricity generation, especially in the long-term, as conventional natural gas supplies are declining. Amid increased costs, generators in Ontario, for example, opt for further coal generation instead of natural gas to meet future demand. As well, coal use increases in Alberta, Saskatchewan and the U.S. Midwest and re-emerges in other markets with economic access to coal supplies.

Hydro power continues to be the primary source of electricity generation in Canada with the development of four new large-scale hydro projects. By 2025, hydro power still accounts for almost one-half of total Canadian generation despite the rapid growth in natural gas-fired generation and increased coal generation in the scenario.

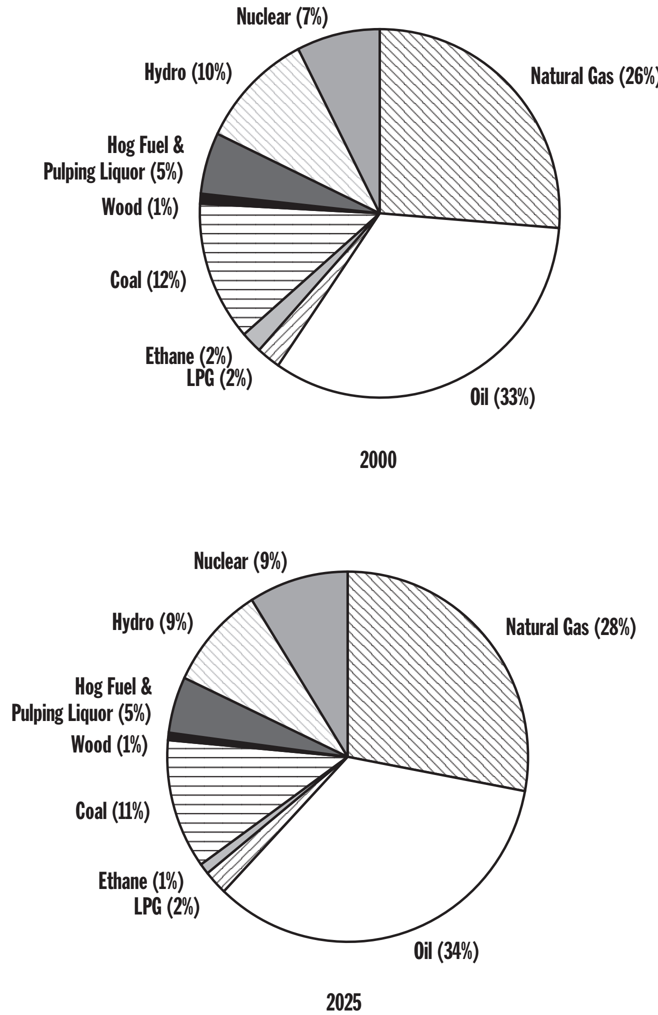
Nuclear facilities also continue to contribute significantly to North American power generation. While no new facilities are added, many nuclear plants undergo life extension programs, including facilities in Ontario, New Brunswick and Québec. This is facilitated by new policies to govern nuclear waste disposal.

Without sufficient improvements in technology to reduce costs, alternative technologies and renewable fuels do not expand appreciably.

Summary

By the end of the projection period, total energy demand reaches 16 247 PJ. While the primary fuel mix has not materially changed, users of energy are relying more on oil and coal to satisfy their energy needs. Oil continues to play the prominent role in Canada's fuel mix, accounting for about one third of our energy use (Figure 2.1).

Figure 2.1 Primary Fuel Shares 2000 versus 2025



2.2 Techno-Vert

What is Techno-Vert?

The ***Techno-Vert*** (TV) scenario is a world in which technology advances more rapidly. In addition, Canadians take broad action on the environment. The main theme of this scenario is the heightened concern for the environment and the accompanying preference for environmentally-friendly products and cleaner-burning fuels. Consumers are also willing to pay more for these products and consider both financial and environmental costs when making purchasing decisions. While governments assist with research and development program funding, reliance is primarily placed on market solutions. Technological breakthroughs and the adaptation of improved technologies ("best practices") result in the development of diverse energy sources and energy efficiency improvements. The new technologies produce and deliver goods and services more efficiently and cost-effectively. Consumers and producers embrace the new products and equipment which result from the technological advances. Productivity is higher in all sectors due to higher pace of technological improvements and the widespread application of new capital and new products. As a result, this scenario generates higher economic growth than the SP.

What is a possible path to Techno-Vert?

The TV scenario stems from a greater concern in North America about environmental degradation, potential health risks and quality of life. This public concern is translated into demand for cleaner and more efficient use of fuels and greater corporate accountability. When comparing various energy options, consumers consider factors beyond the commodity cost. These other factors might include things like healthcare costs due to air pollution or damage to the environment. Consequently, cleaner energy sources are in increasing demand by consumers who are willing to accept some costs in return for the environmental benefits.

Rapid Technological Improvements – Leading to Lower Energy Demand

Improvements and even breakthroughs on some technologies result in growing diversity in our energy sources and significant improvements in energy efficiencies. The North American economy benefits from technological improvements and experiences sustained long-term growth. The rapid diffusion of new technologies is more efficient in the use of resources in the production and delivery of goods and services than the economy represented in SP scenario. Thus, all sectors of the economy, including the energy sector, become more efficient (i.e., use less resources per unit of GDP). In Canada, the economy grows at a brisk annual average rate of 2.7 percent which enables further investment in technology and the environment. A corresponding increase in energy demand is experienced, particularly in the industrial sector to satisfy larger export markets for raw materials and manufactured products. Canadian consumer demand also increases due to a rapid growth in personal disposable incomes. Although the TV economy is larger than SP at the end of the projection period, total energy demand is lower.

Demand for energy increases throughout the projection period, but at declining rates as efficiency gains dampen the effect of growing demand that stems from higher economic growth. At the end of the projection period, the size of the Canadian economy is almost double the size it was in 2000, but energy consumption has only increased by about one third. General public acceptance of environmental responsibility enables governments at all levels to promote conservation, technology and improvements to housing and building standards. Not only do these new standards include better thermal efficiency for buildings and appliances, but also better designs which incorporate more passive lighting, heating and smart technology to control consumption based on occupancy and the time of the day. These gains are supplemented by innovative building and urban design which further increase efficiency. Building materials that generate electricity, such as solar panels, are used in niche areas. Combined heat and power systems are available commercially and become popular in the public sector to demonstrate advancements in energy efficiency.

In response to public concerns about the environment, strong government leadership on environmental action emerges globally, including Canada and the United States. International cooperation results in the implementation of a policy framework covering multi-national corporations. Government and consumer attitudes relating to emissions and pollution help to accelerate energy efficiency improvements in the industrial sector.

Companies, and ultimately the whole economy, benefit from higher returns and profits from capital investments in more productive and energy saving technologies. With increased investment and profitability for becoming greener, companies widely begin to pursue business practices which improve their triple bottom line accounting.

Some of the most dramatic reductions in energy demand stem from technological improvements and breakthroughs in road transportation and transportation fuels. By 2025, vehicles look and operate differently than today. Most vehicles operate on gasoline but the transportation sector is increasingly powered by diesel and alternative fuels. Moreover, cleaner fuels become more available and increased use of bio-fuels occurs early in the projection period. The application of advanced technologies such as variable valve timing and direct fuel injection improves overall fuel economy. For internal combustion engines operating on gasoline or diesel, weight reduction, engine/transmission enhancements and aerodynamics offer significant improvements as well. In addition, the introduction of hybrid electric vehicles and fuel cell vehicles in niche markets and on a small scale would markedly improve the efficiency of the vehicle stock. By the end of the period, hybrid electric vehicles and fuel cell vehicles begin to replace the internal combustion engine in courier and taxi fleets.

Energy Supply – Employing Technology and Becoming Cleaner

Natural Gas Supply

Continuous improvements in upstream technology enable natural gas supplies to keep pace with increases in demand. These technological improvements allow for the faster drilling of natural gas wells and the ability to reduce finding costs; consequently, industry is able to exploit smaller and smaller natural gas pools. As a result, an anticipated decline in conventional natural gas production is deferred.

Commercial success is experienced with CBM in Canada and with time CBM production increases as successful technology is widely applied. As production of conventional natural gas eventually declines, producers shift from small natural gas pools to CBM; as a result, CBM production continues its steady increase.

Additional natural gas supplies are provided from frontier areas, discoveries off the East Coast, a pipeline from Newfoundland and a pipeline from the Mackenzie Delta. To supplement these supplies, an LNG facility is constructed in eastern Canada. Later, natural gas production expands in the frontiers to satisfy growing demand. In the North, the first production is experienced from the Beaufort Sea. Advances in drilling in other northern areas allow producers to drill longer and faster and, at the same time, to leave a smaller environmental footprint. Overall, Canadian natural gas deliverability increases from 17 Bcf/d (482 million m^3/d) to 19 Bcf/d (538 million m^3/d) by 2015.

Oil Supply

Conventional light oil production in North America continues its long-term decline but, in time, the effect of advanced technology is manifested through a wider application of horizontal drilling and improved recovery techniques, including CO_2 flooding. These technologies slow the decline in conventional light crude oil and improve production rates.

The upward trend in conventional heavy crude oil production loses momentum early in the first decade in the face of more stringent environmental controls. Higher environmental costs and higher light/heavy price differentials discourage expansion of production.

Initially, several oil sands projects are postponed in a climate of uncertainty regarding costs of environmental compliance; some projects are eventually cancelled. Regulations, designed to limit environmental impact on a regional basis, are put into effect to address the issue of cumulative effects of oil sands expansion. Operators of oil sands projects and conventional heavy oil projects examine options that minimize the use of natural gas as a fuel source, such as bitumen gasification or vapour extraction (VAPEX). As new cost-effective technologies to meet higher environmental standards become available oil sands expansion resumes.

Canada's oil producers are able to utilize technology to rapidly ramp up production while meeting more stringent environmental standards. Over the 25-year projection period, in spite of falling conventional WCSB production, total oil production increases by 60 percent, with oil sands derived production increasing four fold.

Natural Gas Liquids Supply

As is the case in the SP scenario, supply of ethane tracks the decrease in conventional WCSB natural gas supply. However, small increments of ethane supply early in the period enhance production and help to flatten the decline rate. This supply is further supplemented with the commencement of a pipeline from the Mackenzie Delta. Eventually, about the middle of the outlook period, a shortfall develops which is less pronounced relative to the SP scenario.

Electricity Supply

Hydro power continues to be the primary source of electricity generation in Canada with the development of four new large-scale hydro projects. As well, the experience gained with existing small hydro projects, combined with further technological advances with small turbines and generators, leads to an expansion of small hydro facilities in most provinces.

In the short-term, greater reliance is placed on natural gas-fired generation because of its clean-burning properties and the shorter time period to develop these facilities. In the longer term, however, new electric power generation comes from integrated coal gasification combined cycle (IGCC) and nuclear power plants as they replace conventional coal-fired units.

Accelerated investment in research leads to growth in alternative technologies and renewable fuels. By 2025, renewable fuels (wind, biomass and small hydro) account for ten percent of total electricity generation in Canada.

New nuclear facilities, based on the Advanced CANDU reactor, are located on the sites of existing nuclear facilities as advancements in technology for safety and waste disposal provide for wider public acceptance of these plants.

Fuel Cell Vehicle (FCV)

Fuel cells create electricity through an electrochemical process that combines hydrogen and oxygen. The vehicle motor is powered by the electricity created through this process. Every automobile manufacturer has been researching and developing some type of FCV. Several car manufacturers predict that full commercialization of FCVs will occur within the decade. There is widespread agreement that initial penetration would begin with fleet vehicles. Fleet vehicle penetration has been identified as the best way to gain real world experience with FCVs. It allows for continuing refinement of the FCV and additional time to solve hydrogen and/or methanol fuelling issues.

There are number of obstacles to the penetration of FCVs:

- High price relative to the conventional automobile
- Size and weight of the FCV, hydrogen tanks and reformers
- Infrastructure for the production/distribution of hydrogen or methanol – the two prime fuel candidates for fueling FCVs
- Issues surrounding vehicles parts and trained mechanics
- Safety issues associated with hydrogen and methanol storage
- Higher costs of fuels relative to gasoline
- FCV performance in cold temperatures

In the TV scenario, no new conventional coal plants are built after 2010. However, IGCC coal generation becomes cost competitive and replaces older coal units, mainly in Alberta and Ontario. New units are developed in British Columbia and Saskatchewan. Clean coal technologies, including IGCC, have enabled coal to remain in the overall fuel mix. The IGCC plants are prime candidates for the adoption of carbon sequestration technology as the exhaust gas from these plants is rich in CO_2 and lack other pollutants such as sulphur oxides and nitrogen oxides.

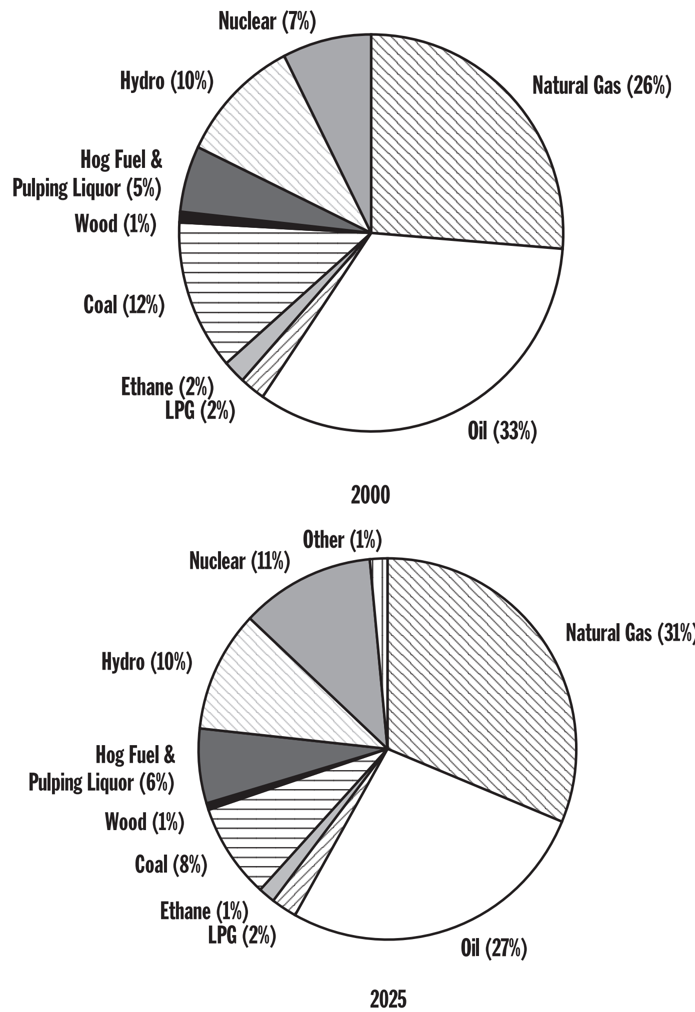
Summary

Small shifts in the Canadian energy demand picture have taken place over a quarter century through diligent efforts to increase energy efficiencies which have lead to lower energy intensity overall. Despite improved energy efficiency, Canadian energy demand has continued to increase to 14 742 PJ by 2025 because of structural constraints on how energy is used in Canada.

Traditional fuels remain important in 2025 but the seeds of change have been planted as North American, and specifically Canadian, energy use is moving towards cleaner fuels and cleaner and/or more efficient use of traditional fuels.

Alternative technologies and renewable fuels have shown impressive growth with an annual average growth rate of about 10 percent over the projection period but their contribution to the overall fuel mix remains a small component of total energy demand by 2025. However, the introduction of these new fuels provides the opportunity for their greater use in Canada's long-term energy future (Figure 2.2).

Figure 2.2 Primary Fuel Shares – 2000 versus 2025



3.0 Macroeconomic and Energy Price Assumptions

3.1 Macroeconomic Assumptions

The projection of economic growth is an essential component in the formulation of energy supply and demand outlooks in the two scenarios. The review and analysis of the major economic inputs and assumptions and their potential impact form the basis for these economic projections. These projections provide outlooks and set out the fundamental assumptions, by region and by sector, for major factors which drive energy demand. Demographic trends, such as population growth, personal incomes, and household formation play a critical role.

Informetrica Limited prepared macroeconomic outlooks based on the Board's scenarios. Table 3.1 shows the main economic indicators underpinning both energy outlooks.

Population is a key factor in projecting economic growth. The same demographic outlook was used for both scenarios. Provinces with the fastest population growth will also experience the fastest economic growth. The population projection reflects current Canadian policy on immigration, which is assumed not to change over the projection period in either scenario. Immigration levels are estimated to remain flat at 250 000 in-migrants per year from 2001 forward, and out-migration is estimated to be approximately 30 percent of this amount. This results in net immigration of approximately 174 000 people per year.

Table 3.1 Main Economic Indicators - Canada (average annual percent change)

		2001-10		2011-20		2021-25	
	1990-00	SP	TV	SP	TV	SP	TV
Real GDP	2.6%	2.7%	2.9%	2.1%	2.6%	1.4%	2.5%
Inflation (CPI)	2.0%	1.9%	1.9%	2.0%	2.0%	2.1%	2.4%
Real Exchange Rate*	0.87	0.64	0.66	0.74	0.74	0.84	0.79
Population	1.0%	0.8%	0.8%	0.6%	0.6%	0.4%	0.4%
Households	1.6%	1.3%	1.3%	1.1%	1.1%	1.0%	0.9%
Real Household Disposable Income	-0.7%	1.2%	1.6%	0.7%	1.4%	0.5%	0.8%
Labour Productivity	1.4%	1.3%	1.5%	1.3%	1.7%	1.4%	2.1%

* end of period
Source: Informetrica, January 2002 and March 2003

It is expected that population growth will slow considerably over the course of the projection period. Household growth also slows; however, it continues at about double the rate of population growth. Demographic trends point to an increase in the average age of the population. The workforce participation rate[1] will change little, or may increase slightly in the current decade.

In SP, as baby-boomers begin to retire, the participation rate declines from about 66 percent to about 64.5 percent. The effect of this decline is offset by the assumption of a moderate increase in labour productivity.

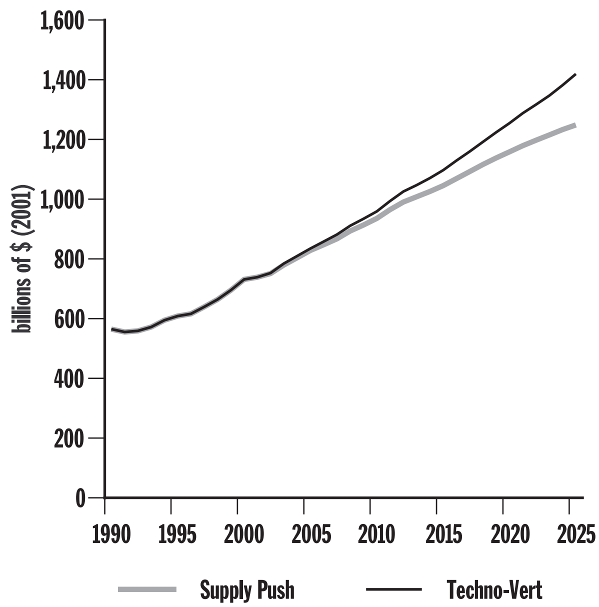
As the economy grows, people have more income - even after adjusting for inflation - and households have more spending money available. However, consumption falls in the latter part of the projection as the population ages and people begin saving money for their retirement rather than spending it. The elderly population places more demands on services such as health care, and requires fewer goods, such as large new homes and other big-ticket items, so demand shifts from goods to service industries. The service industries have lower productivity levels than the goods-producing industries.

In SP, real gross domestic product (GDP) grows by 2.2 percent per year from 2000-2025 (Figure 3.1). Table 3.1 shows that the growth rate is higher in the first decade and then slows as the aging population reduces its demand. The Canadian dollar is assumed to appreciate against the U.S. dollar. In this outlook, inflation is restrained over the medium and longer term, although some pressures emerge in later years as the unemployment rate nears three percent.

In the TV scenario, new technologies will develop at a more rapid pace and their influence spreads to all sectors of the economy as new technology developed in one field is adapted and used in other fields, including the energy demand and supply sectors. New technology also leads to lower costs for a variety of produced goods. Therefore, the outlook prepared for the TV scenario provides a view of a more rapidly growing economy.

In addition, Canadians are assumed to make more effort to find environmental solutions in the TV scenario, including greater emphasis on developing improved methods of production. Some of these efforts would focus on energy efficient technology being added to the capital stock.

Figure 3.1 Canadian Gross Domestic Product



In TV, as new technologies develop at a more rapid pace, Canadians may seek more training and education. A more educated population is more likely to work, and people with more education tend to work until they are older, so the net result should be a moderate increase in the supply of labour. The participation rate rises marginally from 66 percent to 66.7 percent by 2025 in this scenario.

Developing improved methods of production also requires firms to increase their level of investment; thus investment in the overall economy increases, particularly in new equipment and the types of equipment that use more resources (for example, electronic or motorized equipment may replace manual labour). This effect is cumulative over time, particularly after 2010, and adds to the capital stock. The increased capital stock also supports improved labour productivity. In the TV scenario, the gains in productivity result in better earnings by firms, and more money is available for re-investment. Firms also increase

[1] The portion of the population that is employed or seeking employment.

dividend payments to households so real disposable income in 2025 is about 12 percent higher in TV than it is in SP.

Because of the rapid diffusion of new and efficient technologies, the TV economy uses resources more efficiently when producing and delivering goods and services compared with the SP economy. All sectors of the economy, including the energy sector, become more efficient and fewer resources are used in the production of each unit of GDP.

In TV, the average annual economic growth for Canada between 2000 and 2025 is 2.7 percent, albeit with considerable variation between provinces, reflecting the economic structure of each individual province. This variation by province is also true of the SP scenario, although the average growth rate is a more moderate 2.2 percent.

These projections portray long-term trends, guided by the principle of potential economic growth. Growth may be above or below the projections in any given time period, due to business cycles or other factors.

Table 3.2 Regional Economic Growth Rates (average annual percent change)

	1990-00	2000-2025	
		SP	TV
Newfoundland	1.3%	2.5%	2.8%
Prince Edward Island	2.7%	1.5%	1.8%
Nova Scotia	1.9%	1.7%	2.0%
New Brunswick	2.2%	1.7%	2.0%
Québec	2.2%	2.2%	2.6%
Ontario	3.1%	2.4%	2.9%
Manitoba	2.1%	2.0%	2.3%
Saskatchewan	2.4%	1.8%	2.2%
Alberta	3.3%	2.3%	2.9%
British Columbia and Territories	2.5%	2.1%	2.5%

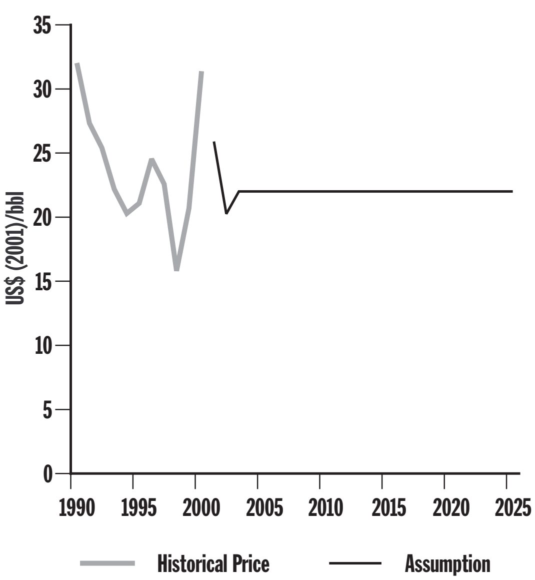
3.2. Energy Price Assumptions

Oil Price

An oil price of US$22 per barrel (West Texas Intermediate (WTI), US$ 2001) over the projection period was assumed for both scenarios (Figure 3.2). In essence, this means that enough world oil supplies will be available at this price to accommodate increases in demand. Canadian prices reflect the WTI price adjusted for transportation, quality and the exchange rate. Transportation costs, distribution margins and taxes were held constant at 2000 levels. While the basic oil price assumption is flat, many factors (OPEC policies, supply disruptions, or economic growth) could cause volatility in oil prices over the projection period.

The differential price between light and heavy crude oil is defined as the Edmonton Par Light price minus the Hardisty Heavy price. In SP, the differential remains at its average over the last decade, US$5.50 per barrel, while it increases steadily to average US$7.50 per barrel in TV.

Figure 3.2 West Texas Intermediate Oil Price



Natural Gas Price

Since different fuels derived from crude oil and natural gas can be used to meet demand, there is competition between fuels, especially in some key U.S. regional markets. As a result, the price of natural gas has generally been in line with heavy fuel oil (HFO) prices in these markets. The market's ability to adjust or switch between fuels is limited, so this price relationship breaks down when there is a significant swing in the supply or demand of either fuel.

In both scenarios, natural gas and crude-derived fuel oils continue to compete, particularly low sulphur (i.e. less than one percent) heavy fuel oil and lighter distillate fuel oil (LFO). In the past, when natural gas has been relatively abundant or fuel oil has been scarce, the prices of natural gas have been similar to or lower than the price of heavy fuel oil, about 60 to 80 percent of the crude oil price. Conversely, when natural gas supply has been tight, the relative price of natural gas has risen and at times exceeded the price of distillate fuel. For example, the natural gas price was approximately 20 percent higher than the crude oil price during the winter of 2000/01.

Competition between fuels will continue in both the SP and TV scenarios. In both scenarios, the natural gas supply-demand balance is characterized as tighter (relative to historical periods of abundance). The SP scenario assumes a natural gas-to-crude oil price relationship of 0.83, rising over the projection period to 0.9 (i.e., from US$ 2.92 in 2002 to US$ 3.58, US$ 2001). In the TV scenario, there is a stronger preference for natural gas and cleaner fuel oils for environmental reasons. We assume the natural gas price reaches parity with crude oil by 2010 (US$ 4.05, US$ 2001). Figure 3.3 illustrates that we are assuming higher natural gas prices in both scenarios than seen in the past decade. Transportation costs, distribution margins and taxes were held constant at 2000 levels to derive end-user prices.

Figure 3.3 NYMEX Natural Gas Price at Henry Hub

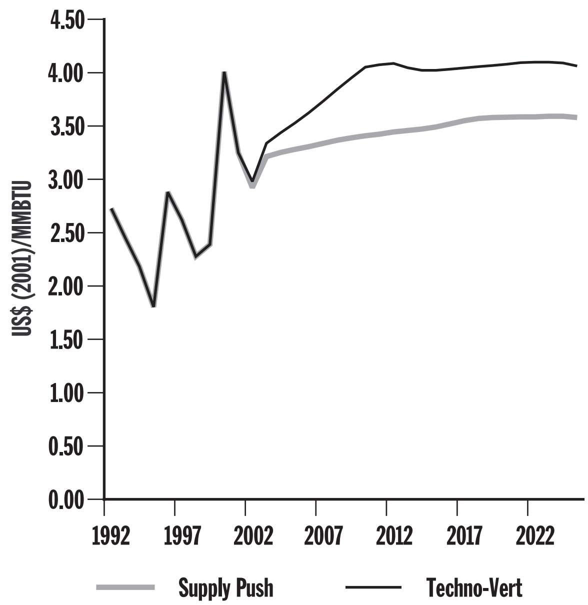
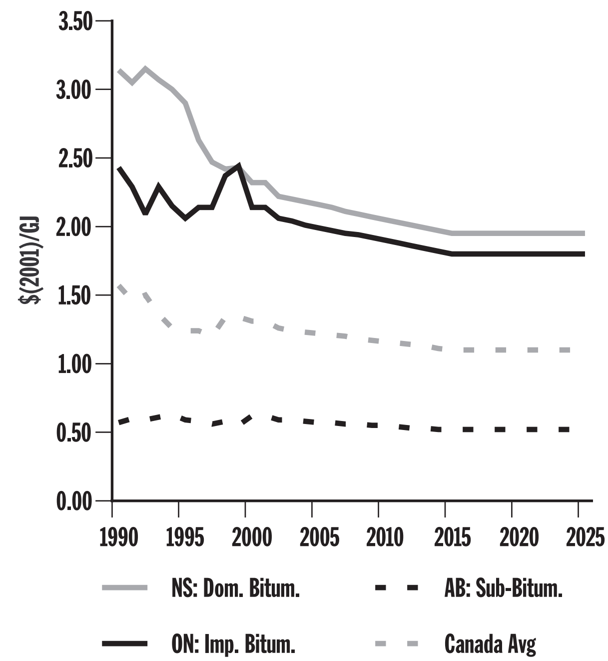


Figure 3.4 Canadian Electric Utility Coal Prices



Coal Prices

Coal prices are determined by supply and demand dynamics in a competitive world market. Over the past 15 to 20 years, mergers in the mining and railway industries, along with technological improvements, have increased efficiency and reduced transportation costs. Reflecting these trends, coal prices in Canada and the U.S. have declined by two to four percent annually. Continued efficiency improvements are assumed. In both scenarios, coal prices decline by one percent per year to 2015, then remain at these levels until 2025 (Figure 3.4).

Electricity Prices

Electricity prices remain regulated in most provinces. Although Alberta and Ontario have introduced competition into the retail market, other provinces have either limited or no retail competition. Both scenarios assume continuation of current provincial policies.

Price differences between provinces continue, largely because of different resource costs for generation, particularly when comparing those provinces with large hydro endowments with those which rely mostly on thermal generation. These price differences could be reduced to the extent that the respective electric utilities (or marketers) can reduce power costs by acquiring lower-cost power from adjacent jurisdictions.

In general, electricity prices in the TV scenario are higher than in the SP scenario, in keeping with the relatively higher cost of natural gas-fired generation in TV.

3.3 Key Uncertainties

➢ Technology

The single most important factor in differentiating the two scenarios is the pace of technological development and its impact on the economy. The TV scenario assumes that new technologies will develop at a more rapid pace leading to higher productivity and higher economic growth. We assume that new technologies and their influence will spread to all sectors of the economy and lead to lower costs for a variety of produced goods. The pace and the extent to which this occurs are very uncertain. Other factors like economic recessions, geopolitical events or actions taken to address environmental concerns could impact Canadian economic growth over the projection period.

➢ Participation Rate

The aging population also greatly impacts economic growth and energy demand. The population projection is the same for both scenarios; however the aging population contributes to the declining growth in the labour force in the SP scenario. Since productivity is assumed not to increase significantly in this scenario, economic growth slows. As the baby-boomer generation approaches retirement, the share of the population over age 65 climbs steeply, beginning in 2010. This could result in a shortfall of workers and corresponding changes to the marketplace. For example, the labour shortfall may result in higher wages, particularly for skilled or experienced workers. Some workers who are eligible to retire may continue working to take advantage of the higher wages, tempering the labour force decline. This is expected to happen to some extent in the TV scenario; however, if it also happened in the SP scenario, economic growth could be higher than projected.

➢ Cultural Change

The population will age, but we do not know whether or not older consumers' habits will be different from younger consumers' habits. This creates a number of uncertainties for future economic growth. These may include the number and type of new vehicles purchased and the demand for multiple-unit housing over single-family dwellings.

4.0 Energy Demand in Canada

4.1 Total Canadian Energy Demand

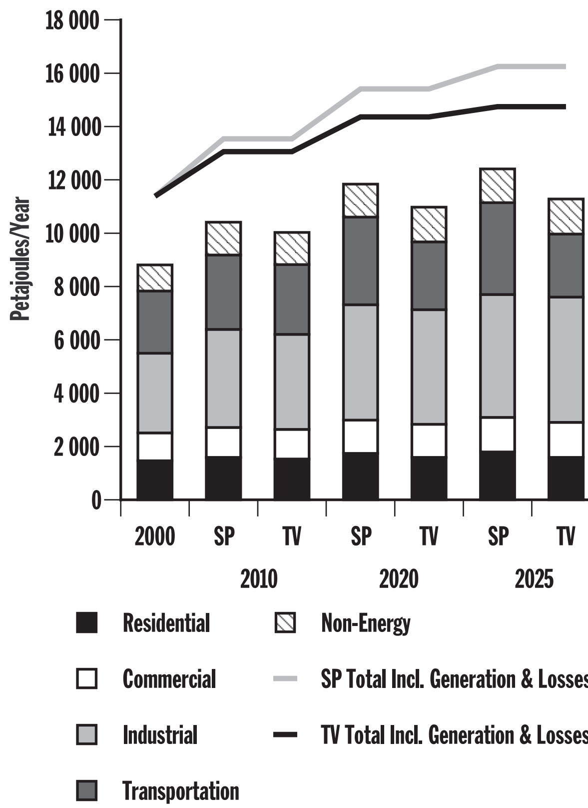
Canadian energy demand is driven by three major factors: population, size and growth of the Canadian economy. The number of people will directly impact the energy requirements for the housing, transportation, and service sectors. The structure and rate of growth of the economy influences energy demand for various industries, commercial transportation, and other end-use sectors. Energy demand is also influenced by demographics and technological advancements. This section examines total Canadian energy demand, with each end-use sector discussed in greater detail in subsequent sections. One limitation of the analysis is that the energy requirements for producing ethanol, methanol or hydrogen were not calculated. Therefore, total energy demand is underestimated.

The industrial and transportation sectors represent the largest sectors of energy end-use today, at 26 percent and 21 percent of total demand, respectively (Figure 4.1).

Although demand grows in all sectors in both scenarios, the greatest increases will occur in the industrial sector. Demand growth is significantly lower in TV than in SP, particularly in the transportation sector.

By 2025, total energy demand in TV is nine percent lower compared to the SP scenario. The higher economic growth in TV is offset by conservation measures, improved technology and structural changes in consuming sectors. Both scenarios see a marked improvement in energy intensity: about 30 percent less than today in TV, and about 15 percent lower in SP.

Figure 4.1 Total Canadian Energy Demand by Sector



In most cases, changes in energy consumption technology or fuel type will be dependent on infrastructure, which will limit the degree and pace of change within each sector. End users that are able to use alternative fuels or those with easily adaptable infrastructure may change more quickly to new fuel sources. For other users, costly infrastructure changes may be required, so change happens gradually.

Figure 4.2 Historical vs. Projected Canadian Energy Demand

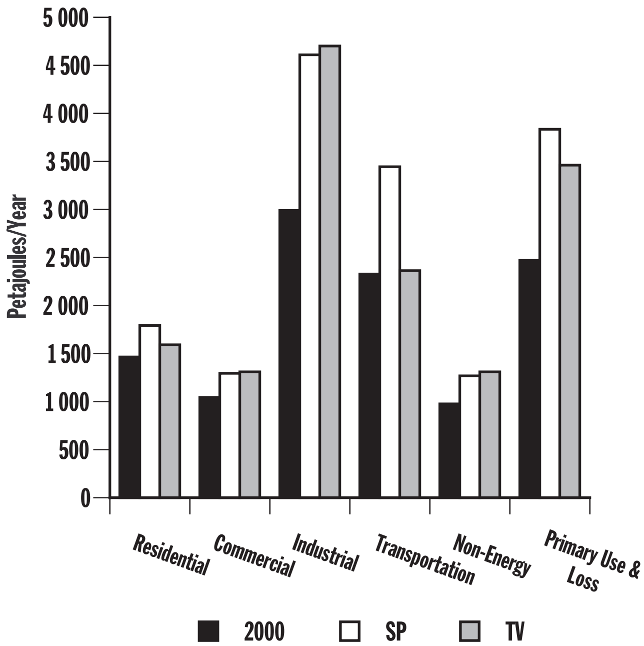
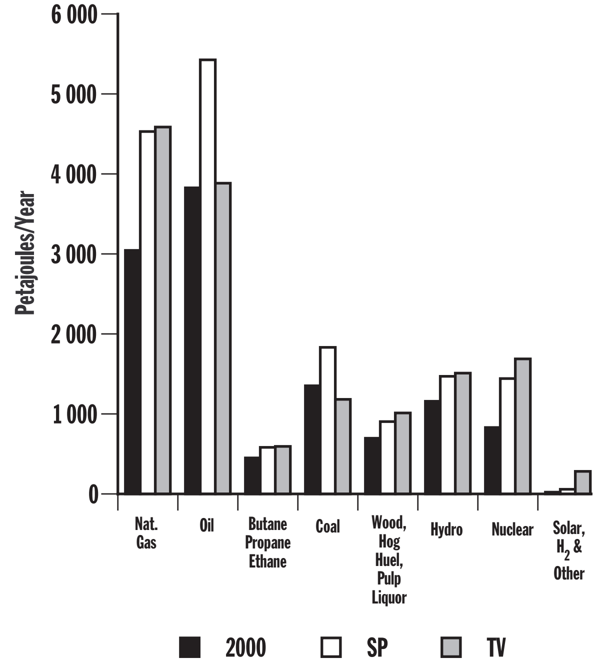


Figure 4.3 Historical vs. Projected Energy Demand by Fuel



Total energy requirements will increase in both scenarios; however, the rate of increase will be significantly lower than the growth rate in the Canadian economy. Overall, total energy demand in 2025 will be 33 percent higher in TV and 46 percent higher in SP, compared to 2000 levels. Total energy demand grows about 1.4 percent per year in SP and about 1.0 percent in TV. In comparison, the annual average GDP is projected to rise 2.2 percent in SP and 2.7 percent in TV (Figure 4.2).

The greatest difference between scenarios is in the choice of fuels used (Figure 4.3). SP relies primarily on existing sources of conventional fuels to meet Canadian energy needs and to provide energy security. The decline in supply of conventional natural gas from the WCSB results in a greater reliance on other fossil fuels such as coal and oil. The slower rate of technological advancement in SP limits the rate of development and use of alternative fuels.

In TV, greater environmental awareness and action shifts future fuel choices towards natural gas, hydro, nuclear, and other forms of energy. Greater technological advancements improve the economics of alternative technologies and renewable fuels. However, fossil fuels remain a key source of energy in both scenarios, despite the emergence and application of alternative fuels and technologies.

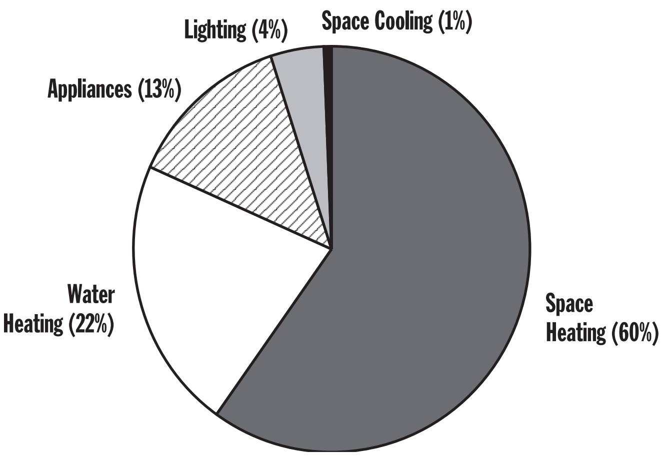
Table 4.1 Average Annual Rate of Change

	1990-2000	SP	TV
Cdn. GDP	2.7%	2.2%	2.7%
Households	1.6%	1.2%	1.1%
Energy Intensity	-0.8%	-1.2%	-1.6%
Energy Demand	1.9 %	1.4 %	1.0%

4.2 Canadian Residential Sector Energy Demand

Residential energy demand is primarily driven by requirements for space and water heating, which accounts for about 80 percent of the total energy used in this sector (Figure 4.4). The other major uses of energy are lighting, operating appliances and other equipment. Demand grows with population and depends on the number of households and energy consumed per household. Since these factors are very similar in both scenarios, the variations in demand will reflect differences in housing and equipment efficiency and energy intensity.

Figure 4.4 2000 Residential Energy Demand by End Use



Residential energy demand is primarily driven by requirements for space and water heating, which accounts for about 80 percent of the total energy used in this sector (Figure 4.4). The other major uses of energy are lighting, operating appliances and other equipment. Demand grows with population and depends on the number of households and energy consumed per household. Since these factors are very similar in both scenarios, the variations in demand will reflect differences in housing and equipment efficiency and energy intensity.

The most significant variable affecting household energy intensity across these scenarios is not technology. Many energy saving technologies that are economic options are available today. For example, some large residential and commercial buildings use district (shared) heating systems. Solar or other alternative energy sources can be used to produce domestic hot water. Thus the stimulus and rate at which action is taken to implement such technology or alter current household consumption behaviour is the deciding factor. Furthermore, it is generally easier and less expensive to use new, better equipment in new installations rather than to retrofit existing equipment. As a result, the pace of change is limited by the rate of new construction and stock turnover in existing housing and equipment.

Figure 4.5 Projected Residential Energy Demand (excluding diesel for farm equipment)

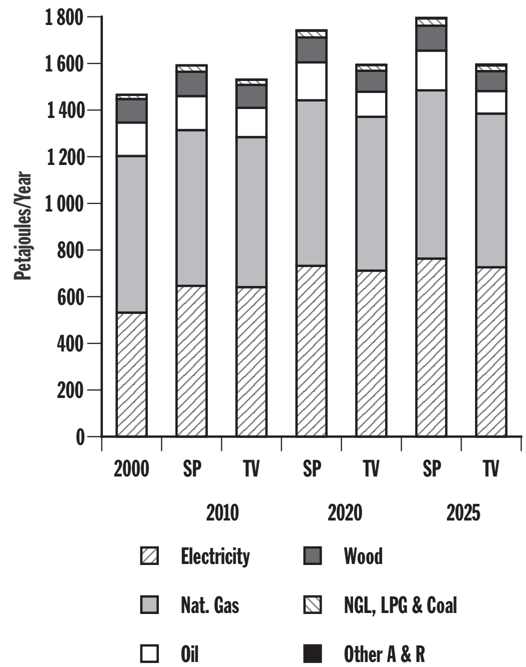


Figure 4.6 Residential Energy Fuel Share

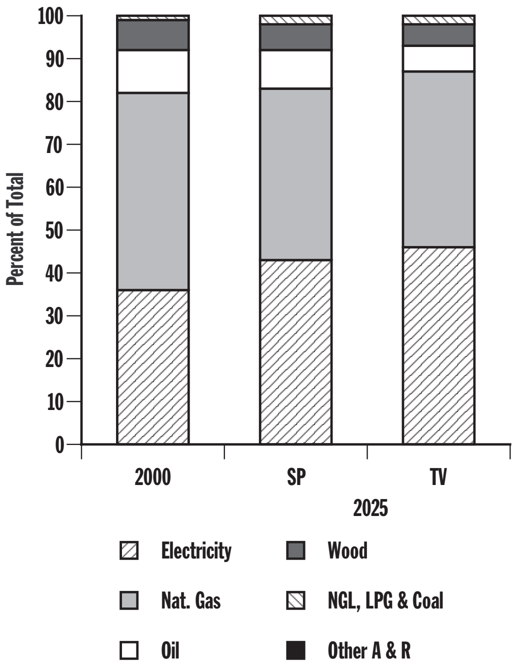
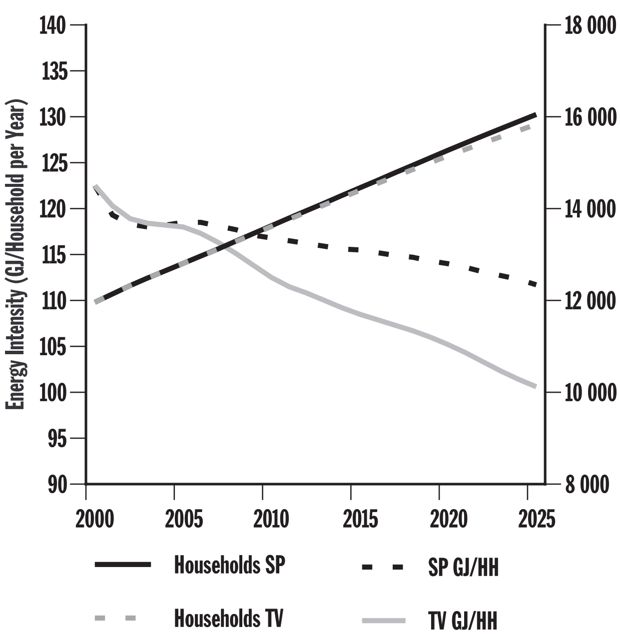


Figure 4.7 Residential Energy Intensity Projection



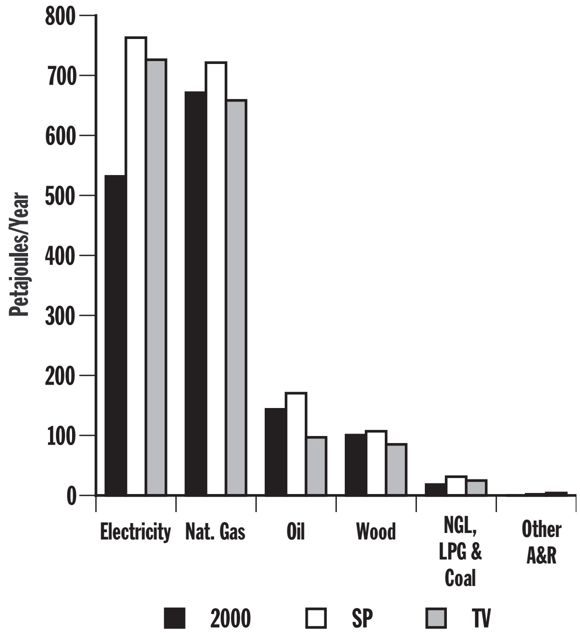
Both scenarios assume that future housing will be more efficient than the residences of today. TV assumes greater advancements in housing and equipment standards, improved technology, and more intense efforts by consumers to reduce consumption than in SP. New residences will be between 10 percent to 40 percent more efficient than new housing available today in the SP and TV scenarios, respectively. This dramatic improvement in energy efficiency, however, only applies to new residences, which accounts for about one percent of total residences per year. Therefore, its impact is limited.

In the future, changes in consumer behavior, improvements to existing residences and more efficient new housing will all improve the average energy intensity in Canadian households (Figure 4.7). However, these improvements are offset by increases in energy demand (mainly electricity for small appliances) driven by greater consumer affluence. New technology and upgrades are effective, but limited by the rate of new housing construction and slow equipment turnover. However, overall energy intensity in the residential sector is projected to improve in both scenarios, by about 9 percent in the SP scenario and by about 18 percent in TV.

In both scenarios, housing and equipment upgrades as well as turnover of stock occur more quickly than at historical rates. In SP, this is attributed to greater price volatility resulting from tighter energy balances. However, stock turnover and upgrades are greatest in TV, driven by stricter building and environmental standards, government incentives, and an improved use of technology leading to more consumer options such as more efficient appliances.

Fuel choice will continue to be heavily influenced by regional fuel availability and local infrastructure to deliver it. Growing electricity demand and continued improvement to the thermal efficiency of housing and furnaces suggests that electricity will capture a relatively larger share of residential fuel demand.

Figure 4.8 Residential Energy Demand by Fuel



A stronger shift in residential fuel share towards electricity, natural gas, and other alternative forms of energy (e.g., solar) occurs in TV (Figure 4.8). However, this trend is limited by the projection timeframe and is greatest in areas of new development or new access to non-traditional fuels. Natural gas market penetration in Atlantic Canada also depends on supply development which varies between scenarios.

Both scenarios project an increase in the use of alternative technologies and renewable fuels. Wood will continue to be the largest source, accounting for up to 18 percent of residential energy use in some regions. In comparison, despite a substantial projected increase in use, solar energy will comprise a mere one percent of total residential demand.

4.3 Canadian Commercial Sector Energy Demand

Economic growth and population are the main drivers influencing energy demand in the Canadian commercial sector. This broad sector includes the buildings and infrastructure used to support the services necessary for a growing economy and changing population. Examples of end-users in this sector include: government and public buildings, offices, hotels, restaurants, schools, other educational institutions, warehouses, healthcare and hospitals, retail, religious, and recreational establishments.

Similar to the residential sector, space and water heating are the primary uses of energy in the commercial sector, making up about 60 percent of the total energy used (Figure 4.9). Other major draws on energy include lighting, equipment operation and space cooling. This rising energy demand in the commercial sector is driven by economic growth, consumer spending, and a growing population (Figure 4.10).

Figure 4.9 2000 Commercial Energy Demand by End Use

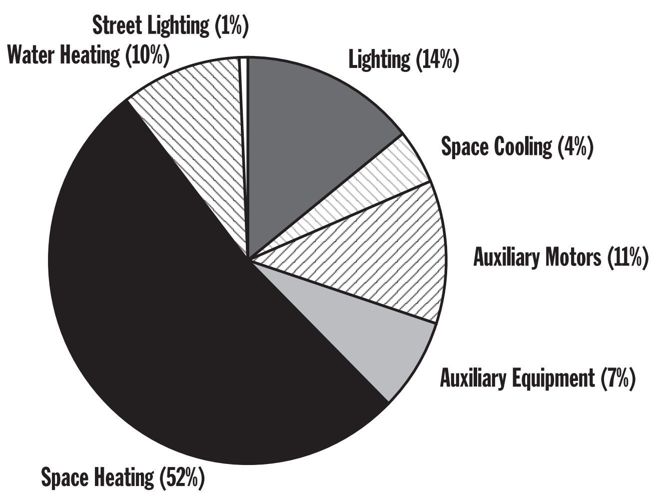
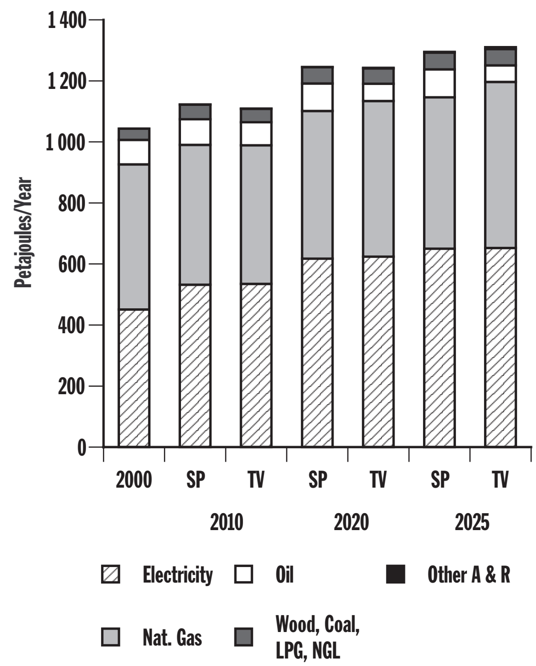


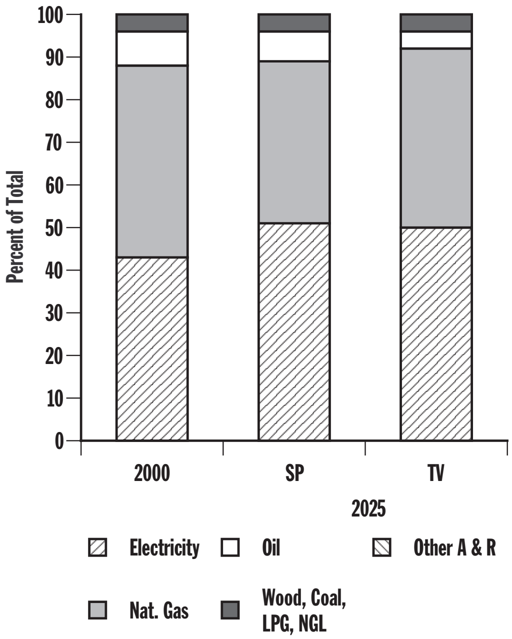
Figure 4.10 Projected Commercial Energy Demand



Potential energy efficiency improvements are greater in the commercial sector than in the residential sector due to the larger size of buildings and a greater share of new building additions. However, the rate at which new buildings are added and at which the stock of existing buildings are turned over limits the overall improvement in energy consumption. In general, the better economies of scale achieved with larger installations and greater participation by governments through public buildings and institutions enables a greater use of energy saving technology and alternative forms of energy in this sector (e.g., district heat and power, or solar hot water systems).

Fuel choice in the commercial sector continues to be largely determined by regional fuel availability and the local delivery infrastructure. In both scenarios, energy demand rises by about 25 percent from current levels, with natural gas and electricity continuing to account for about 90 percent of total energy demand in this sector (Figure 4.11).

Figure 4.11 Commercial Energy Fuel Share



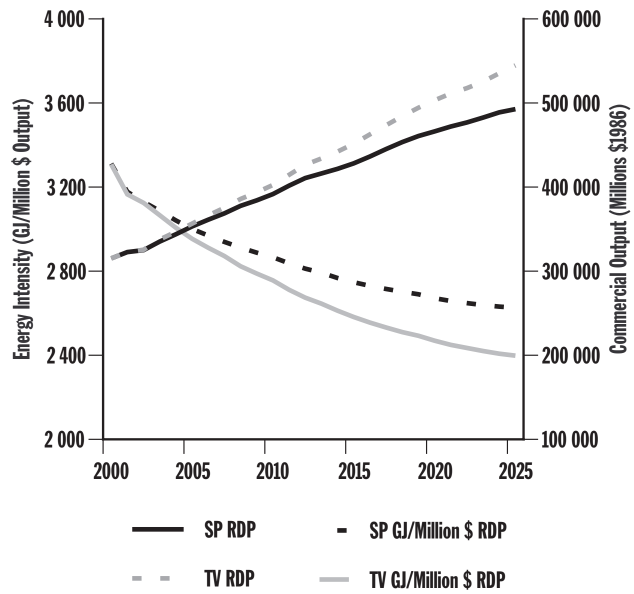
Total energy demand in the commercial sector increases in both scenarios; however, the rate of increase is significantly lower than economic growth (Table 4.2). Energy intensity for this sector is improved through energy conservation, better building standards, more energy efficient technology, and upgrades and improvements to existing facilities.

Table 4.2 Average Annual Rate of Change

	1990-2000	SP	TV
Commercial Sector Economic Growth	2.5%	1.8%	2.2%
Energy Intensity	-0.6%	-0.9%	-1.3%
Comm. Energy Demand	1.9%	0.9%	0.9%

While new commercial buildings and equipment may be more efficient than existing stock, the overall change in energy intensity is limited by the low rate of upgrade and turnover in existing floor space and equipment. In 2025, new commercial buildings will be up to 30 percent more efficient than new buildings available today in SP and 50 percent in TV. However, when the slow rate of turnover and upgrades are taken into account, the overall changes in energy intensity falls to 20 percent and 30 percent, respectively (Figure 4.12).

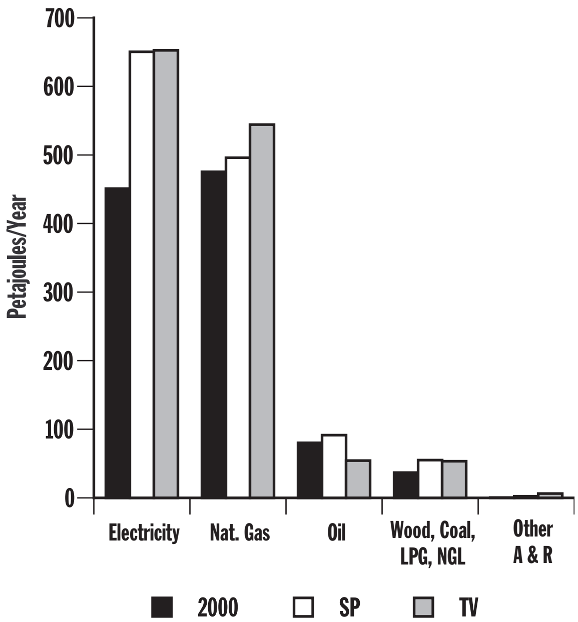
Figure 4.12 Commercial Energy Intensity Projection



The TV scenario has a strong focus on environmental drivers. This leads to higher efficiency standards, improved building design, further advancement in alternative energy, and more energy-efficient technology. In this scenario, future building designs will make greater use of combined heat and power systems or solar energy, especially for passive heating and lighting. Government will support programs that promote more efficient technology for use in public buildings and encourage alternative forms of energy. Alternative fuels and technology (e.g., solar for hot water and combined heat and power systems) will be used in niche markets toward the end of the period, so their effects in the projection period are limited.

Although energy intensity improves, economic growth leads to a greater demand for commercial floor space, which in turn leads to higher commercial energy requirements (Figure 4.12). Both scenarios project total commercial energy demand will be about 25 percent higher in 2025, compared to today's levels. Efficiency improves in the TV scenario, especially in lighting, thermal efficiency, and water heating technology. Therefore, despite having a significantly higher rate of economic growth, the overall demand for energy is only slightly higher than in the SP scenario.

Figure 4.13 Commercial Energy Demand by Fuel

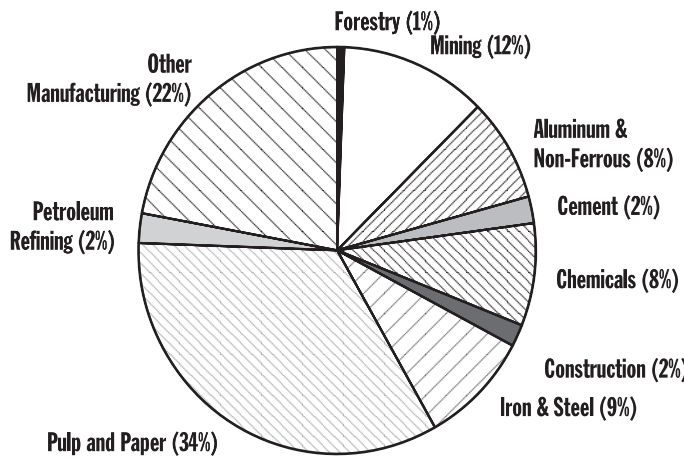


As electricity demand grows and thermal efficiency improves in buildings and equipment, the overall fuel share in this sector gradually shifts towards electricity (Figure 4.13). However, fossil fuels will still remain a key fuel source, especially in existing buildings where conversion costs may be prohibitive. In TV, there is a larger shift to electricity, as well as to natural gas and other alternative forms of energy (e.g., solar). The shift in fuel from traditional sources, however, is limited in the projection timeframe and is greatest in areas of new development or new access to non-traditional fuels (e.g., Atlantic Canada access to natural gas) where economics of new fuel infrastructure are more favorable. Natural gas market penetration in Atlantic Canada is also very dependent on supply development, which varies greatly between scenarios.

4.4 Canadian Industrial Sector Energy Demand

The growth in North American economies influences the type and the amount of products required from Canadian industry. In both scenarios, industrial output will grow, although the rate of growth will differ for each industry (Figure 4.16). Technological advancements, fuel options, and structural changes in each industry may also vary, and will influence the overall energy demand in the industrial sector.

Figure 4.14 2000 Industrial Demand by Industry



In general, energy use per unit of output is relatively higher in industries that process raw materials than in industries engaged in light manufacturing. In both scenarios, the pulp and paper, mining, and manufacturing sectors are the largest energy users, accounting for about 70 percent of total industrial demand (Figures 4.14, 4.15).

Industrial users are usually the most directly impacted by energy commodity prices. Large users with the ability to switch fuels can ensure access to a reliable energy source and can mitigate short-term fuel price fluctuations; however, the capital requirement needed to develop alternative fuel capability is large. These factors influence the fuel choices for many industries (where alternatives are available), and lead to significant differences in fuel mix across scenarios. In TV, industries have the technological means to develop alternative fuel sources, while SP assumes a higher reliance on existing fuel sources.

Total energy demand in the industrial sector increases in both scenarios; however, the rate of increase will be significantly lower than the economic growth rate (Table 4.3). Energy intensity for this sector is reduced, largely through improved efficiency, greater use of technology and structural changes in key industries. The share of fuels used in particular industries is quite different under each scenario (Figures 4.16, 4.17).

Figure 4.15 Industrial RDP by Sub-Sector

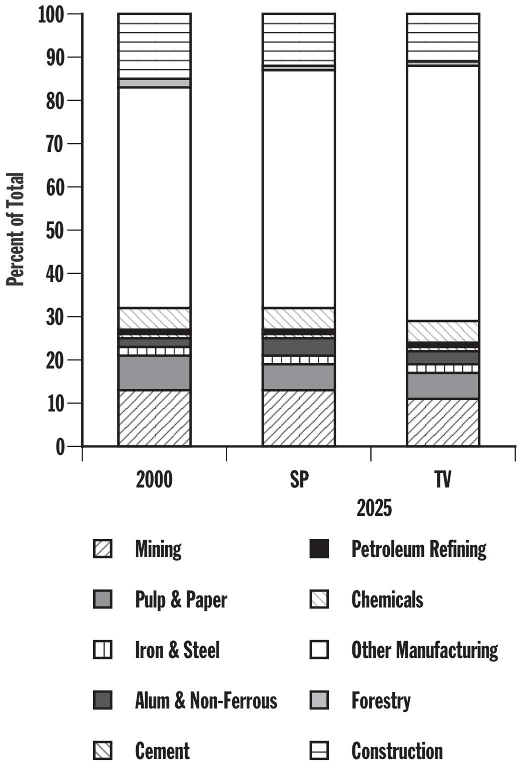


Figure 4.16 Projected Industrial Energy Demand

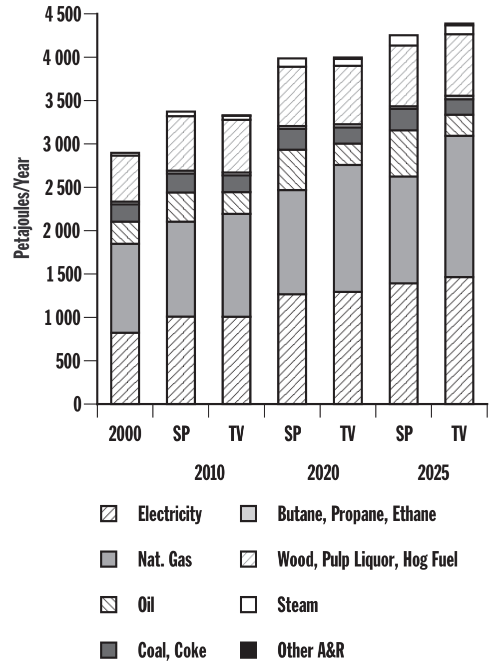


Figure 4.17 Industrial Energy Fuel Share

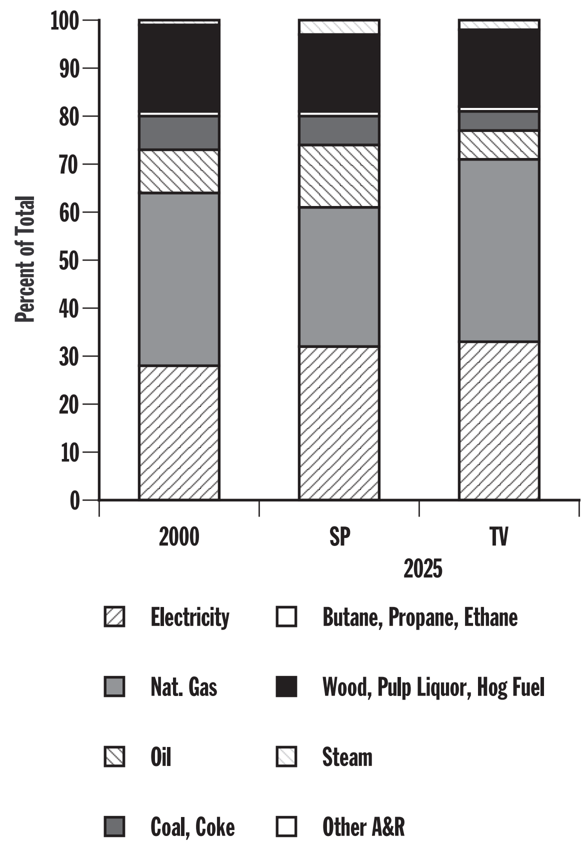
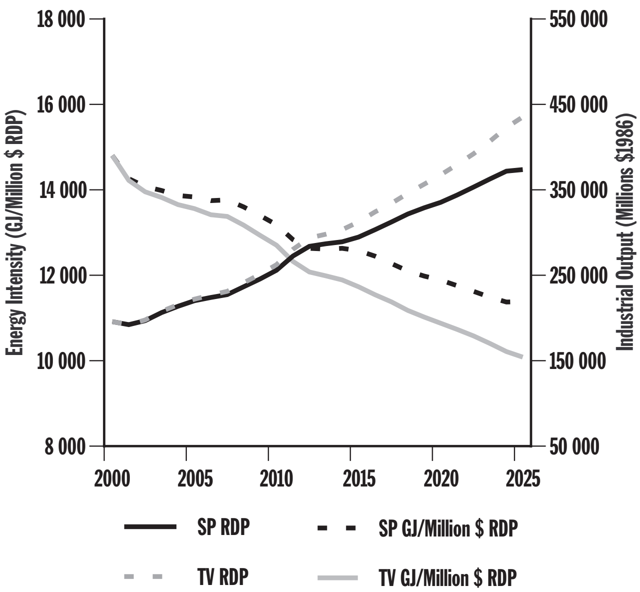


Table 4.3 Average Annual Rate of Change

	1990 - 2000	SP	TV
Industrial Sector Economic Growth	2.8%	2.6%	3.3%
Energy Intensity	-1.0%	- 1.0%	-1.5%
Energy Demand	1.8 %	1.6%	1.7%

Figure 4.18 Industrial Energy Intensity Projection



Energy intensity varies greatly across industries, depending on the processes employed, and the structure or mix of processes used in each industry (Figure 4.19). A shift in the economy towards light manufacturing, greater use of imported semi-finished goods, and energy efficiency improvements all lower the overall projected industrial energy intensity in both scenarios. Energy intensity improvements are expected in all industries, with the possible exception of forestry (logging) and mining (includes oil and gas) sectors (Figure 18). These sectors will likely require development of more remote and difficult to access resources, thus requiring more energy to produce (Figure 4.19).

Figure 4.19 Projected Industrial Demand by Industry

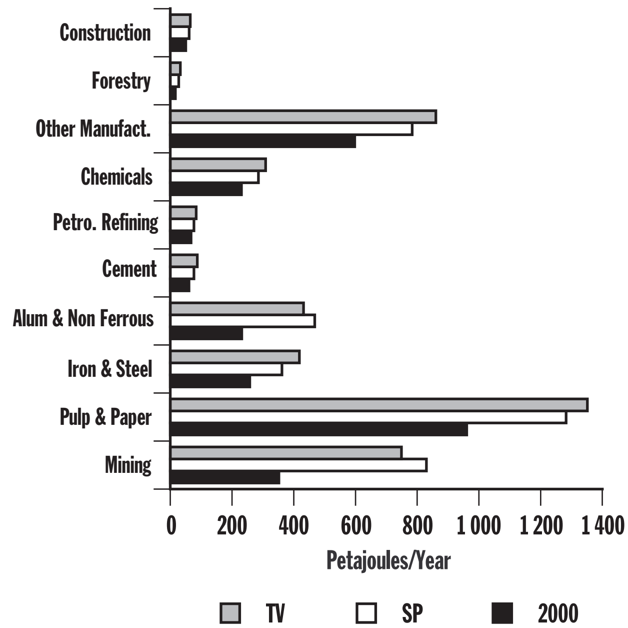
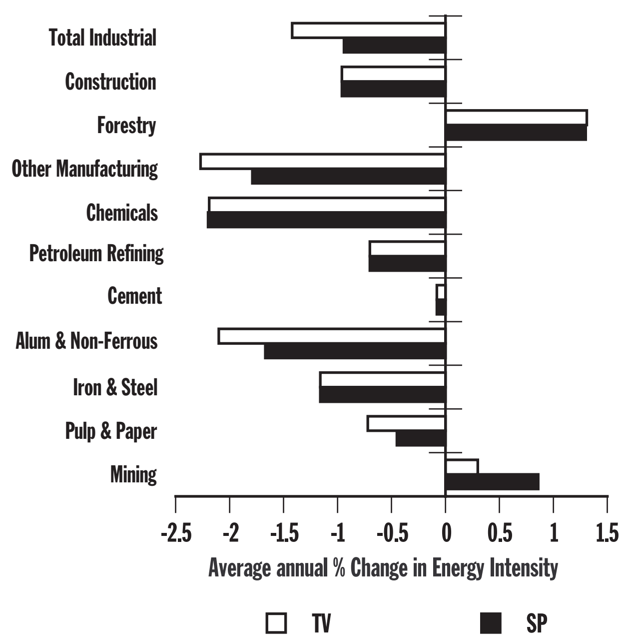
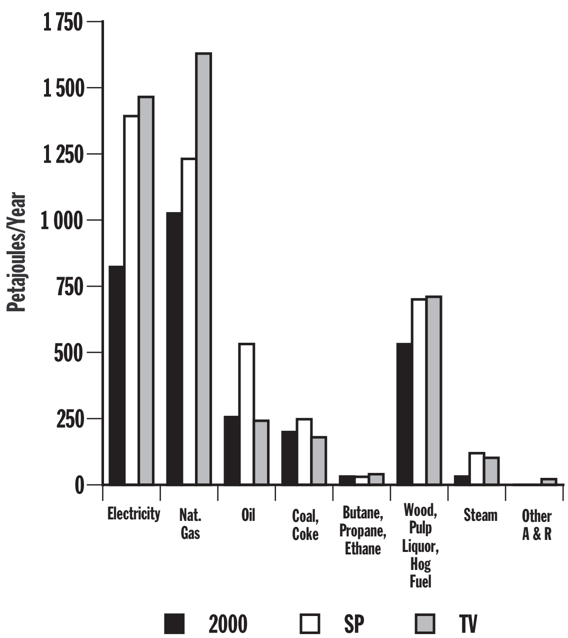


Figure 4.20 Industrial Energy Intensity Projection by Sector



The energy intensity of the industrial sector is projected to decrease at an average annual rate of 1.0 percent in SP, and 1.5 percent in TV (Figure 4.20). Aluminium and non-ferrous metals, chemicals, and other manufacturing industries rely heavily on raw materials for production, which requires more energy per unit of output. These industries are projected to shift their focus towards lighter manufacturing and assembly, use more imported and semi-finished materials, and benefit from energy saving technology.

Figure 4.21 Industrial Energy Demand by Fuel



Energy intensity in the pulp and paper and mining sectors improves significantly in TV relative to SP. Environmental drivers in TV shift fuel consumption in these industries towards natural gas, rather than biomass, oil, and coal, which are more prevalent in SP.

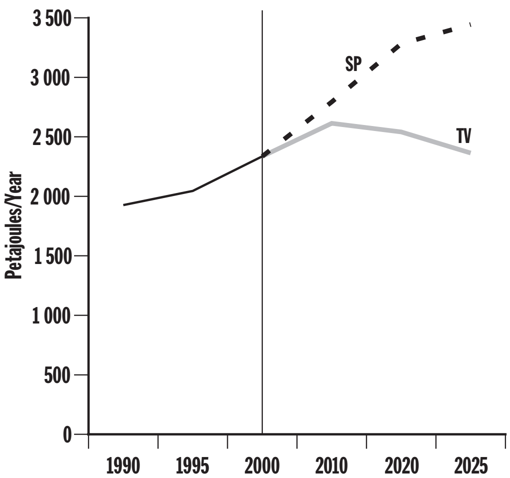
Economic growth is strong in the pulp and paper, mining, aluminium and non-ferrous metal, and other manufacturing industries. Despite significant improvements in energy intensity, energy demand continues to grow over the projection period. Over 80 percent of the total projected change in industrial energy demand in both scenarios stems from increased activity in these industries.

In SP, the more gradual development in technology and the desire for energy security lead to a greater reliance on known conventional energy sources such as coal and oil (Figure 4.21). A tightening natural gas supply and demand balance leads also to higher than historical energy prices and price volatility. This, in turn drives the desire for improvements in energy intensity. SP is characterized by a much greater demand for oil and coal due to its favourable pricing, and by a lower implementation rate for alternative fuel technologies.

In TV, greater technological advancements lead to better economics and advancement of fuel options for industrial users. More stringent environmental and efficiency standards, combined with higher natural gas prices, culminate in greater adoption of energy saving technologies and alternative fuel sources. In addition, there is a structural shift in energy-intensive industries toward lighter processes and the use of imported or recycled materials. Natural gas demand growth is greatest in this scenario, as gas is preferred over other fossil fuels for its high efficiency and cleaner burning properties (Figure 4.21). However, within the projection timeframe the use of alternative fuels (such as recycled solid waste) outside of electricity generation is limited in the industrial sector.

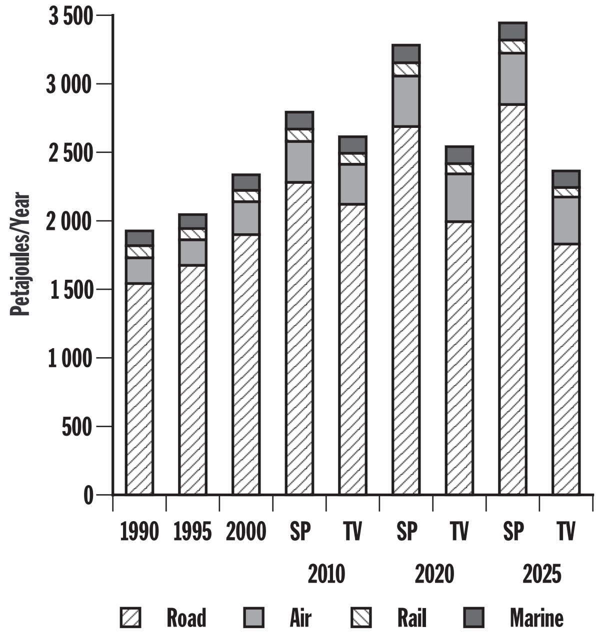
4.5 Canadian Transportation Sector Energy Demand

Figure 4.22 Transportation Energy Demand



In SP, total energy demand for transportation grows to support a growing population and economy, and makes up over 25 percent of total secondary energy demand. In TV, energy demand initially grows but eventually declines. This decline occurs primarily as a result of technological improvements and fuel efficiency gains in the area of passenger vehicles. By 2025, total transportation demand is about the same level as 2000 (Figure 4.22).

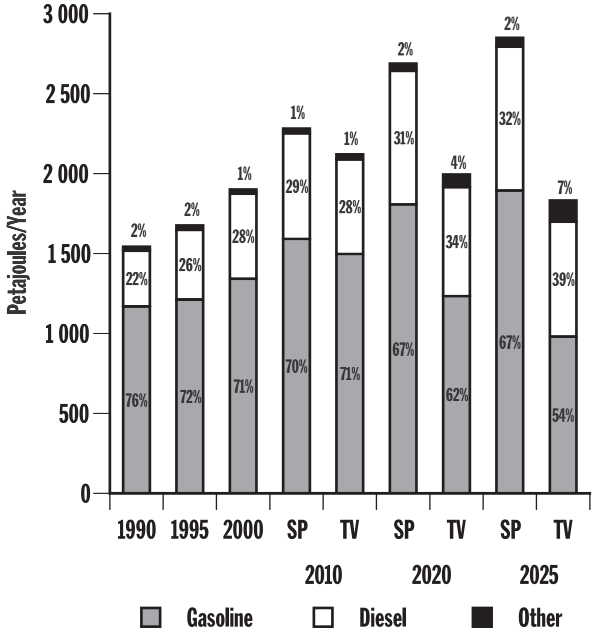
Figure 4.23 Transportation Energy Demand by Mode



Road transportation accounts for approximately 80 percent of energy demand in this sector in both scenarios (Figure 4.23). Between 1991 and 2000, energy demand for road transportation grew on average by two percent per year. SP assumes an average annual growth rate of 1.6 percent. Alternative technologies are not yet commercially available in this scenario to reduce energy demand further. However, government regulations to introduce cleaner fuels and a more efficient ICE are put into effect.

In TV, energy demand for road transportation grows much more slowly than in SP, and by 2013 begins to decline. By 2025, total energy demand in this sector falls back to the 2000 level. This decline is attributed to improvements in fuel economy, to significant penetration of the passenger vehicle market by alternative vehicles and to the increased use of bio-fuels. In addition, increased usage of public transit systems moderates energy demand.

Figure 4.24 Road Transportation Energy Demand by Fuel



In SP, gasoline continues to be the fuel of choice for road transportation, although diesel fuel makes some small gains in overall market share (Figure 4.24)

In TV, gasoline's market share is more significantly impacted, but not until 2010. There is a greater shift away from gasoline to the use of diesel fuel and other alternatives such as ethanol, natural gas and hydrogen.

In SP, technological advancements are slower to reach commercialization. The dominance of the ICE, operating on petroleum products, continues into the future. Penetration of HEVs and FCVs is limited. Transportation energy demand is strong, with North Americans unwilling to reduce their consumption in favour of smaller vehicles or more expensive alternative technologies.

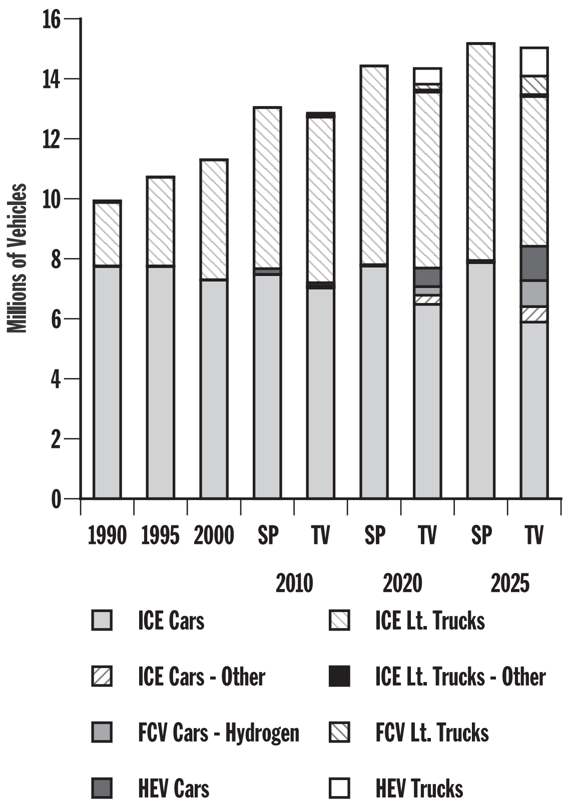
Hybrid Electric Vehicle (HEV)

An HEV combines a gasoline-powered engine and an electric motor. HEVs are roughly twice as efficient (i.e., 4.8L/100 km city/highway) as a conventional vehicle, and emit fewer pollutants into the air. An HEV has:

- A gasoline engine similar to that of a conventional vehicle, but smaller.
- A fuel tank to store gasoline to operate the engine.
- An electric motor used primarily for low speed cruising (city driving) or to provide additional power for acceleration or climbing hills.
- A generator to produce electricity to run the motor and charge the batteries.
- Batteries to provide energy that is used to power the electric motor and to store energy for later use.

Today, there are two car manufacturers that produce commercially available HEVs for the market. In addition, several other car manufacturers are developing HEVs that should be available by the end of the decade.

Figure 4.25 Personal Use Vehicle Stock

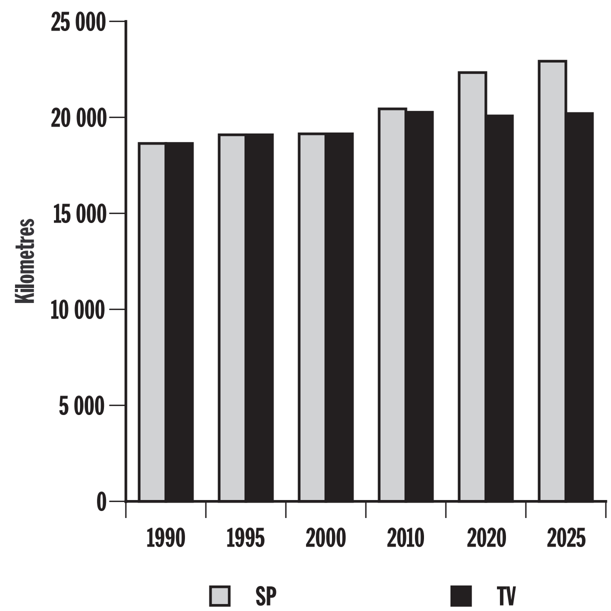


The largest portion of the transportation sector is personal transportation, or passenger vehicles. These include cars and light duty vehicles such as vans, light duty trucks and sport utility vehicles (SUVs). The key drivers affecting energy demand for passenger vehicles are the total stock of vehicles, the average fuel economy of the stock and the average number of kilometres travelled per vehicle. An important determinant of the number of vehicles is vehicles per household which is held constant at 1.01 vehicles in both scenarios. Over the 25-year scenario timeframe, the number of households is expected to grow by an average of 1.2 percent per year. However, the composition of households is expected to change, declining from 2.6 persons per household in 2000 to 2.3 persons per household in 2025. It is anticipated that these changes will affect vehicle ownership rates and ultimately the number of vehicles in the stock.

In both scenarios, the passenger vehicle stock grows over the projection period (Figure 4.25). However, where the growth occurs differs between scenarios. In the SP scenario, the trends that have been occurring over the last 10 years continue through the 25-year period. In 2000, the split between cars and light duty vehicles is 55/45. In 2025, the split is expected to be about 45/50. The remaining five percent of the new vehicle share is made up by HEVs, as some market penetration occurs in the latter part of the period.

In TV, the growth in the vehicle stock is slightly lower than in SP; however, vehicles based on alternative technologies become cost competitive with traditional ICE vehicles and become a larger part of the vehicle stock. Fuel cell and hybrid electric vehicles become a significant part of the vehicle stock by 2025, at almost 10 percent and 14 percent, respectively. Alternative fuelled vehicles in 2025 become almost 4 percent of the vehicle stock. The ICE vehicle running on diesel or gasoline continues its dominance, accounting for 72 percent of all vehicles.

Figure 4.26 Personal Use Distance Travelled per Vehicle

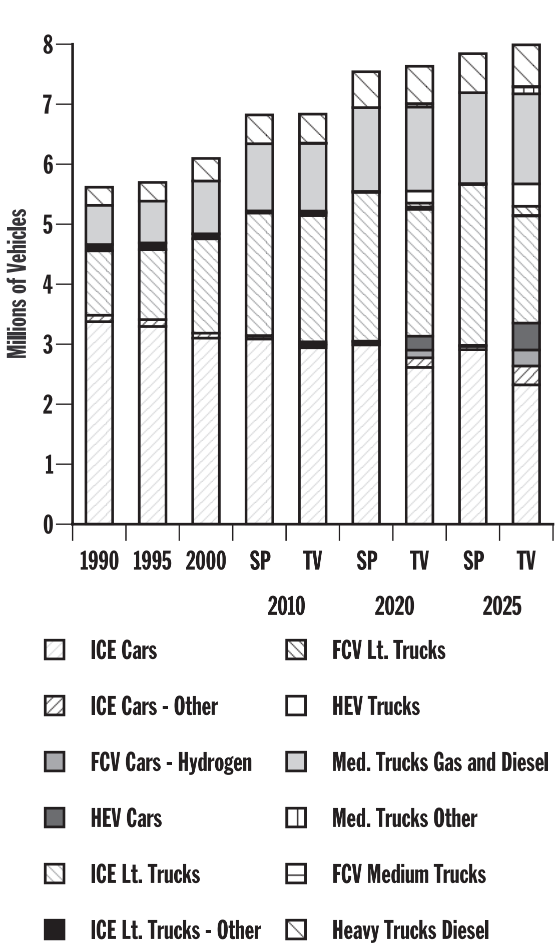


The average distance travelled per passenger vehicle is highly dependent on the age of the vehicle and household demographics (Figure 4.26). It decreases as a vehicle ages. Vehicle travel over the past two years has been experiencing strong growth, primarily as a result of the unstable geopolitical climate following the events of 11 September 2001.

In SP, kilometres travelled per vehicle grows at a rate of 1.8 percent per year. We assume that this growth continues in this scenario as the current trend towards increased vehicle travel in the over 65 age group continues.

In TV, we assume an increased use of public transportation. Although kilometres travelled per vehicle grow at 1.3 percent per year, it is lower than in SP, reflecting the difference in consumer behavior between the two scenarios.

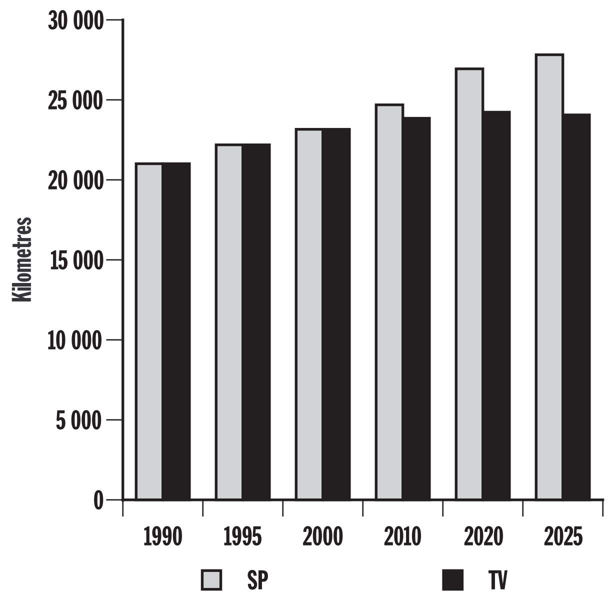
Figure 4.27 Commercial Use Vehicle Stock



Population growth is a key driver for the light-duty commercial vehicle stock, as these types of vehicles are primarily used for taxicabs, courier services and light duty commercial applications. In the medium and heavy stock category, which consists of buses, medium trucks and heavy trucks, the key driver is economic growth.

The commercial stock grows on average by 1.0 percent per year in SP and 1.1 percent per year in TV (Figure 4.27). In SP, incremental improvements are made to the conventional ICE vehicle and the introduction of new vehicle technologies is muted. In TV, HEVs and FCVs are introduced into courier and taxicab fleets. In addition, alternative fuels such as ethanol and compressed natural gas become more widely used.

Figure 4.28 Distance Travelled per Commercial Vehicle

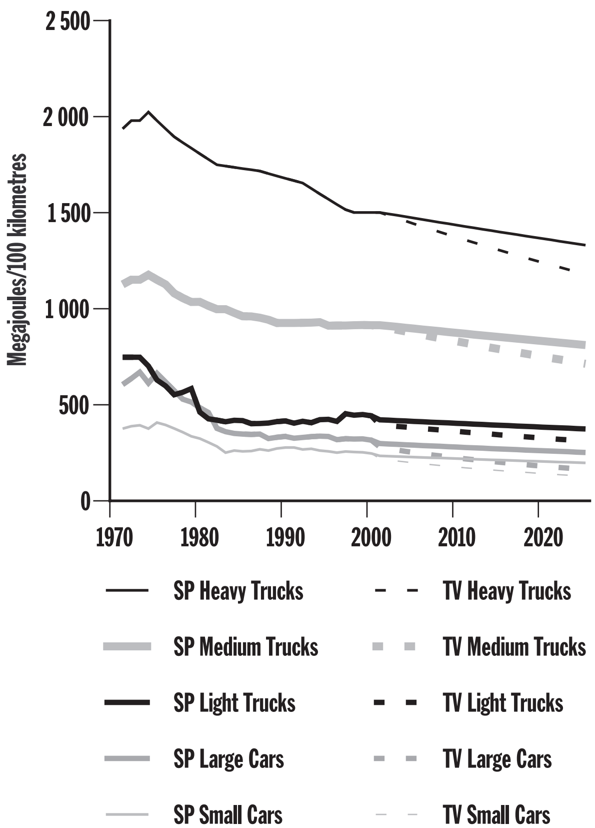


In both scenarios, average kilometres travelled per vehicle increases, particularly for medium and heavy trucks (Figure 4.28). This can be explained by strong economic growth, especially in TV.

In TV, we assume that freight truck travel is reduced for environmental reasons in favour of moving goods by rail. However, medium truck travel, which includes buses, witnesses very strong growth resulting from increased use of much improved transit systems.

In Canada, the Company Average Fuel Consumption (CAFC) for passenger cars has remained unchanged since 1986 at 8.6 litres/100 km. For light duty trucks, the CAFC standard is 11.4 litres/100 km, unchanged since 1995. Of note, fuel economy levels have remained unchanged despite significant technological improvements over the past 15 years (Figure 4.29).

Figure 4.29 Average Vehicle Lab Fuel Economy



New federal government regulations for sulphur levels in gasoline and diesel fuel would offer improved air quality. In July 2002, sulphur level restrictions were reduced to average 150 ppm over the period 1 July 2002 – 31 December 2004. By 1 January 2005, all gasoline sold in Canada will average 30 ppm. These sulphur reductions will support the introduction of a new generation of cars (Tier 2) with improved anti-pollution controls. The proposed regulations for diesel fuel provide for a maximum limit of 15 ppm of sulphur by 1 June 2005. This is a significant reduction from the 500 ppm sulphur which is now the average for diesel fuel. This reduction is required primarily to enable the efficient operation of the advanced engine technologies incorporated into the new heavy-duty diesel vehicles that are expected to be available for the 2007 model year.

In SP, new vehicle fuel economy is expected to improve to 6.7 litres/100 km for cars and 10.6 litres /100 km for light duty vehicles by 2025. This marginal increase reflects the continuing popularity of SUVs and light duty trucks and the desire to have engine power and size at the expense of fuel economy. In addition, small improvements in fuel economy occur in medium and heavy trucks.

In TV, new vehicle fuel economies are expected to improve significantly. The ICE vehicles demonstrate fuel economy increases through incremental improvements (e.g., weight reduction, engine/transmission enhancements, aerodynamics, etc..). In addition, cleaner and alternative fuels, coupled with improvements in the conventional vehicle, facilitate an increase of almost 40 percent in fuel economy during the projection period. By 2025, overall fuel economy improves from 8.7 litres/100 km to 5.4 litres/100 km.

HEVs and FCVs offer considerable improvements in fuel economy over conventional vehicles. It is expected that by 2025 fuel economy levels for the HEVs will be 2.9 litres/100 km, while FCVs are expected to offer even greater fuel economy improvements.

Key Uncertainties

➢ Fuel Economy improvements and the introduction of alternative vehicle technology

The two biggest uncertainties around road transportation energy demand are the level of fuel economy improvements and how quickly alternative vehicle technologies will be introduced commercially. The ratification of the Kyoto Protocol by the federal government in December 2002 will provide a strong impetus to achieving improvements in these areas. In addition, the *Climate Change Plan for Canada* document released in November 2002 provides for a number of actions to achieve the Kyoto targets in the transportation sector. These include:

- A 25 percent improvement in new vehicle fuel efficiency by 2010
- Increased use of ethanol – up to 35 percent of gasoline supply, and setting a target of 500 million litres of biodiesel in use by 2010
- Development and demonstration of refuelling technologies and infrastructure for commercialization of FCVs.
- Development of strategies, technologies and planning to reduce urban transportation emissions and to encourage increased use of public transit
- Negotiation of voluntary agreements with air, rail, truck and marine sectors to improve fuel efficiency of goods transport.

Despite the U.S. diverging with Canada in its stance on the Kyoto Protocol, the U.S. has many initiatives underway which will have significant impacts for Canadian public policy. A key announcement by the Bush government in January 2003 was the FreedomCar and Fuel Initiative. In this announcement President Bush proposed a total of US$ 1.7 billion over the next five years to develop hydrogen-powered FCVs, hydrogen infrastructure and advanced automotive technologies. The thrust behind this policy initiative was to improve Americans' energy security by significantly reducing the need for imported oil.

➢ Demographics

In the SP and TV scenarios, the economy and the population are growing. An increase in the kilometres travelled is synonymous with a growing population. In both scenarios, the latter part of the projection period sees slowing growth and changing demographics. The population is aging and this may change the driving habits of consumers. It has been documented that people over the age of 55 drive less than those in the 35-54 age group[2]. However, recently this segment of the population is driving more than in the past. Therefore, one can conclude that as baby boomers age, there is a strong possibility that they may drive more than has been the norm for this age group in the past. The unstable geopolitical climate is contributing to this increased vehicle travel, especially in the U.S. Air travel in much of the world has declined since the events of September 11th.

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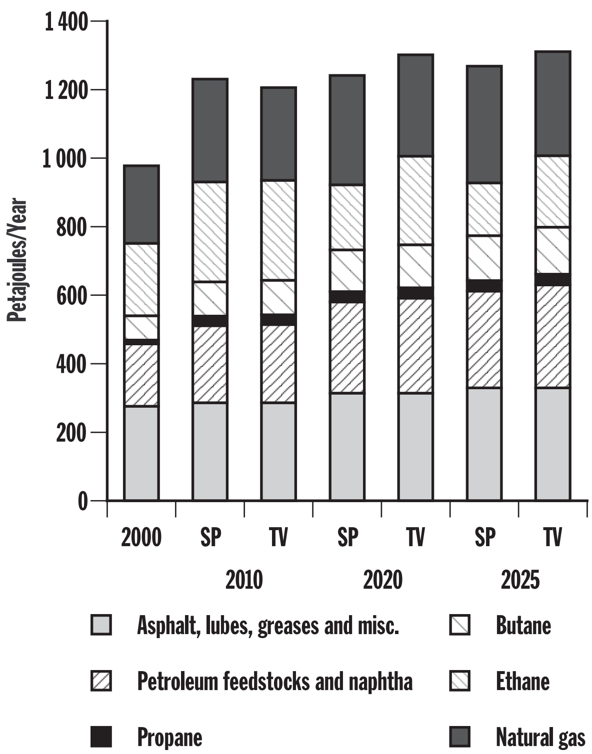
[2] According to the ***Summary of Travel Trends, 1995 Nationwide Personal Transportation Study,*** **released in December 1999 by the U.S. Department of Transportation and the Federal Highway Administration, as people age they drive less.**

4.6 Canadian Non-Energy Demand for Hydrocarbons

Figure 4.30 Canadian Non-Energy Use of Hydrocarbons



Natural gas, natural gas liquids and other petroleum products have non-energy applications, such as in the production of petrochemicals, fertilizers, lubricants, and asphalt.

Non-energy demand continues to grow in both scenarios, largely driven by growth in the North American economy (Figure 4.30). The exception may be non-energy demand from ethane and natural gas-intensive users in western Canada. Feedstock demand growth for these users will be limited by available supply of ethane and natural gas in both scenarios. These users face additional economic pressures from higher feedstock prices and price volatility, as demand for natural gas supply increases.

Since natural gas is the preferred fuel source in other market sectors, there is greater competition for an already-limited regional supply. Natural gas feedstock users may be required to periodically reduce throughput. Ethane supply remains limited and its price is impacted by high natural gas prices. Nevertheless, a sufficient natural gas price differential (U.S. Gulf of Mexico versus Alberta) is expected to be maintained over the long term, suggesting that ethylene produced from Alberta will remain competitive. When natural gas prices are relatively high, ethane cracking throughput could be reduced. Therefore, to maintain existing capacity utilization rates, ethylene producers may have to pass increased feedstock costs on to customers.

Based on the level of natural gas development assumed in Atlantic Canada, it is unlikely that a petrochemical industry will develop in that region in either scenario.

Heavier natural gas liquids, such as propane and butane, are less susceptible to competition from the natural gas market. This is because the supply of these components is not as tight and a portion of their production comes from refinery processes. As a result, demand will be driven mainly by economic growth in the key end-use sectors (i.e., petrochemicals and transportation).

The supply of petroleum-based feedstock (naphtha, fuel oil, asphalt, etc..) is adequate in both scenarios. Demand is driven by economic growth in the petrochemical, construction and manufacturing sectors.

4.7 Canadian Energy Demand: Issues and Implications

➢ Scope for efficiencies in energy

Scope for efficiencies in the residential and commercial sectors is limited by the rate at which stocks can be turned over. There is a slow turnover of housing and commercial buildings and it is often easier and less expensive to build new equipment rather than retrofit existing equipment. The rate at which existing stocks, buildings and equipment are replaced is a key constraint to reducing absolute energy demand.

Scope for efficiencies in the industrial sector is limited by the nature of production processes. Resource extraction industries have grown in Canada due to the abundance of resources and inexpensive energy. Some of these industries, such as forestry and mining, will increasingly move to more remote locations and will require more energy to transport their products.

Scope for reduction in kilometres traveled in the transportation sector is limited given urban design and living patterns of Canadians. Vehicles will become more efficient but kilometres driven will likely increase with growth in population. Urban design is a key constraint to significant increases in the use of mass transit. In addition, driving patterns of baby-boomers as they age is also an uncertainty.

There will be continued and significant improvements in the ICE and vehicle fuels will become cleaner over time. Hence, HEVs and FCVs will compete with gasoline-powered vehicles on price, fuel efficiency and environmental standards. This competition will limit the rate of penetration of FCVs and HEVs in the automobile sector.

➢ Natural Gas Demand

Natural gas will be in high demand because of its efficiency and clean burning properties. However, there is great uncertainty associated with the availability and cost of production from future natural gas supplies to meet increased demand. This suggests that there may be periods of market imbalance, price volatility and required market adjustments by energy users. For example, industrial consumers may switch fuels, temporarily reduce production, accept lower profits, or in some cases, relocate.

➢ Cultural Change

From a socio-economic perspective, some will say that cultural shifts and consumer behavior are perhaps more important than having the technology available to enable reductions in energy demand. However, for consumers to embrace technologies like HEVs or FCVs or alternative fuels such as ethanol they have to be convenient, available, safe and economic. In addition, they have to be competitive on cost and performance with existing technologies or products.

There are other cultural changes to consider, such as the number of people per household or the population density of urban areas that have direct and significant implications for energy demand. The current Canadian trend is an increase in the number of residences with less people living in each house. Standards of living are changing as well; as Canadians become more affluent, they may build bigger, more luxurious houses which require more energy to heat and light. However, this may be offset by more energy-efficient appliances, or triple-paned windows filled with argon gas for improved insulation. Cultural changes will likely be gradual and may begin to have a noticeable effect in later years (post 2020) in the TV scenario. Environmental events, government actions, or market developments may also affect the pace of cultural change and significantly alter energy consumption.

5.0 Energy Supply in Canada

5.1 Electricity

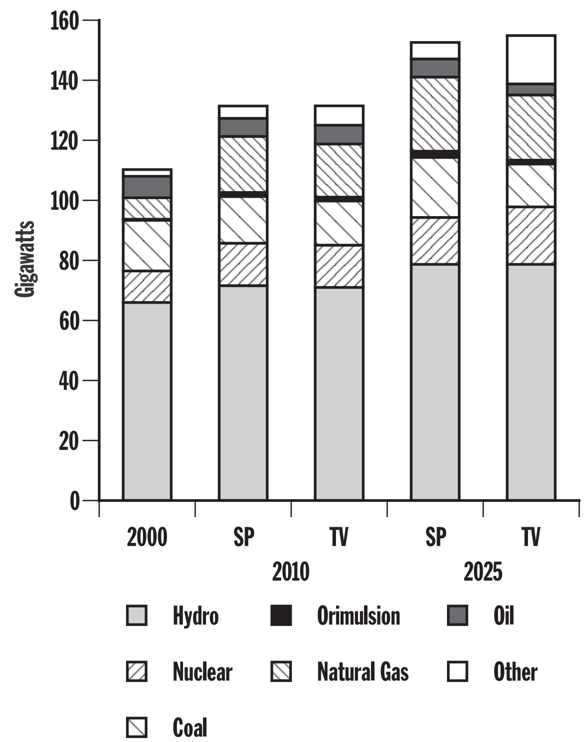
5.1.1 PRODUCTION OUTLOOK

Capacity and Generation

The combination of an increasing population, economic growth and increased use of electrical equipment means demand for electricity will keep rising in Canada. Generating capacity will increase by about 38 percent in the SP scenario and 41 percent in the TV scenario, or 42 GW and 45 GW, respectively. These capacity additions are required to meet projected domestic load during peak periods, while maintaining adequate reserve margins for reliability. Although both scenarios project that total generation rises by 1.8 percent annually over the projection period, the generation mix evolves differently in each scenario. Canada's electricity supply will be further diversified as sources other than hydro power are increasingly used to produce electricity.

In SP, electricity generators continue to rely mainly on conventional technologies to meet rising domestic load requirements, while alternative technologies and renewable fuels generally remain uneconomic. In this scenario, new coal-fired facilities are added in Ontario and in the western provinces, use of Orimulsion™ expands in the Maritimes, and alternative technologies and renewable fuels penetration is limited. In SP, natural gas-fired generation increases from about six percent of total generation to 16 percent by 2025 (Figures 5.1 and 5.2).

Figure 5.1 Generating Capacity by Fuel



In TV, technological developments and increased action on the environment accelerate demand for cleaner energy. Rapid technological advancements make alternative technologies and renewable fuels economically more attractive. The shift to cleaner generation options (such as clean coal technologies and advanced nuclear reactors) accelerates. Overall, renewable fuels are expected to account for about ten percent of total Canadian generation by 2025 in TV compared with four percent in SP.

Both scenarios assume that distributed generation (generation sited close to load centres) increases, but technological innovations enable this to happen more rapidly in the TV scenario. The implementation of distributed generation reduces transmission losses and network load requirements.

Hydro: Currently, about 60 percent of Canadian electricity generation is hydro-based. In addition to already-announced hydro projects, both scenarios assume large-scale hydro development will be pursued at Gull Island (Labrador), Grande-Baleine (Québec), Peace Site C (B.C.) and Gull Rapids (Manitoba). Most of these projects are located far from load centres and require major transmission investments. Total hydro-based capacity, excluding small hydro, is projected to reach 79 GW by 2025 under both scenarios, an increase of almost 20 percent over current levels. While large hydro projects are expensive to build, the associated fuel and operating costs are generally low, making hydro the least expensive source of base-load electricity supply. However, the remaining sites for hydro development are limited, and both scenarios project hydro supply alone will not be sufficient to meet increased demand. Therefore, non-hydraulic generation sources (e.g., fossil fuel, wind, biomass, etc.) will be required. As a result, the share of hydroelectricity declines over time, although it still accounts for about 50 percent of total generation in both scenarios by the end of the projection period.

Nuclear: Both scenarios assume the operating lives of all nuclear units in Ontario are extended and all laid-up units return to service. The Point Lepreau (N.B.) and Gentilly-2 (Québec) generating stations will be refurbished. However, the power industry's preference for fossil fuels in SP does not encourage construction of new nuclear power plants. In TV, the relatively high economic and operating performance of the advanced CANDU reactor (ACR), the Nuclear Fuel Waste Act and heightened public/government concerns about GHG emissions make new nuclear generation conceivable. Therefore, in the TV scenario, new advanced nuclear reactors are constructed at existing facilities in Ontario and New Brunswick.

Natural gas-fired: The power industry's preference for natural gas stems from the fact that it is the cleanest burning hydrocarbon fuel; natural gas-fired generation is also highly efficient and requires a relatively low capital investment and shorter construction lead time. In recent years, the relatively high level and volatility of natural gas prices have been a concern to generators, investors and promoters of natural gas-fired facilities. Assuming natural gas prices remain in the projected range, both scenarios anticipate significant natural gas-fired capacity additions over the projection period: 17.6 GW in SP and 14.6 GW in TV. By 2025, natural gas demand for power generation rises markedly from 335 PJ to 1 067 PJ in SP and to 746 PJ in TV. The lower natural gas demand in TV reflects the increased roles of nuclear power and alternative technologies and renewable fuels.

In most provinces where it is available, natural gas-fired generation is generally the most expensive fuel option; thus, it determines the marginal cost of electricity. An exception is natural gas-fired cogeneration facilities, which are so efficient that they are often a low cost source of energy.

Significant natural gas-fired cogeneration facilities are developed in conjunction with the growing number of oil sands and in situ bitumen projects. Alberta experiences the largest growth in natural gas demand followed by Québec, Ontario and B.C. The Atlantic Provinces will also experience increasing natural gas demand for power generation.

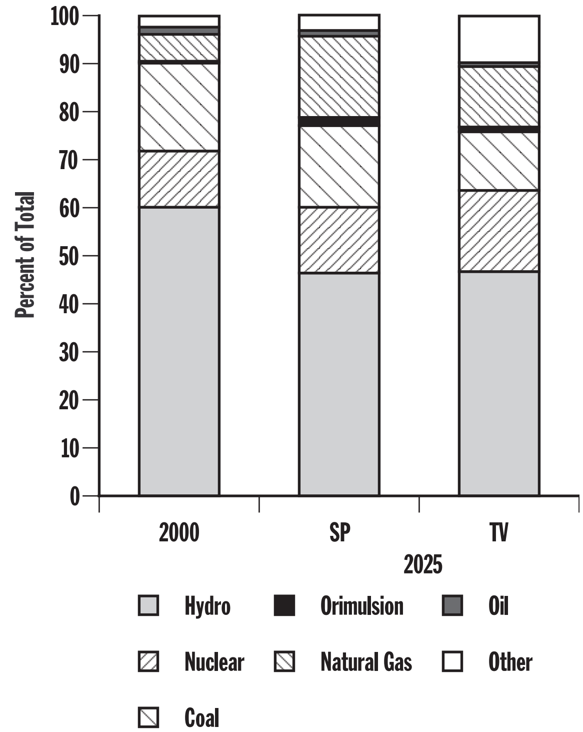
Advanced Nuclear Reactors

In recent years, renewed interest in nuclear generation has led to a number of new reactor designs such as the German/South African Pebble Bed Modular Reactor, the American Advanced Boiling Water Reactor and the Canadian Advanced CANDU Reactor (ACR). While these designs use different technologies, they share a common design goal - to make nuclear energy more economical by reducing capital costs and reducing construction time through a combination of pre-approved standardized designs and modular construction.

The ACR is a typical member of this family of new reactor designs. Atomic Energy of Canada Limited (AECL) has set targets of US$ 1000 / MW for capital cost and four years for regulatory approval and construction. The capital cost target is significantly less than current CANDU reactors (US$ 1500 / MW). Cost savings are anticipated from the use of slightly enriched uranium to reduce the amount of heavy water required, and new modular construction techniques, which have been successfully tested in Asia.

Based on its lower costs, the ACR could be among the most economic options for new generation in Canada. In the TV scenario the ACR is assumed to meet its cost targets, justifying their construction at existing nuclear sites.

Figure 5.2 Shares of Generation by Fuel



Coal-fired: In SP, the reliance on conventional technologies supports the emergence of new coal-fired power plants, especially in Alberta and Saskatchewan where abundant low-cost coal can successfully compete with natural gas. By 2010, coal-fired generation is built in B.C. In TV, an increase in the number of coal-fired power facilities occurs but for different reasons. A substantial improvement in the environmental performance of coal is realized through the development of clean coal technologies such as IGCC.

Though coal plants require large capital investments, they produce less expensive power than wind turbines or natural gas generators. New coal power plants generally trigger environmental concerns; however, much of the coal found in Alberta is considered to be of the "clean burning" variety, which emits less SO_2 when burned.

Orimulsion™: A mixture of bitumen and water, Orimulsion™ is currently used for power generation in New Brunswick. In SP, we assume that New Brunswick continues to use Orimulsion™, and Nova Scotia begins using it as well. In TV, the use of Orimulsion™ does not expand beyond existing and already-announced facilities in New Brunswick because of relatively high action on the environment.

Oil-fired: In most cases, oil-fired power facilities provide generation during peak demand periods, or in areas where other fossil fuels are not available. Both scenarios anticipate declining shares of oil-fired generation, which currently account for less than two percent of total generation in Canada. However, the decline is larger in the TV scenario due to concerns about the associated environmental impacts of burning oil.

Alternative technologies and renewable fuels: In SP, generation from these sources is constrained by slower technological developments. Therefore, generation costs are higher than those required for conventional technologies, which makes them unattractive except in some niche markets. In this scenario, consumers may recognize the environmental benefits of alternative technologies and renewable fuels, but are reluctant to pay a premium for them.

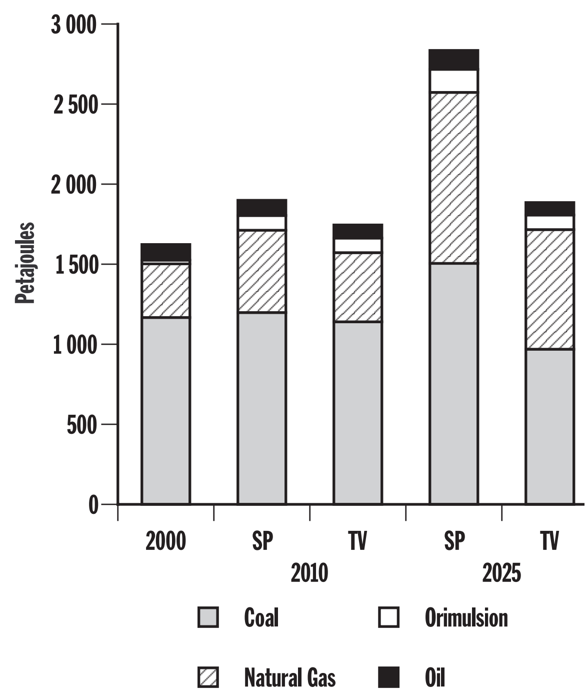
In the TV scenario, alternative technologies and renewable fuels grow more quickly than in the SP scenario. The most common developments are wind, biomass and small hydro with niche applications of solar, tidal and geothermal power. Wind power costs are expected to drop as capital costs are reduced due to improvements in turbine aerodynamics, the development of strong, light-weight materials, and advances in small generator technology. Biomass could become a more commonly used energy source, if biogas by-products from feedlot operations and municipal solid wastes are developed in large urban centers.

The development of alternative technologies and renewable fuels relies in part on government support for co-ordinated public awareness programs, research and development funding, and financial incentives. For example, the federal government stimulates wind power development with production credits. Most provinces have also considered or introduced initiatives (e.g., renewable portfolio standards, production credits) to foster the development of alternative technologies and renewable fuels.

As technology progresses and renewable fuels become more affordable, these fuels provide a greater portion of generation. In both scenarios, wind power provides the greatest capacity increases, rising from 0.2 GW in 2001 to 3.3 GW by 2025 in the SP scenario and to 11.2 GW in the TV scenario.

Fossil Fuel Energy Demand For Power Generation: One key difference between the scenarios relates to projections for fossil fuel-based generation (Figure 5.3). While total demand for electricity is similar in the two scenarios (higher economic growth in TV is offset by increased efficiency), the increased use of alternative technologies and renewable fuels and nuclear generation in the TV scenario results in a significant difference in the consumption of fossil fuels. In the SP scenario, the share of fossil fuel-based generation increases substantially. In TV, it remains at the current level of about 27 percent of total generation. As a result, the demand for fossil fuels (coal, natural gas, Orimulsion™ and oil) almost doubles over the projection period in SP. Conversely, in the TV scenario, it rises just 16 percent above the current level.

Figure 5.3 Fossil Fuel Energy Demand for Electricity Generation



Heat Rates

Heat rate is the amount of input energy used to generate electricity, commonly expressed in gigajoules per gigawatt-hour (GJ/GW.h). The lower the heat rate, the higher the efficiency of the technology.

The amount of fuel used to generate electricity is calculated by multiplying the electricity generated by the heat rate. Where available, historical heat rates for existing units are used. For future units or other cases where this information is not available, the heat rates used are shown in the following table. Improvements to heat rates are assumed in both scenarios, with the improvements being greater and coming more quickly in the TV scenario.

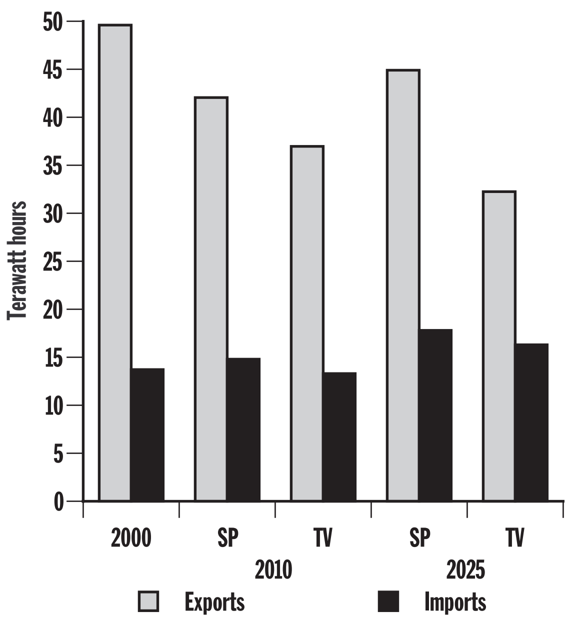
Heat Rate Assumptions

Generation Technology	SP (GJ/GW.h)		TV (GJ/GW.h)	
	To 2015	After 2015	To 2010	After 2010
Conventional Coal	9 900	9 600	9 900	NA
IGCC	NA	NA	NA	7 200
Cogeneration	5 500	5 500	5 500	5 500
Combined Cycle	8 000	7 200	8 000	6 700
Combustion Turbine	12 000	10 800	12 000	8 440
CANDU ACR	NA	NA	NA	9 000

5.1.2 SUPPLY AND DEMAND BALANCES

Exports & Imports: Canada has historically been a net electricity exporter, with exports accounting for about seven to nine percent of total generation. Most exports originate from hydro-rich provinces, because hydropower is relatively inexpensive to produce. Increased reliance on natural gas fired generation in Canada will raise the average generation cost. This may affect exports since customers in the U.S. will have the option of importing natural gas and generating electricity at comparable costs. However, as regional transmission organizations develop, Canadian exporters will gain access to larger, cross-border regional markets, and provinces with hydro storage capacity will continue to benefit from their ability to buy power during off-peak periods and resell it when demand peaks (Figure 5.4).

Figure 5.4 Electricity Exports and Imports



In SP, exports increase assuming that export transmission capacity is available and no long-term congestion exists in the North American electrical network. The increase in exports results from the development of oil sands cogeneration capacity, the projected return of nuclear units in Ontario, and a potential surplus available from the Lower Churchill expansion. Exports in this scenario fluctuate between 40 and 60 TW.h.

In TV, power from oil sands development is used domestically, instead of being exported. Therefore, export levels fluctuate between 30 and 50 TW.h per year.

Projections of power exports are largely based on historical average water conditions, since most power exports come from hydro-rich provinces. A change in water conditions could greatly affect exports – for example, a five percent improvement in water levels could increase exports by nine to ten TW.h annually.

Electricity imports are similar across both scenarios. In both scenarios, imports reflect the desire to benefit from short-term trading opportunities, rather than a need to satisfy long-term domestic load requirements. The import projections take into account the Columbia River Treaty which provides for up to half of the power generated at hydro-electric plants in the U.S portion of the Columbia River being returned to B.C. and/or resold in U.S. markets.

Interprovincial Transfers: In 2001, interprovincial electricity transfers totalled 45 TW.h. About 66 percent of this power flowed from Labrador to Québec, in accordance with a long-term contract. Generally, electricity transfers between a hydro-based system (e.g., Manitoba, B.C., and Québec) and a thermal system (e.g., Ontario, Alberta, Saskatchewan) improve the operational efficiency of both systems. Thermal systems can export cheaper power at night, while the hydro-based systems conserve water. During high-demand periods, hydro-based systems send electricity to thermal systems, reducing the need for more expensive thermal generation.

In both scenarios, transfers between Labrador and Québec increase noticeably when the Lower Churchill project is completed. The proposed 1 250 MW transmission interconnection between Ontario and Québec results in higher transfers between these two provinces. Inter-provincial transfers increase even more in the TV scenario as Alberta transfers surplus power from oil sands projects near Fort McMurray, to B.C.

5.1.3 ISSUES AND IMPLICATIONS

➢ **Restructuring**

Electricity restructuring will continue in Canada, although the pace will differ between provinces. Ideally, restructuring enhances competition, improves market efficiency and offers a greater choice of services and suppliers. To date, restructuring in Canada has not influenced consumer prices as anticipated, and its impact remains uncertain. Restructuring is expected to gradually change the electricity sector by increasing the number of market participants, by introducing new market structures and regulatory environments, and by offering consumers more supply options.

➢ **Natural Gas Supply and Prices**

Concerns about natural gas availability and price volatility could affect fuel choices for power generation. In SP, this may lead generators to consider building dual fuel capability and consider other options such as Orimulsion™ in the Maritimes; nuclear or Orimulsion™ in Québec; coal or nuclear in Ontario; and coal in the western provinces. In TV, generators may rely more on nuclear in Atlantic and eastern Canada, and on clean coal in western Canada. The expanded use of natural gas for power generation promotes the convergence of electricity and natural gas markets and prices.

➢ **Transmission**

Canada's existing transmission capacity is generally adequate for interprovincial and international flows. However, as electricity trade increases, more transmission capacity is needed. Provincial restructuring initiatives, and the U.S. Federal Energy Regulatory Commission's regional transmission organisation and standard market design initiatives, may influence Canada's transmission system.

Both scenarios assume additional transmission capacity between Labrador and Québec to accommodate the projected Lower Churchill development, and assume that the proposed 1 250 MW Québec-Ontario transmission project comes on line. In addition, the SP scenario assumes the NorthernLights project or a similar project links Alberta's oil sands region to the Pacific Northwest, while the TV scenario assumes increased transmission capacity between Alberta and B.C. Neither scenario has contemplated an east-west transmission grid; however, any expansion of the interprovincial transmission network could increase trade opportunities between the provinces.

➢ **Nuclear**

There are advantages to nuclear generation: secure uranium fuel supply, low generation cost and negligible greenhouse gas emissions. However, these benefits are offset by public concerns around radioactive wastes and plant safety. The nuclear industry may need to assure the public on both the safety and waste disposal issues before building new plants. If nuclear power is not developed, significantly more natural gas-fired and/or coal-fired capacity (depending on the scenario) will be required. Critical issues for Ontario's future electricity supply include bringing currently laid-up nuclear units back on-line, and an environmental policy regarding coal-fired generation. Whether or not the public accepts new nuclear facilities will be a key factor for nuclear development.

➢ **Oil Sands Development**

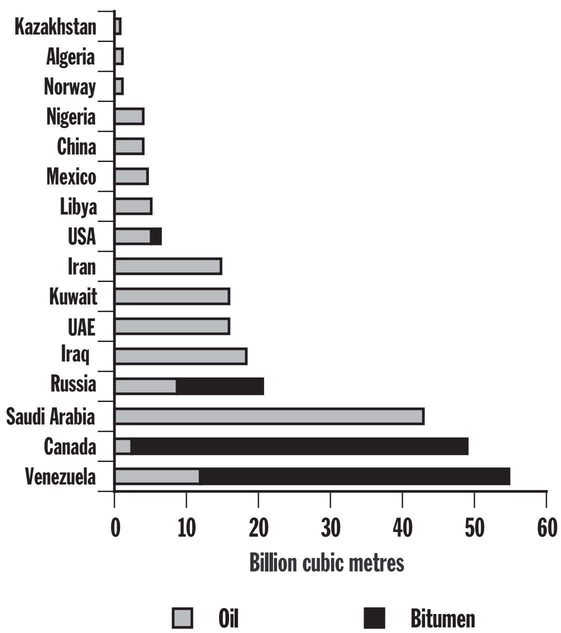
The extent of oil sands development has a direct bearing on new natural gas-fired capacity in Alberta. Overall, the SP scenario projects greater oil sands development and associated surplus energy available for export from cogeneration facilities, favouring the development of new transmission dedicated for export. In the TV scenario, the relatively smaller amount of power from oil sands cogeneration plants favours the enhancement of the existing transmission network, with the energy mainly destined for the domestic markets in Alberta and B.C.

5.2 Crude Oil

5.2.1 CRUDE OIL AND BITUMEN RESOURCES

Canada ranks first in the world in terms of bitumen resources and second in the world, behind Venezuela, in terms of total discovered recoverable resources of crude oil and bitumen.

Figure 5.5 World Oil and Bitumen Resources

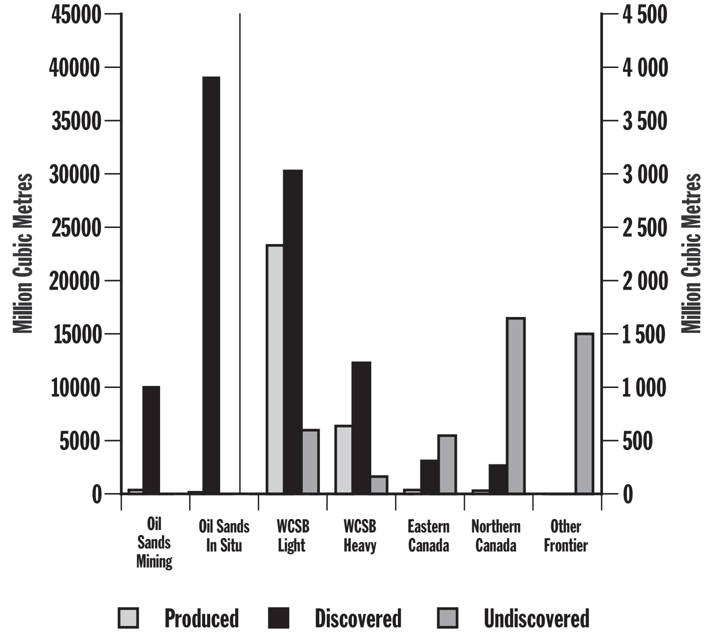


Source: Petro-Canada, EUB, O&G Journal
Note: Values for Saudi Arabia are proven reserves

Estimates of Canadian crude oil and bitumen resources are the same in both scenarios. Bitumen resource estimates are adopted from the Alberta Energy Utilities Board, while the conventional resources are based on estimates published by provincial energy agencies, offshore petroleum boards, the Geological Survey of Canada, and the NEB.

The Alberta oil sands deposits contain an estimated 400 billion m^3 of original bitumen in place, of which 12 percent is currently deemed to be recoverable. About 10 billion m^3 can be accessed through surface mining methods, with about 39 billion m^3 assigned to in situ recovery methods. By year-end 2000, only one percent of Canada's bitumen resources had been produced.

Figure 5.6 Oil Sands Resources and WCSB Conventional Resources



In contrast, conventional crude oil resources in the WCSB reflect a mature producing environment: 64 percent of recoverable light crude oil resources and 46 percent of heavy oil resources have already been produced.

Eastern Canada has an estimated 547 million m^3 of undiscovered conventional crude oil resources with the bulk of this situated offshore Newfoundland and Nova Scotia. Only a small portion of Northern Canada's estimated 1 646 million m^3 of crude oil resources have been discovered (approximately 266 million m^3). The majority of this resource is believed to be in the Mackenzie Delta-Beaufort Sea and Arctic Islands regions.

"Other Frontier" resources are those in regions where resources are thought to exist, but no discoveries have been made, such as in the Laurentian Basin and B.C. offshore regions.

Appendix Table A5.1 shows a more complete breakdown of Canada's crude oil and bitumen reserves.

5.2.2 PRODUCTION OUTLOOK

The key factors influencing oil production are: price, supply costs, market forces, the light-heavy price differential, the availability of blending agents for heavy oil, the availability of skilled labourers and professionals, environmental constraints, water usage, the volume of remaining recoverable resources and the pace of technological development.

The oil price assumption, US$22 (2001) for WTI, provides for robust economics for the majority of the oil projects we considered, allowing sufficient return to the operator for many oil sands projects and also for improved recovery schemes in conventional oil pools. Recognition is given to the fact that oil prices will be volatile, and periods of low prices will sometimes delay the onset of additional production.

Declining production of conventional crude oil in the WCSB and in the U.S., combined with rising demand, create an expanding market for Canadian oil sands derived crude oil, both upgraded and bitumen blends, and for East Coast production. Market expansion is also supported by purchase of downstream refining assets in the U.S. by Canadian producers.

Improvements in supply costs in the Canadian oil industry are largely due to the continuous development and application of new technology, especially in the oil sands. Thus, the assumed rates of technological advance are important distinguishing features of these scenarios.

In the SP scenario, governments take action to improve supply security. This results in aggressive expansion of oil sands production in North America, and provides a ready market for Canadian exports. Although Canadian heavy crude oil would periodically saturate the American market and create higher light/heavy differential prices, it is not a major issue in this scenario. Expansion of production in the SP scenario is not constrained by environmental concerns.

Canadian oil supply in the TV scenario is influenced by contradictory forces. A faster rate of technological advance means lower supply costs, especially for oil sands and conventional heavy oil projects. On the other hand, greater environmental emphasis combined with higher natural gas prices and a less robust market for heavy blends results in a preference for light crude, and higher overall light/heavy differential prices. The net result for oil sands and heavy oil production is initially lower production levels than in the SP scenario, although technological advances eventually close the gap in production levels. This scenario features higher levels of light production than in SP, due to the bias towards light crude, but also better finding rates and lower supply costs resulting from faster technological advancement.

Some major assumptions are common to both scenarios:

- Pipeline takeaway capacity does not unduly constrain production. Production capacity could periodically exceed pipeline capacity, but for the most part, pipeline capacity is added in a timely manner.
- Production is not unduly constrained by availability of condensate for blending heavy crude oil.
- Oil sands projects will have access to sufficient quantities of natural gas throughout the projection period.
- Environmental issues prevent oil production in the West Coast offshore.
- High oil supply costs prevent oil production in the Mackenzie Delta/Beaufort Sea region.
- Production and reserves expansion will not be unduly limited by availability of drilling rigs or oil field services.

Major assumptions specific to each scenario are outlined below:

Table 5.1 Oil Supply Major Assumptions

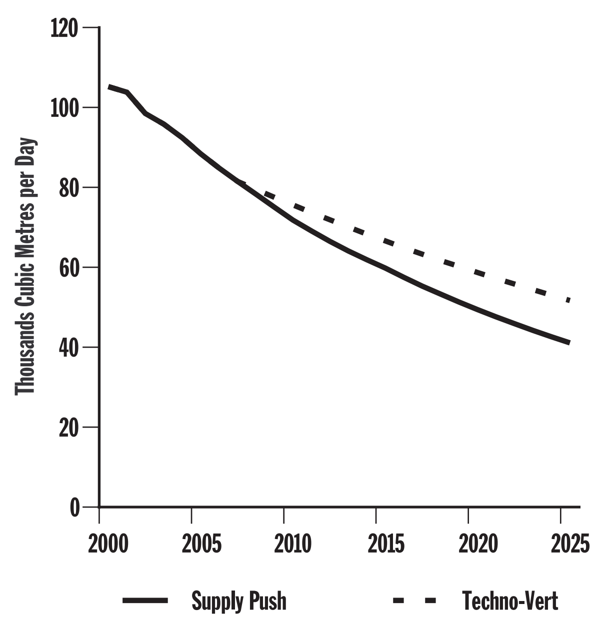
Supply Push	Techno-Vert
• Differential price between light and heavy crude oil as defined by Edmonton Par Light minus Hardisty Heavy remains constant at its long-term average of US$5.50 per barrel. • Governments initiate policies that encourage Canadian crude oil and bitumen production. • Production is not unduly constrained by environmental issues. • Technological advancement moves at same pace as last decade.	• Differential price between light and heavy crude oil will increase with time, but will average US$7.50 per barrel, about US$2.00 above its average over the last decade. • Governments initiate policies that encourage environmental protection. • Production is constrained by environmental issues. • Technological advancement moves at an accelerated pace.

Supply projection highlights for each crude oil category are briefly discussed below. For ease of comparison, the projections for the SP and TV scenarios are shown on the same charts.

Conventional Light Crude Oil – WCSB

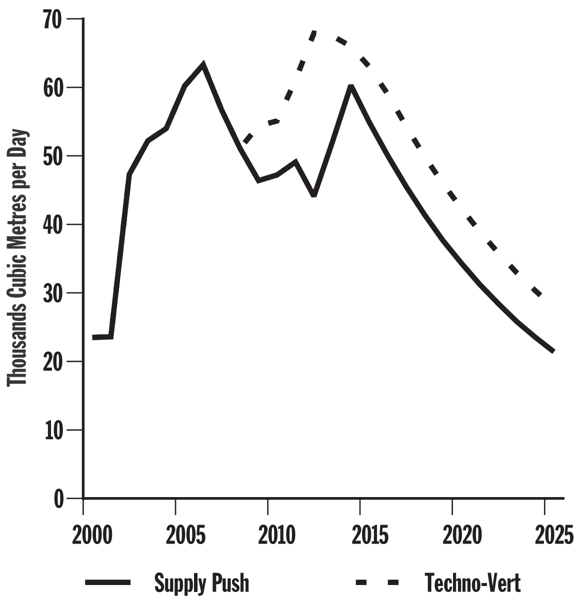
- In SP, the long-term declining trend of four percent is maintained, consistent with a mature supply basin.
- In both scenarios, significant reserves additions from new discoveries, infill drilling, and improved recovery techniques maintain the production levels shown.
- In TV, the effects of advanced technology and the bias for light crude versus heavy leads to higher production than in SP after 2007. By 2025, the two projections differ by 20 percent, or about 10 000 m^3/d.
- In TV, better finding rates, wider application of infill drilling and improved recovery methods lead to higher production than in SP.

Figure 5.7 Conventional Light Crude Oil – WCSB



Eastern Canada Light Crude Production

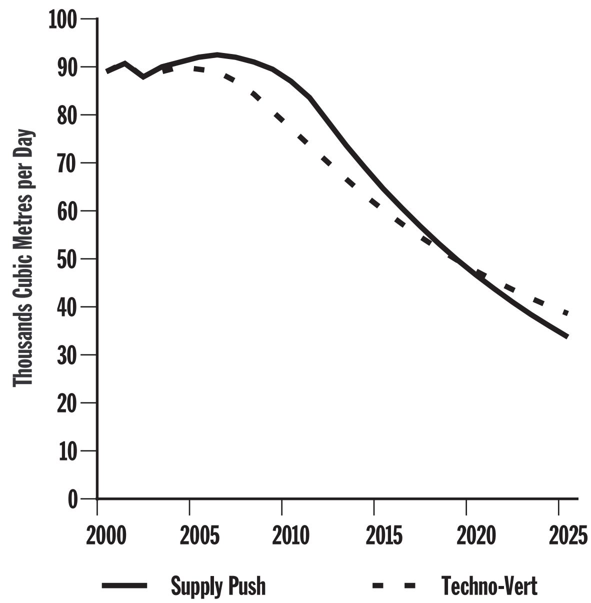
Figure 5.8 Eastern Canada Light Crude Production



- Current production is almost entirely from offshore Newfoundland, with minor amounts from Ontario.
- Hibernia and Terra Nova are already producing and the onset of White Rose in 2005 is common to both scenarios. Hebron begins production in 2009 in the TV scenario and begins in 2010 in SP. Contributions from smaller satellite pools in the Jeanne d'Arc Basin are also included.
- An additional Terra Nova-sized pool is found in the relatively unexplored regions of the East Coast, potentially in the Deepwater Scotian Shelf, Laurentian Basin or Flemish Pass regions. This pool comes on-stream in 2011 in TV and 2013 in SP. The decline in production levels after 2014 reflects the natural decline in the producing pools combined with a dearth of discovered resources.
- By 2025, TV production levels are 6 500 m^3/d greater than in SP.

Conventional Heavy Crude Oil – WCSB

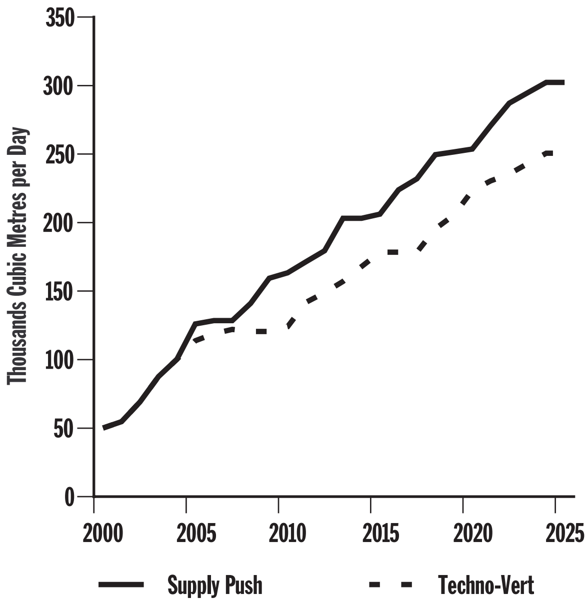
Figure 5.9 Conventional Heavy Crude Oil – WCSB



- Alberta and Saskatchewan are the primary sources of conventional heavy crude oil, with B.C. contributing minor amounts.
- In the SP scenario, the historical trend of increased production continues, with production peaking at 92 500 m^3/d in 2006. After that, rates decline based on the total resource available.
- In the TV scenario, the costs of more stringent environmental conditions slow the early production momentum, coupled with higher light/heavy differentials and tighter markets for heavy crude. This is countered by greater uptake of technology and wider application of horizontal drilling, especially multi-laterals, and wider application of improved recovery methods such as SAGD, VAPEX or Toe-to-Heel Air Injection (THAI), a new experimental variant of in situ combustion, to conventional oil pools.

Mining/Upgraded Bitumen Supply

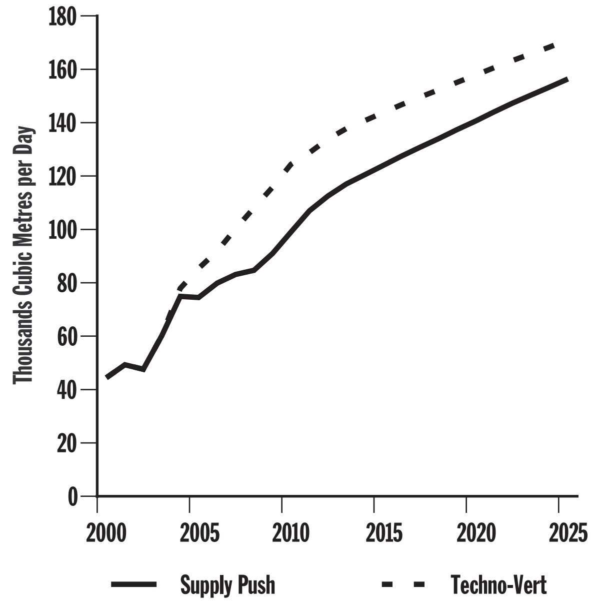
Figure 5.10 Mining/Upgraded Bitumen Supply



- The US$22 price for WTI generates sufficient cash flow for oil sands operators to expand production levels in a fairly aggressive manner in both scenarios.
- The rate of technological advance has a direct bearing on operating costs. In the SP scenario, operating costs are assumed to be in the range of C$12 -C$14 per barrel, compared with C$8-C$10 in the TV scenario.
- In the TV scenario, expansion is slowed by the greater environmental hurdles facing oil sands mining operators, and by the greater (perceived) economic risk posed by potential future environmental measures.
- In the TV scenario, by 2007-2010 operators adjust to the new rules and the effect of more rapid technological advance lowers costs and encourages production expansion. While the rate of production expansion is similar to that of the SP scenario, overall mining/upgraded production in the TV scenario remains well below that of the SP scenario, some 51 700 m^3/d less by 2025.

In Situ Bitumen Supply

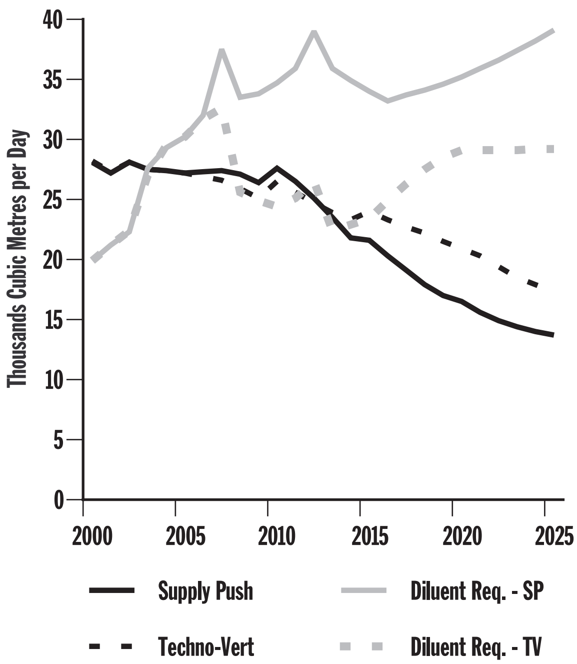
Figure 5.11 In Situ Bitumen Supply



- The assumptions on price and light/heavy differentials generate sufficient cash flow for oil sands in situ operators to aggressively expand production levels in both scenarios.
- Primary or "cold production" levels are held at current production levels in both scenarios.
- The SP scenario features rapid increases in production from thermal projects, primarily SAGD and CSS, with some application of VAPEX as well.
- In the TV scenario, production expansion is slowed by: the higher costs of enhanced environmental conditions, uncertainty regarding the economic impact of future environmental measures, higher light/heavy differentials, higher natural gas prices and tighter markets for bitumen blends.
- In the TV scenario, producers lower production costs by a greater application of advanced technology and less energy intensive, more environmentally benign recovery techniques, such as VAPEX and THAI, for example. Production levels will be about 15 000 m^3/d below SP levels in 2025.

Condensate Supply & Diluent Requirement – WCSB

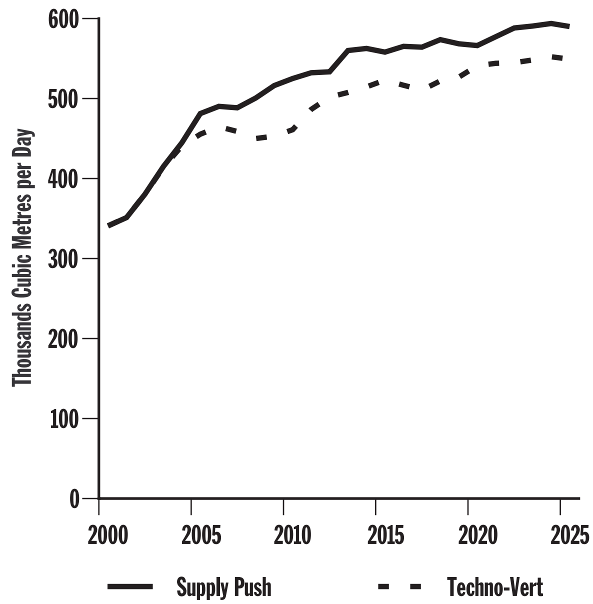
Figure 5.12 Condensate Supply & Diluent Requirement – WCSB



- The bulk of the condensate supply is derived from the processing of natural gas. Therefore, the condensate projections are directly related to the natural gas projections in both scenarios.
- On average, conventional heavy oil blends contain about seven percent condensate diluent, while oil sands bitumen blends contain about 33 percent.
- In SP, the Husky Upgrader expansion occurs in 2006, while it is delayed until 2008 in TV. Both scenarios assume the Petro-Canada Strathcona refinery conversion takes place in 2008, with an additional phase in 2013.
- The tightness of condensate supply for diluent that appears in both cases by 2004 is based on current condensate usage patterns. Condensate supply can be augmented by re-directing other-use supply to diluent usage, and by utilizing light crude, refinery naphtha or synthetic crude as blending agents.

Crude Oil Production – Total Canada

Figure 5.13 Crude Oil Production – Total Canada



- In the SP scenario, production expands by about five percent per year until 2007, supported by increasing oil sands mining, in situ production, and by the East Coast offshore. Production expansion gradually declines to about 0.5 percent per year by 2013, peaking in 2024 at 594 000 m^3/d. After 2013, expanding production from oil sands only slightly outpaces declining WCSB and East Coast production.
- In the TV scenario, production levels plateau between 2004 and 2008 as oil sands and heavy oil producers adjust to a more environmentally protective setting, higher light/heavy differentials, higher natural gas prices and tighter heavy oil markets. After 2008, production increases are roughly parallel to those of SP.
- By 2025, the TV scenario production levels are about 40 000 m^3/d below the SP scenario levels. Refineries in Alberta convert to process blended bitumen in the TV scenario, reflecting the demand for cleaner fuels.

5.2.3 SUPPLY AND DEMAND BALANCES

Supply Push

Figure 5.14 Supply and Demand Balance – Light Crude Oil: Supply Push

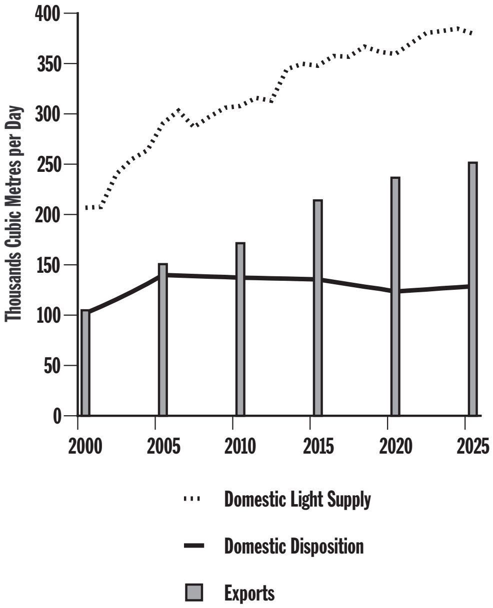
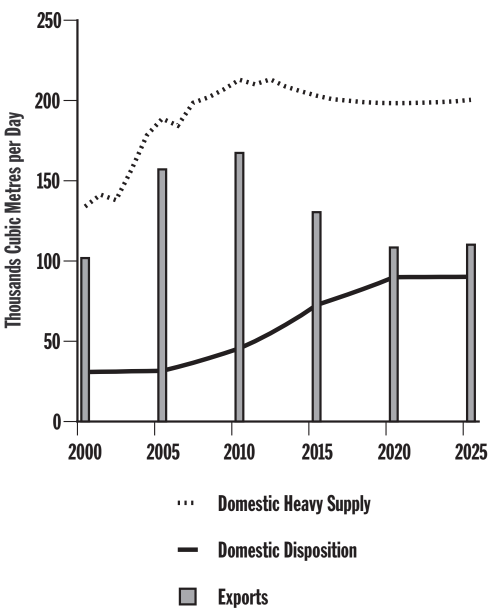


Figure 5.15 Supply and Demand Balance – Heavy Crude Oil: Supply Push



Exports of light crude oil rise steadily throughout the projection period. In the SP Scenario, exports increase from 105 000 m^3/d to 170 000 m^3/d between 2000 and 2010, then increase by an additional 50 percent to 250 000 m^3/d by 2025. Heavy crude oil exports increase from 100 000 m^3/d in 2000 to a peak of about 170 000 m^3/d in 2010, then decline. These export levels underscore Canada's role as a major U.S. supplier.

Because Québec and Atlantic refineries do not have access to western Canadian crude oil, they will continue to import most of their feedstock requirements. While East Coast offshore production will make its way into Ontario, Québec and Atlantic refineries, it will displace only a small portion of the imported volumes.

By 2015, some Alberta refineries are assumed to increase capacity and be converted to process heavy crude oil and blended bitumen, instead of light crude oil. This lowers the domestic feedstock requirement for Canadian light crude oil, and conversely, increases demand for heavy crude oil. Both scenarios assume other Canadian refineries continue to process their historic crude oil types.

In the SP scenario, supply security is a key driver and the U.S. market absorbs the bulk of Canada's increased production. However, refinery investments and pipeline expansions may be required to accommodate the growing outputs, and price discounts may be required from time to time.

Oil Sands: Opportunities and Challenges

The vast bitumen resources contained in Alberta's oil sands deposits offer attractive opportunities for developers, because:

- The resource is known and well delineated; there is virtually no exploration risk.
- Projects offer reasonable rates of return over a 35 to 40 year life, with significant opportunity for project expansion.
- A stable, generic fiscal regime is in place.
- Operating costs for integrated mining/ upgrading plants have been roughly halved since 1990 through the continuous application of new technology, a trend that is expected to continue. This applies as well to in situ bitumen recovery, both primary and thermal, where advances in horizontal drilling, and development of new technologies such as SAGD, THAI and VAPEX, hold great promise in increasing recovery factors and reducing supply costs.
- The U.S. requirement for crude oil imports is projected to expand as demand grows and domestic oil production declines. Canadian producers appear to be well positioned to take advantage of this opportunity. Supply costs for oil sands-derived Canadian crude oil are roughly competitive on a world-wide basis and expanding markets in Asia represent an additional potential opportunity.

Although the potential rewards are substantial, there are many challenges facing oil sands developers, such as:

- Projects are capital intensive, on the order of C$6 billion to C$8 billion for a grassroots integrated mining and upgrading project, and C$300 million to C$1 billion for an in situ thermal project.
- Long lead times, typically 5 to 7 years from start of planning to first production.
- Volatile oil and natural gas prices, and volatile light/heavy crude oil price differentials facing in situ bitumen producers, add considerable risk in predicting rates of return on investment.
- Competition for a limited supply of skilled labour can result in significant cost over-runs during construction of large-scale oil sands projects.
- A shortage of condensate for blending bitumen is expected in the 2004 to 2006 timeframe, requiring the use of non-traditional diluents, such as light synthetic crude oil or specifically manufactured naphthas, for instance, all resulting in added cost to the producer.
- The industry views uncertainties regarding future environmental legislation as a considerable challenge, because it is difficult to estimate the extent of these measures and their cost implications.
- In certain aboriginal communities in the oil sands regions, there are unresolved issues concerning land access and resource rights. While industry and governments have been actively engaged with local stakeholders, there are still considerable challenges in reaching a final and timely resolution on many of these issues.

Techno-Vert

Figure 5.16 Supply and Demand Balance – Light Crude Oil: Techno-Vert

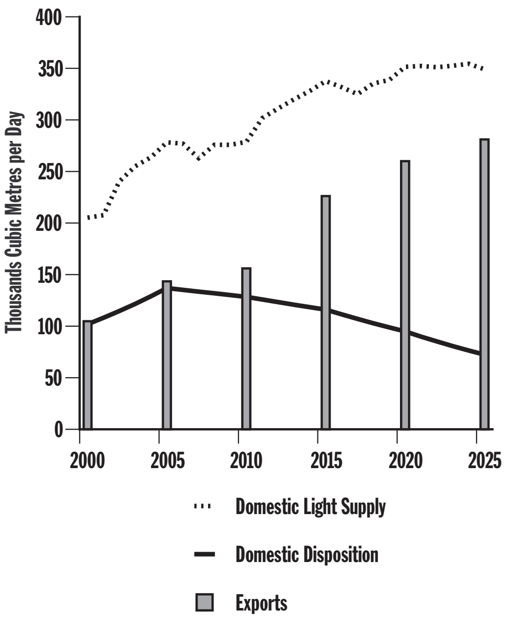
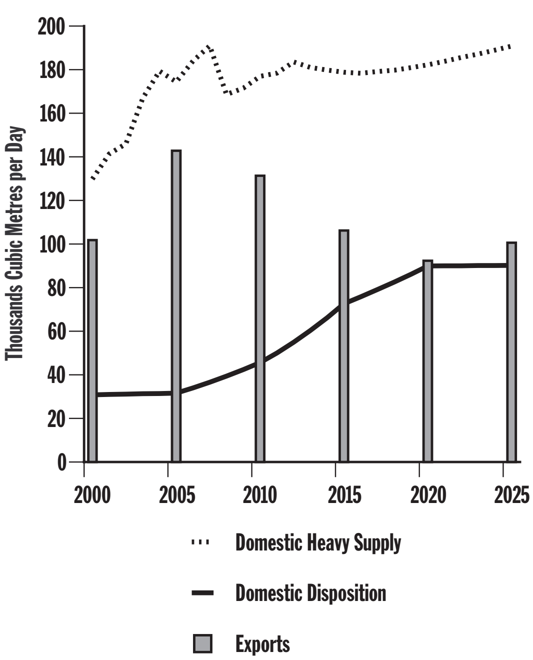


Figure 5.17 Supply and Demand Balance – Heavy Crude Oil: Techno-Vert



Exports of light crude oil reach 141 000 m^3/d by 2005 and continue to increase steadily, climbing to 275 000 m^3/d by 2025. In contrast, heavy crude oil exports peak in 2005 at 143 000 m^3/d, then decline to 100 000 m^3/d by 2025. In the TV scenario, Canada continues to be a significant U.S. supplier.

The TV scenario's emphasis on cleaner burning feedstocks results in lower heavy crude oil production and correspondingly lower export levels. Fuel switching and changes in transportation demand result in a slower growth rate in the demand for petroleum products, thus reducing demand for North American heavy crude oil.

The SP scenario assumptions around Alberta's refinery conversions are also expected to take place in the TV scenario. However, faster technological development in TV encourages refiners to make greater advancements in producing clean fuels.

The TV scenario assumes U.S. demand is sufficient to absorb any crude oil production in excess of Canada's domestic requirements. Again, it is recognized that refinery investments may be required to accommodate this supply and price discounts may be required from time to time.

5.2.4 ISSUES AND IMPLICATIONS

➢ Condensate

Condensate is used to dilute bitumen. Therefore, as non-upgraded bitumen production increases, there is a corresponding increase in demand for condensate. Current condensate usage patterns indicate a shortfall could occur as early as 2004. Some steps could be taken to augment the condensate supply, such as:

- Re-directing condensate volumes previously used as petrochemical feedstock
- Directing Caroline condensate to the condensate pool
- Directing more light crude to the condensate pool

Even with these measures in place, a condensate shortfall is projected to occur between 2006-2007. In the SP scenario, the shortfall reaches 25 000 m^3/d by 2025, compared to 22 000 m^3/d by 2025 in TV. Proposed solutions include: using synthetic crude oil as a blending agent to create a "50/50"synthetic/bitumen blend, or SynBit; utilizing refinery naphtha and upgrader naphtha; more complete recovery of liquids from natural gas recycling schemes and situations where liquids are stranded from lack of pipeline connection; and recycling international diluent by truck and tank car. However, each of these solutions increases production costs. Of course, the addition of local upgrading capacity or partial upgrading reduces demand for diluent.

➢ Natural Gas

The extraction and upgrading of oil from oil sands requires substantial amounts of natural gas. Integrated mining and upgrading projects use natural gas as a source of process heat and feedstock, using about 0.4 Mcf of natural gas per barrel of oil produced. In situ projects use natural gas as a source of heat to produce steam for thermal operations, using about 1.0 Mcf/bbl. The total natural gas requirement for SP and TV is estimated at 1.8 Bcf/d and 1.6 Bcf/d, respectively, by 2025. Thus, natural gas supplies and prices are major concerns for oil sands operators. If natural gas prices become prohibitively expensive or if natural gas becomes in short supply, other sources of fuel will be needed. Proposed solutions include: gasification of bitumen, use of coal through clean coal technology, and even nuclear energy.

➢ Skilled Labour

Competition for skilled labour contributed to cost overruns of 60 to 85 percent for some recently-completed integrated mining projects. Improved project management, and training programs to increase the number of skilled labourers may be a remedy. However, maintaining an adequate supply of skilled craftsmen and professionals is a major concern for the oil industry as Canada's baby-boomers near retirement. These limitations were incorporated into the scenarios. Capital expenditures of C$3.5 billion per year, yielding 110 000 bbl/d of incremental production, were used a proxy for the upper limit of annual production expansion for large-scale oil sands plants.

➢ Environmental Legislation

Future environmental legislation is uncertain. It is a considerable challenge for the energy industry to estimate the extent and cost of these measures. Although the environmental impact of oil sands operations has been considerably reduced on a per unit of production basis, legislation may require further efforts to minimize emissions, water usage, and the overall environmental footprint. Regulators may also consider the overall cumulative effect of oil sands operations when considering approval for project applications. The Kyoto Protocol is also impacting the industry. The production cost of complying with the first stage of the Kyoto protocol (as set out by the federal government) is estimated to be only about 20 to 30 cents per barrel. However, compliance costs after 2012 have not been projected.

5.3 Natural Gas Liquids (NGLs)

5.3.1 NGLS SUPPLY AND DISPOSITION

NGLs include ethane, propane and butanes. Pentanes plus (or condensate) are discussed in section 5.2.2. Outlooks for NGL supply (including pentanes plus) are derived from the natural gas production outlooks. Current production ratios (i.e., barrels of liquid per thousands of cubic feet of natural gas) are held constant through 2025.

The majority of Canadian propane and butanes production is currently derived from natural gas, with production from crude oil refining making up about 15 percent of propane and 40 percent of butanes. As natural gas supplies decline, the propane and butanes production share from refinery processes is expected to increase in both scenarios to accommodate increasing demand.

- Unconventional natural gas from LNG and CBM is not expected to contribute to Canadian liquids supply.
- Alliance pipeline liquids are excluded.
- Extraction of liquids is assumed to be economic under both scenarios over the long term given the price assumptions. However, from time to time, when the price of natural gas reaches parity with or exceeds the price of oil, extraction may not be economic.
- Excess volumes of propane are available for export throughout the projection period under each scenario. However, in light of the expected high/volatile natural gas price environment, propane supply (particularly in the United States) could be periodically reduced when it is more economic to leave lighter hydrocarbons in the natural gas stream.
- Butane balances are expected to be tighter than for propane. By 2019, butane demand (e.g., for motor gasoline blending) in SP will surpass supply, creating a shortfall to the end of the projection period.

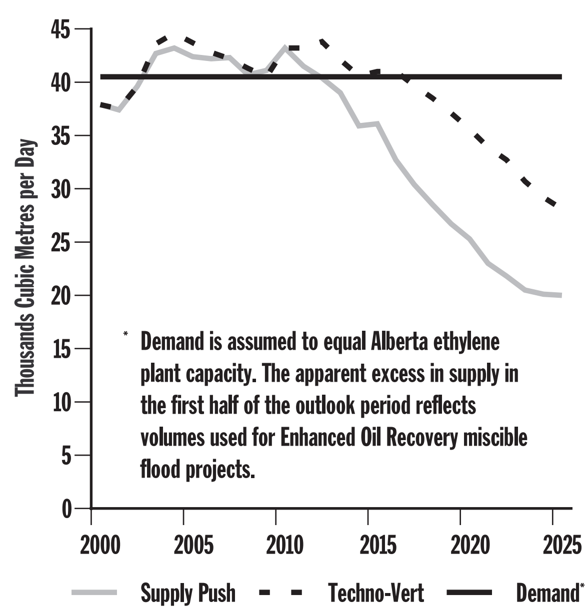
5.3.2 ETHANE PRODUCTION OUTLOOK

The major assumptions common to both scenarios are:

- The supply outlook does not include any potentially available ethane from the East Coast or British Columbia offshore.
- Assuming that some straddle plant expansion occurs, about 5 200 m^3/d of incremental ethane is added early in the period, with another 2 700 m^3/d added about mid-period.
- Natural gas supply from the Mackenzie Delta adds about 3 000 m^3/d of ethane, commencing in 2010, increasing to about 5 000 m^3/d in 2015 (assuming the natural gas stream contains about four percent ethane).
- Small amounts (1 600 m^3/d each) of unconventional ethane from oil sands off-gas and ethane recovered upstream of Alliance pipeline are added.
- There is insufficient ethane to support development of a petrochemicals industry in the Atlantic provinces. As a result, both scenarios assume ethane is left in the natural gas stream.

5.3.3 ETHANE SUPPLY AND DEMAND BALANCES

Figure 5.18 WCSB Ethane Supply and Demand: Supply Push versus Techno-Vert



Demand growth is limited under both scenarios due to decreasing ethane supply. The decline in supply follows the decrease in conventional WCSB natural gas production in both scenarios. However, small increments of ethane supply (related to straddle plant capacity expansion and Mackenzie Delta, etc. – as discussed above) flatten the decline rate.

Demand from Alberta ethylene plant capacity, as depicted in Figure 5.18, exceeds supply by the middle of the projection period, with the shortfall increasing to about 19 800 m^3/d by 2025 in SP. Therefore, there is no supply available for export in either scenario. In TV, demand exceeds supply about the middle of the analysis period and the ethane shortfall increases to about 11 900 m^3/d by 2025.

5.3.4 ISSUES AND IMPLICATIONS

➢ Ethane Supply

Long-term ethane supply is an important issue, particularly as conventional WCSB natural gas production declines. Given that only about 60 to 65 percent of theoretically available ethane is currently extracted, investment in deep-cut extraction may increase ethane production. However, the economics of deep-cut extraction are uncertain because of the relatively high capital cost and added expense of removing associated increased CO_2 volumes. Whether deep-cut expansion is a practical solution ultimately depends on the competitiveness of North American petrochemical producers in the global market.

Nevertheless, petrochemical producers will assess other options to supplement ethane supply, including a combination of additional unconventional ethane, alternative hydrocarbon feedstocks (i.e., propane and butane), and ethane extracted from Alaskan natural gas.

5.4 Natural Gas

5.4.1 RESOURCES

Estimates of Canada's natural gas resources, including undiscovered resources, total 548 Tcf (15 525 billion m^3) in the SP scenario and 596 Tcf (16 880 billion m^3) in the TV scenario (Figures 5.19, 5.20). In TV, a higher resource estimate is assumed for the WCSB, reflecting the expectation that a higher rate of technological advance leads to more effective exploration and development techniques, which in turn results in increased resource and production levels. Approximately one-half of the natural gas resources in Canada are located within the WCSB, and of this portion about one-half has already been produced. Estimates of resources were adopted or modified from studies conducted by the Canadian Gas Potential Committee, the Geological Survey of Canada, the Canada-Nova Scotia Offshore Petroleum Board, the Canada-Newfoundland Offshore Petroleum Board and the NEB.

Figure 5.19 Natural Gas Resources in Canada – Supply Push

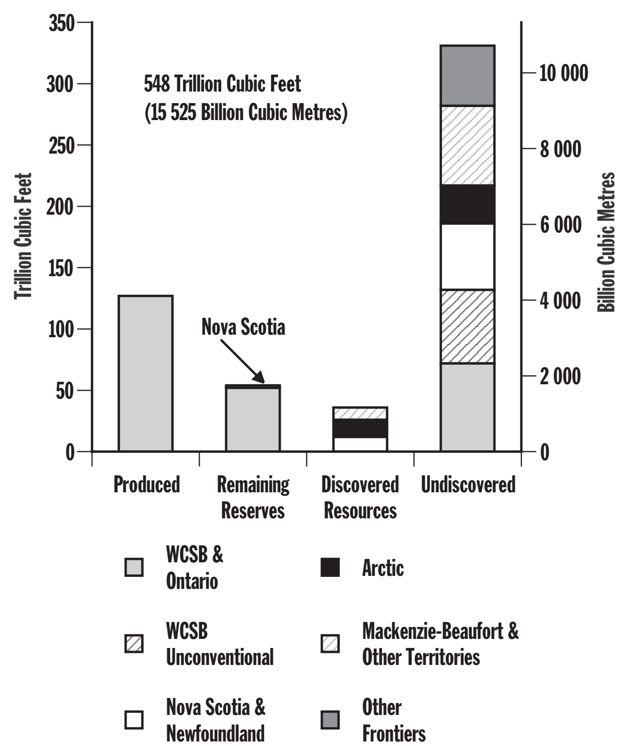
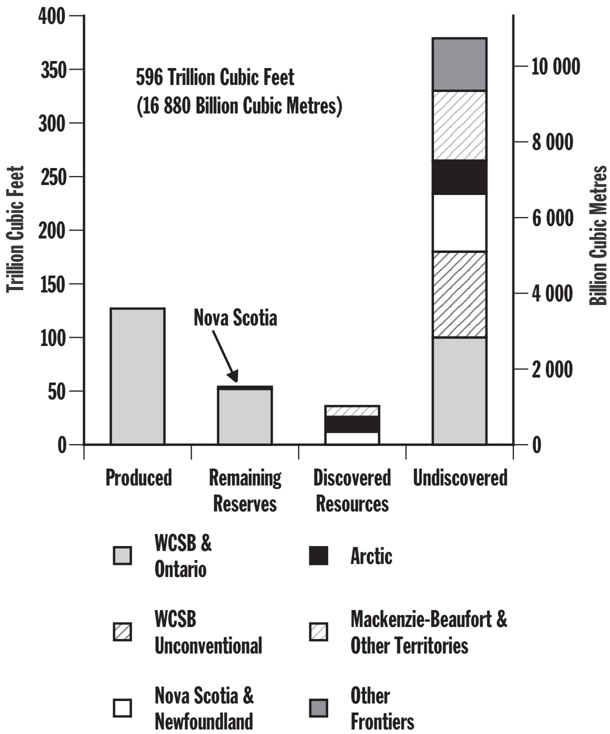


Figure 5.20 Natural Gas Resources in Canada – Techno-Vert



The WCSB also contains unconventional natural gas resources, including CBM and shale gas. CBM would be the main source of natural gas produced in this category over the projection period. The estimates for unconventional resources are considered preliminary since these natural gas sources are in the very early stages of development in Canada.

With the exception of offshore Nova Scotia, most frontier resources are situated in areas that are not currently producing natural gas. Resources in a number of the frontier areas were discovered decades ago, but their exploitation has not been economically feasible, and today they remain without access to transportation systems.

Uncertainties Regarding Natural Gas Resources

The size of Canada's natural gas resource base continues to be a significant uncertainty, especially for the frontier regions and unconventional natural gas. Through exploration drilling and development, industry's knowledge of the WCSB has improved and resource estimates have generally increased. Continuous development of technology further enhances the ability to identify and exploit pools. At the same time, improved information leads to a narrower range of estimates. However, as with other basins, opinions still vary on the actual size of the WCSB resource base.

As technology improves and exploration increases in both scenarios, perhaps new geological concepts can be proved that would enable further increases to natural gas resource estimates. However, recent drilling and production data suggests that the WCSB may be maturing; and changes in natural gas resource estimates may be warranted for some areas.

Very little development of unconventional natural gas has occurred to date; consequently, the uncertainty associated with estimates of unconventional natural gas resources is high. A few producers have successfully developed CBM and if success continues, the unconventional natural gas resource base could be much larger. Estimates of resources for most of the frontier regions have a much greater degree of uncertainty than estimates for the WCSB, reflecting the limited state of exploration in those areas. Although discovered resources may exist in some frontier areas, in general these basins are relatively undeveloped compared to the WCSB. Estimates of resources for the frontier areas rely on more limited information and therefore are subject to significant upward or downward revisions as new information becomes available. Some of these regions, such as the Arctic Islands, may have discovered resources but are not expected to produce any natural gas over the projection period due to the high cost of developing production and transportation facilities in remote areas.

5.4.2 PRODUCTION OUTLOOK

Figure 5.21 Deliverability by Project – Supply Push

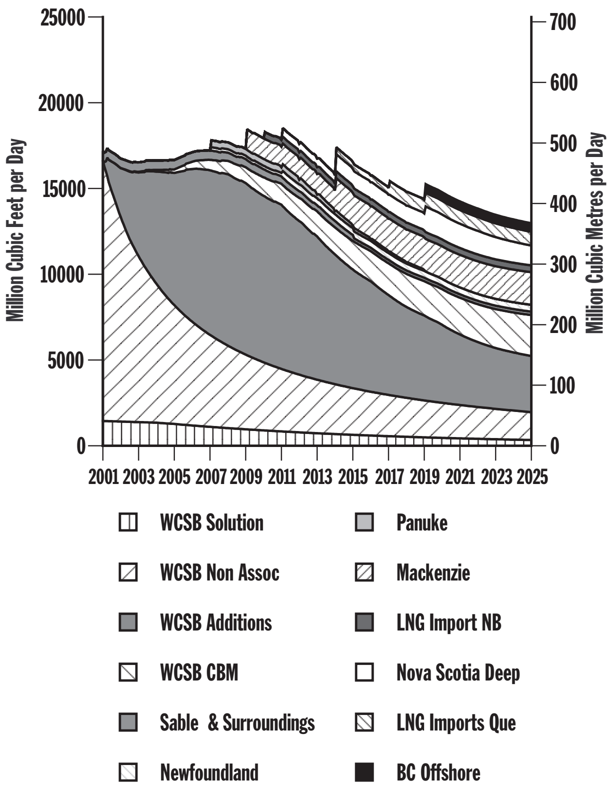
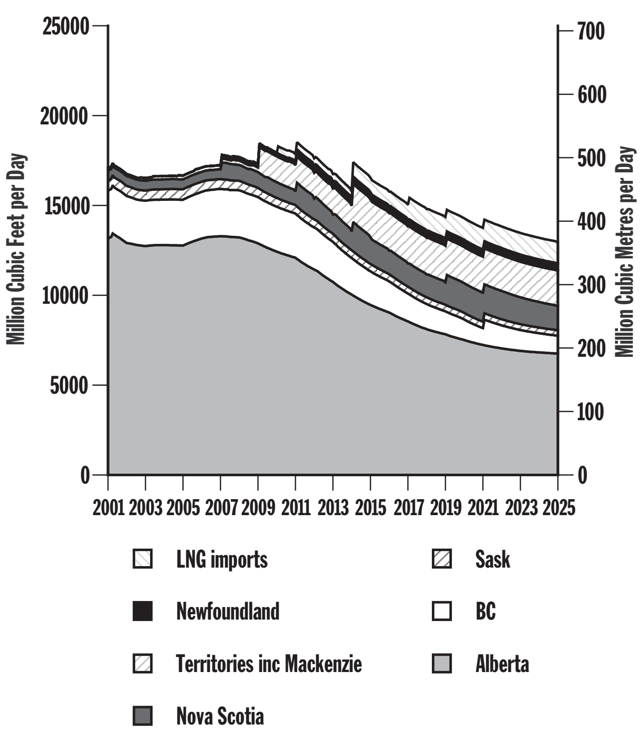


Figure 5.22 Deliverability by Region – Supply Push



Some resources in the WCSB are located in isolated areas or in small pools that may not be economical to develop at natural gas prices consistent with either scenario. Consequently, 64 Tcf (1 813 billion m^3) or 90 percent of the available undiscovered resources in the WCSB was utilized for determining deliverability in SP (Figures 5.21,5.22). In TV, better economics through improved technology and higher natural gas prices, enable 92 Tcf (2 606 billion m^3) or 95 percent of the available undiscovered resources to be used for determining deliverability (Figures 5.23, 5.24). The larger resource base in TV also allows deliverability from the WCSB to be maintained longer than in SP.

The supply profile for the WCSB assumes that drilling levels similar to those experienced in 2001 are maintained until about 75 percent of available resources have been produced. At this point, the size of the remaining resource begins to limit prospective drilling locations and constrains production. Both scenarios also assume that the producing characteristic of new wells would be similar to current wells in the same area.

In SP, CBM development is expected to gradually increase from 300 wells in 2003 to nearly 3 000 wells per year by 2010 and this level is maintained to the end of the projection period. On average, each CBM well commences production at a rate of 100 Mcf/d (2 830 m^3/d) and recovers 0.375 Bcf (10.6 million m^3) of natural gas. Total production of CBM steadily increases, reaching 2.4 Bcf/d (68 million m^3/d) by 2025.

The higher rate of technological advancement in TV results in higher productivity (150 Mcf/d, 4 250 m^3/d) and natural gas recovery (0.5 Bcf, 14.2 million m^3) per CBM well. Lower drilling costs are also achieved. Drilling activity increases to about 3 500 wells annually by 2010 as a result of the lower drilling costs. CBM production in TV is expected to reach 4 Bcf/d (113 million m^3/d) by the end of the projection period.

Both scenarios assume frontier supply from three additional projects located offshore Nova Scotia, each producing 500 MMcf/d (14.2 million m^3/d). A similar-sized project offshore B.C., in operation by 2020, is included in SP but is excluded from TV because of heightened environmental sensitivity.

Unconventional Natural Gas

Canada's unconventional natural gas resources fall into three categories – coalbed methane (CBM), shale gas and gas hydrates. CBM consists of methane bonded or adsorbed onto the large internal surface area of the coal. This methane can be released by either reducing the pressure within the coal seam or by replacing the methane molecules with CO_2. CBM is generally present wherever coal is found. Production of the CBM does not impact the quality of the coal for mining later and may make the mining safer by removing a hazard. Shale gas consists of methane adsorbed onto the surface areas of organic matter in the shale – again, the gas can be released by reduction of pressure. The best potential shale gas deposits are those shale deposits with a high organic content, and several shales in western Canada qualify as targets. Pressure reduction is accomplished by producing the formation water, which lowers the pressure in the formation and allows the gas to be released. Fracturing, both natural and induced, is generally required to provide flow pathways to the well bore. Gas hydrates consist of methane molecules trapped in and encased by a cage of ice molecules. Gas hydrates are found on or under the ocean bottoms, or on land under permafrost areas. This gas can be released by raising the formation temperature, by reducing the formation pressure, or by injecting chemicals to melt the ice. The chance of achieving any commercial methane production from gas hydrates before 2025 is very low. The technical challenges regarding viable extraction methods, the nature of the hydrate deposits and how they will perfrom are still largely unknown.

CBM is the first unconventional gas to be commercially developed in Canada and is expected to provide the majority of the unconventional production in the Board's scenarios. Shale gas should be developed second, and there is some indication that these shales could be helping to support current conventional gas production in the shallow gas areas of the WCSB. The development of gas hydrates requires the solving of several complex technical challenges, but there is some possibility of gas hydrates being developed before 2025. If economical development of these gas types can be achieved, the total gas resource potential is very large.

While CBM has been successfully developed for a number of years in the U.S., coal seams in Canada tend to be thinner than coal seams in the U.S. and to have lower permeability. The challenge has been to find local areas with better coal characteristics while learning the techniques that work best for that particular coal. Other challenges to be overcome include a number of issues related to water disposal, legal issues over CBM ownership, land availability, and the cost of compressing produced gas to pipeline specifications. CBM development is more a function of cost control than technology development.

Commercial production of CBM was reached in Canada in January 2002. A successful project near Calgary is believed to have been producing about 5 MMcf/d (142 thousand m^3/d) at the end of 2002. There are also several other projects underway (under experimental status) on the plains of the WCSB, in the mountain regions of Alberta and B.C., and on Vancouver Island, but no further information is available.

The Mackenzie Valley pipeline system is expected to flow natural gas by 2010, at a rate of 1.2 Bcf/d (34 million m^3/d). An expansion by 2015 to 1.9 Bcf/d (54 million m^3/d) is common to both scenarios.

In SP, discovered resources in Newfoundland are developed by utilizing CNG technology and transportation by ship. The lower capital requirement for transportation by ship, as opposed to pipeline, enables economic development of smaller known resources and gradual development of new resources. In SP, Newfoundland production begins at 0.2 Bcf/d (5.7 million m^3/d) in 2008 and increases to 0.4 Bcf/d (11.3 million m^3/d) by 2012. Improved technology and economics in TV allow for larger-scale development which can support larger investments for pipeline transportation. However, development is delayed in order to maximize oil recovery in reservoirs containing both oil and natural gas. In TV, Newfoundland natural gas production starts in 2015 at 0.8 Bcf/d (22.7 million m^3/d) and is maintained at that rate for the remainder of the projection period.

In the SP scenario, Canadian natural gas deliverability peaks around the year 2010, at a rate of about 18 Bcf/d (510 million m^3/d). At this point, unconventional natural gas and frontier areas begin to significantly supplement supply from the WCSB. By the end of the period, unconventional natural gas and frontier areas provide 50 percent of Canadian deliverability.

In TV, Canadian deliverability gradually increases from 17 Bcf/d (482 million m^3/d) at the beginning of the projection period to 19 Bcf/d (538 million m^3/d) (excluding LNG imports) by 2015. The higher deliverability rate is possible in TV because of the larger available undiscovered resources in the WCSB.

Figure 5.23 Deliverability by Project – Techno-Vert

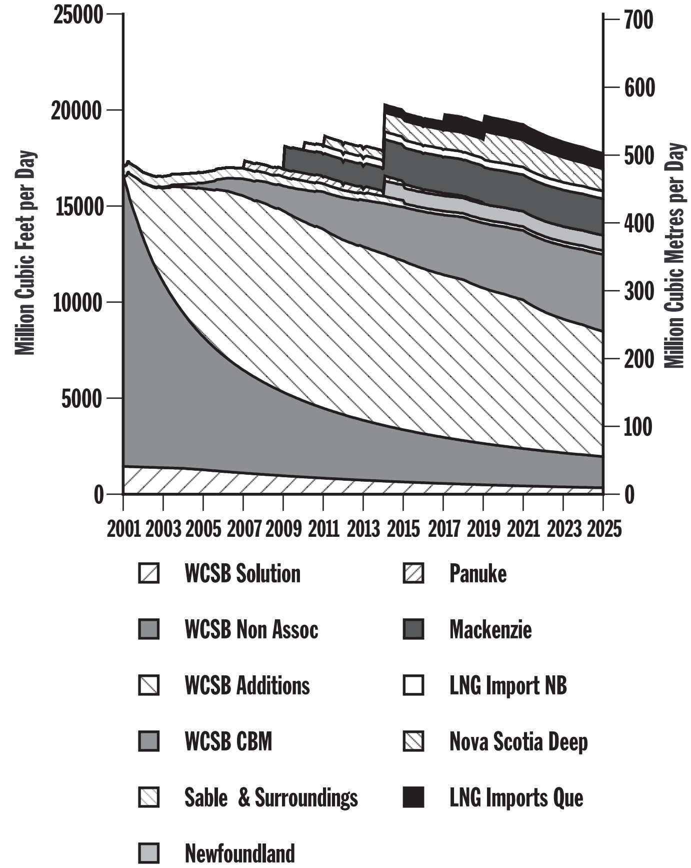
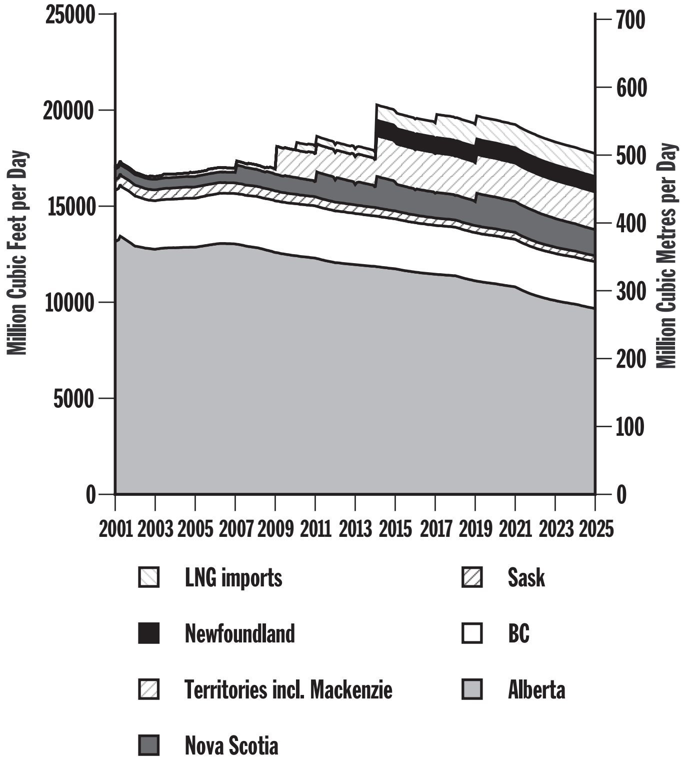


Figure 5.24 Deliverability by Region – Techno-Vert



Uncertainties Regarding Resource Development

Uncertainty regarding the size of the resource base for the WCSB has significant implications for the deliverability projections. In fact, most of the difference in the deliverability projections for the two scenarios is due to differences in estimates for conventional resources in the WCSB. The WCSB is a well understood basin and its producing and resource characteristics are well established; consequently, estimates of ultimate potential fall within a narrow range. Any future revision to natural gas resource estimates, either upward or downward, will have a corresponding impact on deliverability and the amount of natural gas available to meet demand.

Drilling levels also directly influence WCSB deliverability projections, especially in the early part of the projection. However, for both scenarios, it is conceivable that drilling could be even higher in the pursuit of increased natural gas production. Similarly, lower drilling levels will result in reduced production.

The timing and magnitude of production from many frontier areas are uncertain and are highly dependent on the degree of exploration success. Projects in these areas typically require long lead times between discovery and commencement of production. Estimates of the timing and size of these projects also tend to change as these projects develop. A recent example is the deferral of the Deep Panuke project located offshore Nova Scotia. This is a significant development which almost doubles the current production from that region.

Resource estimates for frontier and unconventional natural gas supply greatly exceed the amounts needed to justify the projects included in the scenario projections. Although there is greater uncertainty, estimates for these resources are not a major constraint and have only minimal impact on deliverability projections.

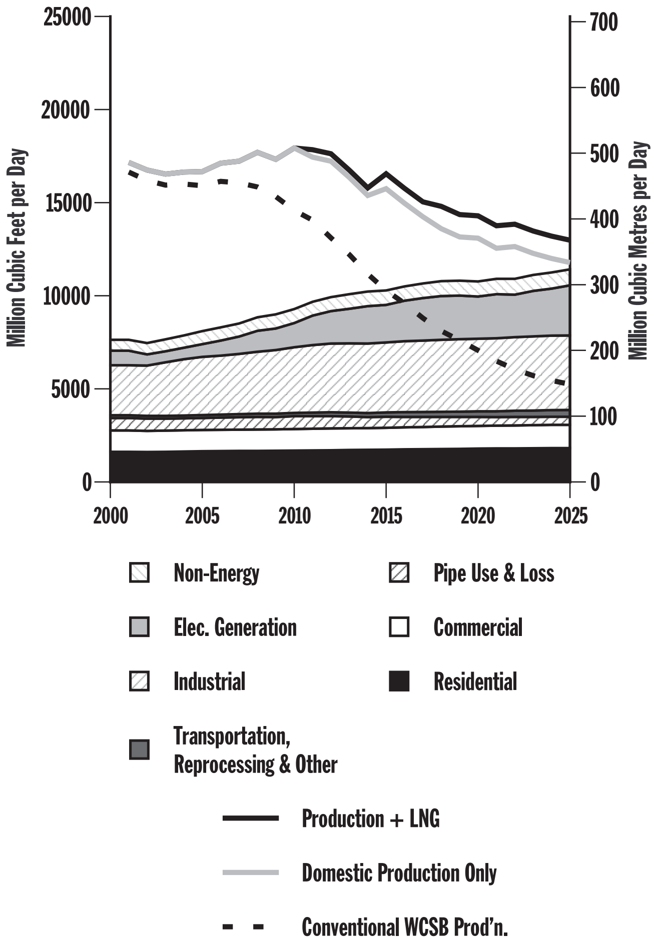
The development of some frontier areas may be limited by factors other than uncertainty regarding resource estimates. For example, areas such as Mackenzie-Beaufort and Newfoundland/Labrador, have sufficient discovered resources to justify the startup of the projects included in these projections. However, these projects have not been developed due to economic limitations, land claims, and market uncertainty. In contrast, new projects in other frontier areas with less discovered resources are more dependent on exploration success.

Similarly, the development of CBM is not restricted by the size of the resource. This unconventional resource has high potential as large volumes of natural gas may exist, but the exploitation of this resource is very dependent on the industry being able to consistently find coals with the capability to produce gas at acceptable rates, and being able to develop new technology to reduce costs.

5.4.3 SUPPLY AND DEMAND BALANCES

Supply Push

Figure 5.25 Canadian Production vs. Domestic Demand – Supply Push



The SP scenario projects a tight balance between natural gas supply and demand, which increases the likelihood of higher prices and greater price volatility. In this scenario, significant adjustments in natural gas markets and actions to increase supply are required to avoid the potential for prolonged imbalance and volatile prices (Figure 5.25).

As western Canada's conventional natural gas production declines, there is greater reliance on developing new supply sources. However, these new sources bring greater uncertainty and risks with respect to their associated timing, cost, and production levels. Natural gas markets, particularly those most distant from conventional WCSB supply, will face increased competition for natural gas, higher prices, and greater volatility in prices. Natural gas intensive users that are sensitive to prices may be required to make greater adjustments and consider alternative fuels, periodic reductions in operations, or in some cases, closure or relocation.

SP projections show natural gas demand growth across all sectors, led by increases for natural gas-fired electricity generation and development of massive oil sands projects. However, there is significant uncertainty associated with the incremental natural gas demand. While new natural gas-fired generation and natural gas for oil sands projects are currently planned, the actual level of demand may be reduced in the future as project developers consider alternative fuels. On the other hand, a large increase in natural gas demand to satisfy these projects pressures other natural gas users to use an alternative fuel or reduce demand.

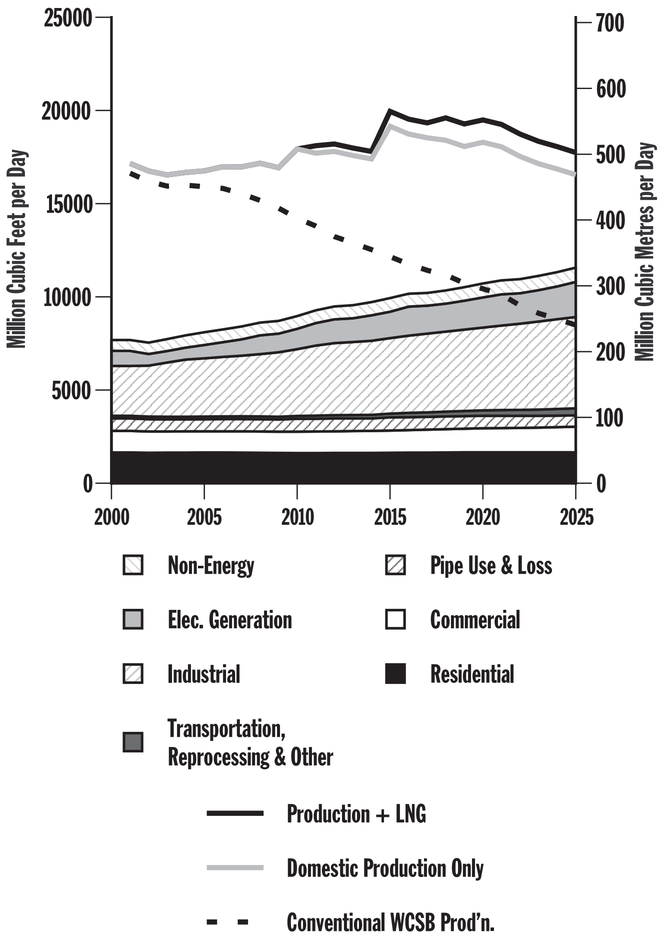
The ability to turn to other fuels such as coal and fuel oil, and the greater potential to increase imports of LNG into North America, keeps long term natural gas prices from escalating beyond that in TV.

Although all end-users are impacted by high prices and volatility, the implications for and the responses from the various end-use sectors may differ. For example, fuel options for the residential and commercial sectors are limited by local delivery infrastructure. Therefore, response may be limited to conservation and improving the energy efficiency of equipment and buildings. Other end-users, such as some industrials and power generators are more sensitive to price, and may consider using alternative fuels and more energy-efficient technology, especially later in the SP scenario. Finally, end-users heavily reliant on natural gas and lacking the ability to use alternative fuels or feedstock are more susceptible to regional and periodic imbalances. Those end-users are limited to reducing their demand or relocating.

In Atlantic Canada, natural gas availability increases with the further development of offshore natural gas supply and possible LNG import facilities. This presents further opportunities to expand the natural gas market in the region. However, the growth in eastern natural gas supply does not offset the decrease in supply from western Canada, resulting in an overall tightening of the Canadian natural gas balance.

Techno-Vert

Figure 5.26 Canadian Production vs. Domestic Demand – Techno-Vert



Similar to SP, the balance between natural gas supply and demand in TV tightens through the projection period and requires the development of new sources to compensate for declining production from conventional sources in western Canada (Figure 5.26). Although there is higher natural gas demand in TV, the greater technological advances may extend production from existing sources and enable the further development of new conventional as well as unconventional sources.

Technological advances in TV also reduce the overall energy intensity in all end-use sectors relative to SP. However, a stronger preference for clean-burning natural gas in this scenario results in an overall higher natural gas demand across all end-use sectors. In particular, natural gas-fired electricity generation, development of oil sands, and the industrial sector lead the natural gas demand growth.

Natural gas markets in both scenarios face challenges that result from declining production from conventional sources. Users can respond by altering their source of natural gas supply, diversifying to other fuels, or by reducing demand during periods of imbalance. Scenario projections suggest, however, that the imbalances and market adjustments required in TV may be less drastic than required in SP.

Uncertainties Regarding Natural Gas Balances

As the natural gas supply and demand balance tightens, the SP scenario presents significant challenges and leads to competition for supply amongst consumers. Possible impacts to end-users may be felt through higher and volatile natural gas prices. End use markets with limited fuel options (e.g., residential, commercial, natural gas intensive industries, distant exports, etc.) that are most distant from the supply sources are likely to be susceptible to more of these factors and require significant adjustments.

Although there is a more favourable projection of supply and demand balance in TV, there is still significant uncertainty and risks around the timing and development of new natural gas supply. Deviations and uncertainty in the available production, cost, and the timing of the various new supply projects result in short-term imbalances and price variations.

In both scenarios, LNG is expected to play a key role in bridging any gap in Canadian and even North American supply, especially in the near term with expansions of existing U.S. LNG terminals. Greater imports of LNG provide the necessary lead-time to find and develop new resources or to develop other LNG terminals in the U.S., Mexico and Canada. There is potential for further development of LNG in North America in the latter part of the projection as the natural gas supply and demand balance tightens. In addition to LNG, there will also be increased reliance on frontier sources and unconventional natural gas to meet natural gas demand requirements into the future.

Development of Alaskan natural gas resources is consistent with SP. It is assumed to flow to lower 48 markets utilizing available capacity on Canadian pipeline systems. Such a development improves utilization of Canadian pipelines as supply from western Canada declines, thereby moderating transportation rates.

The significantly tighter supply and demand balance in SP likely means greater competition amongst all end-use markets and increased pressure for natural gas producers to develop other unconventional, smaller, and/or more remote sources of supply. This may be a challenge without rapid technological advances.

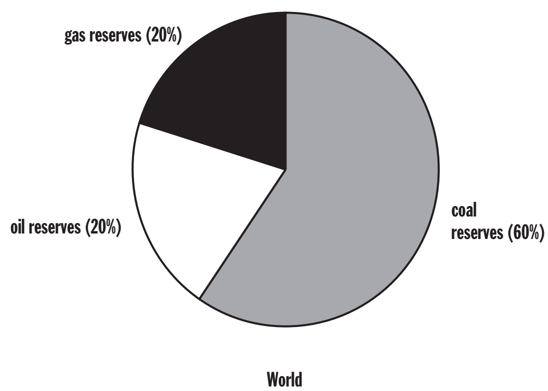
5.4.4 ISSUES AND IMPLICATIONS

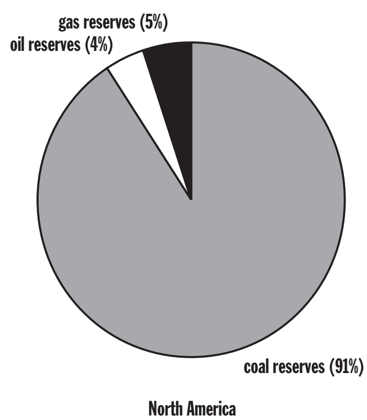
- The SP scenario seems to be unsustainable for the natural gas industry over the twenty-five year projection period. Without rapid improvements in technology to increase supply or reduce demand, increasingly large adjustments will be required in the marketplace.
- Despite a "push" to develop supply, conventional natural gas production from the WCSB begins to decline gradually before the end of the current decade. Initially, production from CBM offsets the decline in conventional production but, after a few years, CBM production cannot keep up. In addition, we assume that natural gas supplies from the North will be available in 2010.
- Eventually, significant market adjustments will be necessary. These adjustments occur primarily in the industrial sector, likely in the form of fuel-switching, perhaps with some non-energy industries relocating or discontinuing operations. Developers of oil sands deposits and electric power generators may also be pressured to reconsider their reliance on natural gas. Impacts on the residential and commercial sectors would be felt, especially in the form of higher and more volatile prices should there be delays in the connection of new supply sources.
- The SP scenario will likely result in significant changes to historical export patterns. For example, with declining production over time, Alberta natural gas may no longer reach the U.S. Northeast, requiring this market to increase imports from Atlantic Canada instead. Other U.S. markets, such as California, may reduce their dependency on Canadian imports, relying instead on growing supply from the U.S. Rockies, Alaska or imported LNG.
- In TV, end-users will also face market adjustments, although to a lesser degree than SP, as technology enables extended production from existing sources and more rapid development of others. However, adjustments are still necessary in response to the need for new or alternate transportation, higher natural gas and transport costs, and changes to supply reliability.
- The Maritimes natural gas market will be less constrained by supply and should have the potential to grow over the projection period. The growth, however, will be dependent on the extent of exploration success. Portions of the market in central Canada may be satisfied, to some extent, by Atlantic production as it seeks to reduce its primary reliance on western Canadian supplies.

5.5 Coal

Coal is abundant throughout the world, comprising 60 percent of the remaining reserves of hydrocarbons (Figure 5.27). In 2001, global reserves of coal were sufficient to provide about 216 years of production at current rates, as compared with 40 years for oil and 62 years for natural gas. In the U.S. and Canada combined, coal accounted for 91 percent of hydrocarbon reserves, excluding oil sands and oil shale. Coal reserves could provide about 236 years of production in 2001, whereas the corresponding reserves to production ratios for oil and gas were 10 years and 9 years, respectively.[3]

Figure 5.27 Composition of Hydrocarbon Reserves – 2001





Source: BP Statistical review of World energy 2002. Estimates are based on the conversion of oil, gas and coal, as reported inthis publication, to their respective equivalents.

Whereas over 70 percent of the world's oil and gas reserves are located in the Middle East and the Former Soviet Union, these two regions account for less than one quarter of coal reserves. Thus, coal reserves are widely dispersed over other regions, notably North America, Europe, China, Australia and India.

5.5.1 CANADIAN RESOURCES AND RESERVES

Coal resources include those deposits which occur in coal seams within specified limits of thickness and reflect the technical feasibility of exploitation. Over 95 percent of coal resources occur in Western Canada, and most of these consist of sub-bituminous deposits in Alberta and lignite in Saskatchewan (Table 5.2).

Table 5.2 Coal Resources (megatonnes)

	Bituminous & Anthracite	Lignite & Sub-Bituminous	Total
Western Canada[4]	32 765	44 450	77 215
Eastern Canada[5]	1 480	180	1 660
Total	34 245	44 630	78 875

Source: *Coal Resources of Canada,* Paper 89-4, Geological Survey of Canada, 1989; reported in *Canadian Energy Supply and Demand to 2025,* NEB, 1999, Table 8.1.

[4] Saskatchewan, Alberta, British Columbia and the Territories

[5] Nova Scotia, New Brunswick and Ontario.

Reserves include those resources that have been identified through exploration and sampling and are considered to be economic employing current technology. A national reserves estimate was last compiled in 1987 (Table 5.3). Deducting coal production since that time suggests that there are currently about 6 200 megatonnes of reserves at 2001 year-end which would be about 90 years of production. This compares with 8 years for oil and 9 years for natural gas.

[3] In this report, the concept of "reserves to production" is used simply to express the amount of reserves, as measured in a given year, relative to annual production in that year. The concept should not be utilized to infer that reserves would be fully produced within a specific time period. In fact, reserve additions from ongoing exploration and development over future years would extend the overall period until reserves might be exhausted.

Since the late 1980s, substantial consolidation has occurred in the coal industry; the number of major companies has been greatly reduced and those less attractive mining operations closed down in both the East and the West. However, this trend has been at least partially offset by new developments in recent years. Therefore, simply deducting production without accounting for new reserves may understate the coal inventory. Either way, remaining coal reserves are substantial.

Table 5.3 Remaining Established Coal Reserves Year-End, 1985 (megatonnes)

	Thermal[6]	Metallurgical[7]	Total
Western Canada[8]	5 069	1 793	6 862
Eastern Canada[9]	321	115	436
Total	5 390	1 908	7 298

Source: *Coal Mining in Canada,* 1986, Report 87-3E, CANMET, 1987. Reported in *Canadian Energy Supply and Demand to 2025,* 1999, NEB, Table 8.2.

[6] Thermal coals generally include lignite, sub-bituminous and some bituminous and anthracite classes.

[7] Metallurgical coals generally include bituminous coals from the medium-low and high-medium volatile classes.

[8] Saskatchewan, Alberta and British Columbia.

[9] Nova Scotia and New Brunswick.

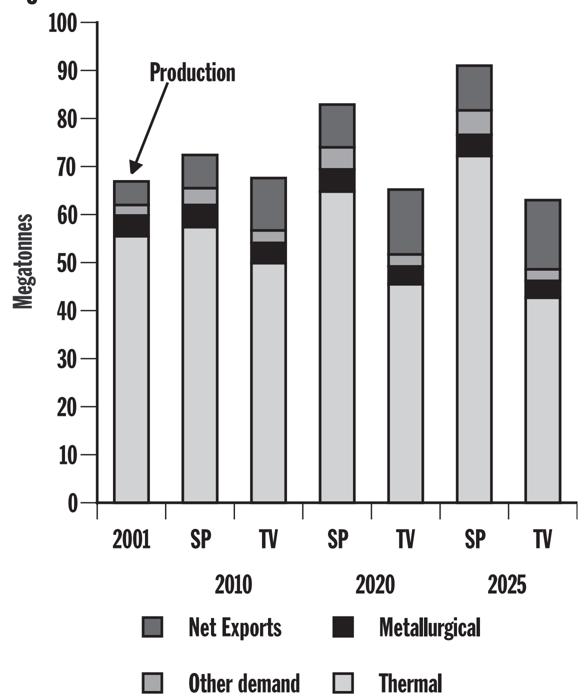
5.5.2 PRODUCTION OUTLOOK

Without significant resource constraints on coal production, coal prices are projected to decline moderately over the next decade. The Canadian production outlook in both scenarios is thus driven primarily by the domestic demand in power generation, which accounted for 90 percent of Canadian coal consumption in 2001, and by export demand, which is mostly for metallurgical coal. Production is therefore significantly affected by the choices made in power generation and the competitiveness of Canadian coal in international markets.

In the SP scenario, production increases moderately to 2010 (Figure 5.28). Growth in domestic thermal demand in the near term is limited to the increased utilization of existing power plants. In the longer term, the construction of new coal-fired power generation facilities in Ontario and in the West results in an increasing demand for coal. Rising thermal requirements along with higher domestic demands in other end-use categories, and higher exports, result in production rising to over 90 megatonnes per year by 2025, from 70 megatonnes in 2001.

In the TV scenario, coal production declines over time. This trend is mainly accounted for by declining thermal demand, even though power generation from coal increases slightly. In this scenario, new coal-powered units employ clean coal technology, specifically IGCC. Because these units are more efficient than conventional coal units, they require less coal per unit of electricity produced. Thermal requirements are lower than in the SP scenario, due to this increased efficiency and higher utilization of alternative generation sources, such as small hydro and wind, and increased nuclear generation.

Figure 5.28 Coal Demand and Production[1]



1 Production is equal to domestic demand (thermal, metallurgical and other) and net exports

Table 5.4 Main Determinants of Canadian Coal Production

Supply Push	Techno –Vert
• abundant, low-cost resource • increased demand in power generation utilizing conventional technology (price competitive) • Canadian coal production is competitive in international markets	• abundant, low-cost resource • new power plants employ “clean coal” technology • declining use in power generation, due to higher efficiency and available alternatives • Canadian coal production is competitive in international markets

5.5.3 SUPPLY AND DEMAND BALANCES

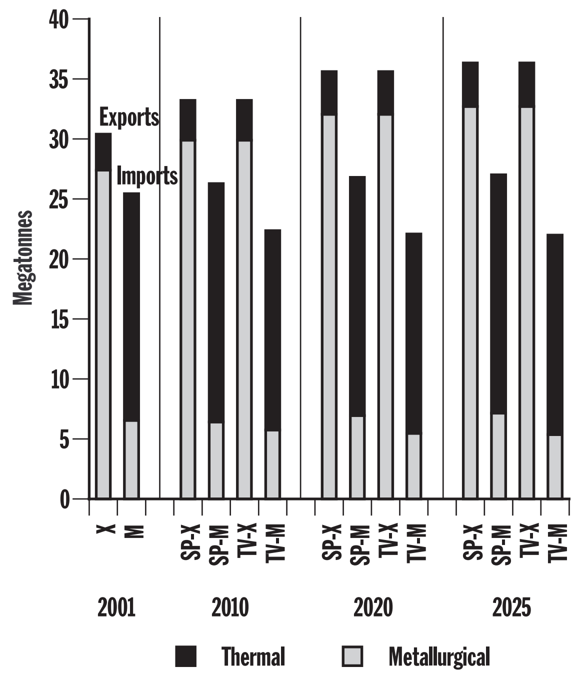
The coal industry engages in important international trade. Western Canadian coal is shipped to offshore export markets, while imports satisfy most of the Eastern Canadian demand. The outlook for Canadian coal trade is summarized in Figure 5.29.

Despite a transportation disadvantage, Western Canadian coal is generally competitive, mainly in Japan, South Korea and other diverse markets, and exports are expected to rise above recent levels.[10]

In Ontario and the East, Western Canadian coal faces competition, mainly from U.S. sources. Thus, while there may be limited shipments from Western Canada, most incremental demand is assumed to be met by imports.

In both scenarios, Eastern Canadian production is assumed to remain constant at recent levels through the projection period.

Figure 5.29 Exports and Imports



[10] Refer to Appendix A7, Table A7.1.

Clean Coal Technologies

Clean coal technologies refer to the methods by which emissions resulting from coal combustion can be reduced, particularly in power generation. Efforts during the 1990s focussed on SO_x and NO_x removal to address acid rain and smog formation. With escalating concerns about global warming, efforts to develop clean coal technology are focusing on reducing emissions of CO_2. In comparison with natural gas, coal emits about twice the amount of CO_2 per unit of power produced. Clean coal technologies may be generally characterized as:

- improved efficiency in combustion, resulting from the application of technologies at various stages of development, including supercritical and ultra-supercritical boilers and integrated coal gasification combined cycle (IGCC);
- stack-gas clean-up, including scrubbers to remove CO, NO_x, SO_x and particulates and selective catalytic reduction to remove NO_x; and
- capture and sequestration of CO_2 .

Supercritical and ultra-supercritical boilers achieve higher efficiencies through a combination of higher temperatures and operating pressures. The Genesee Phase 3 plant, scheduled for 2004-2005 startup in Alberta, would have supercritical boilers. Its thermal efficiency of approximately 40 percent is estimated to be 18 percent more efficient than other coal-fired generation facilities in Alberta.

In essence, an IGCC plant uses natural gas combined-cycle technology, front-ended by a coal gasifier. IGCC units achieve efficiencies typically approaching 45 percent and higher. There are a number of units in operation in main power plants in the U.S., Europe and Japan. While IGCC is expensive, it is expected that efficiency could be further improved. Its competitive position would be further enhanced in a world of sustained high natural gas prices. Another advantage of IGCC is that, as the result of the gasification process, it produces a relatively pure CO_2 stream making it a good candidate for sequestration projects.

Unlike other gaseous compounds such as NO_x and SO_x, CO_2 is not readily broken down, or converted, to minimize environmental impacts. The only way to reduce CO_2 that is produced from combustion processes is to increase the efficiency of the process, as discussed above, or to change the fuel mix to lower-carbon fuels. This has led to a number of proposals for the sequestration of CO_2, which could be integrated with the electricity generation, such as injection into salt caverns and abandoned gas and oil reservoirs, expanded use in miscible floods for enhanced oil recovery and ocean disposal. One project currently in operation is the sequestration of CO_2 from a coal plant in North Dakota; the gas is piped into Saskatchewan for use in enhanced oil recovery.

The quest to develop clean coal technology has led to a number of other initiatives, recent examples being a proposal by the Canadian Clean Power Coalition (CCPC) and the U.S. Department of Energy's clean fuels development program, Vision 21.

The CCPC, which includes seven Canadian companies with interests in coal generation and two international participants, plans to utilize the latest available combustion and post-combustion technologies to enable future coal-burning plants to meet anticipated environmental requirements, including complete capture of CO_2 emissions. The technology would be developed for retrofit of an existing plant by 2007 and a "greenfield" plant by 2010, likely in Western Canada. The proposals would include options for sequestration of CO_2.

With potentially significant impact over the next 15 years, Vision 21 systems would release no net CO_2 emissions and have no adverse environmental impacts. The program extends technologies already under development. With respect to clean coal technologies, this includes improving IGCC efficiencies to 45-50 percent in the near term and to 60 percent over the next decade or so, and would include the capture and sequestering of CO_2.

Future clean coal developments could witness the evolution of zero emissions, highly integrated technologies to produce hydrogen and/or electricity from coal and water while simultaneously capturing CO_2, SO_x, NO_x and particulates. The ZECA Corporation, a collaboration of Canadian, U.S. and European companies, integrates coal gasification and hydrogen production while incorporating a fuel cell system and the sequestration of CO_2. This is one pathway that could eventually provide an efficient and environmentally benign source of hydrogen and/or electricity.

5.5.4 ISSUES AND IMPLICATIONS

- The use of coal raises environmental concerns, particularly with respect to atmospheric emissions of SO_x, NO_x, particulates and CO_2. Future utilization thus depends on the ability of the industry to adapt to emissions standards and other regulatory requirements, such as for situating new facilities.
- Coal-fired generation currently accounts for about 52 percent of electricity production in the U.S. and about 18 percent in Canada and is expected to makes substantial contributions in both scenarios.[11] However, the consensus tends to be that natural gas will be favoured over coal in the development of new power generation. The contribution from coal will be enhanced in an environment of scarce natural gas supplies, volatile natural gas prices, or when other generation options are limited.
- Coal is very price competitive. Depending on the location, coal prices have typically been US$2-$3 per million Btus (C$2.75-$4.25 per gigajoule) below natural gas in recent years. A continued price differential goes some way in helping to cover the cost of more efficient coal-fired power plants and clean coal technology.
- In the SP scenario, the security of energy supply in North America is a main concern. In this regard, the abundance of coal could provide a strategic advantage.
- Extensions of clean coal technologies, for example in the TV scenario, could lead to coal being an economic source of hydrogen to power the “hydrogen economy.” Although significant strides in that direction may occur within the time horizon of these scenarios, substantial contributions to energy supplies seem unlikely.

[11] **Coal accounts for about twelve percent of total Canadian energy consumption.**

List of Figures, Tables & Acronyms

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ACR	Advanced CANDU reactor
CAFC	Company average fuel consumption
CBM	Coalbed methane
CNG	Compressed natural gas
CO_2	carbon dioxide
FCV	Fuel cell vehicle
GDP	Gross domestic product
GHG	Greenhouse gas emissions
HEV	Hybrid electric vehicles
HFCs	Hydrofluorocarbons
HFO	Heavy fuel oil
ICE	Internal combustion engine
IGCC	Integrated Coal Gasification Combined Cycle
LFO	Light fuel oil
LNG	Liquified natural gas
NEB, the Board	National Energy Board
NGL	Natural gas liquid
NYMEX	New York Mercantile Exchange
N_2O	Nitrous oxide
PFCs	Perfluorocarbons
SAGD	Steam-assisted-gravity-drainage
SF_6	Sulphur hexafluoride
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
SP	Supply Push Scenario
SUV	Sport utility vehicle
THAI	Toe-to-Heel Air Injection
TV	Techno-Vert Scenario
WCSB	Western Canada Sedimentary Basin
WTI	West Texas Intermediate

Glossary

Alternative Technologies:

(Technologies de remplacement) It applies to new and emerging technologies used in the production and consumption of energy such as electric and fuel cell vehicles and IGCC.

Associated Gas:

(Gaz associé) Natural gas which overlies and is in contact with crude oil in a reservoir.

Baby-Boom:

(Baby-boom) Canadians born after the Second World War; from the years 1947 to 1966. Over 9.8 million babies were born during this time, more than any other demographic period of our time.

Base Load Capacity:

(Capacité de production de la charge de base) Electricity generating equipment which operates to supply the load over most of the year.

Biodiesel:

(Biodiesel) It is a diesel fuel substitute that can be made from vegetable oil, recycled cooking oil or tallow.

Biomass:

(Biomasse) Organic material such as wood, crop waste, municipal solid waste, hog fuel and pulping liquor, processed for energy production.

Bitumen:

(Bitume) A highly viscous mixture of heavier hydrocarbons than pentanes. In its natural state, it is not usually recoverable at a commercial rate through a well.

Blended Heavy Oil:

(Pétrole brut lourd mélangé) Heavy crude oil to which diluent has been added in order to reduce its viscosity to meet pipeline specifications.

Capacity (Electricity):

(Capacité [électricité]) The maximum amount of power which a device can generate, utilize or transfer, usually expressed in megawatts.

Coal Bed Methane:

(méthane de gisements houillers) Natural gas, primarily methane, found in most coal seams. The methane is created during coalification, the natural process that converts organic matter into coal over time.

Cogeneration:

(Cogénération) A facility which produces process heat as well as electricity.

Combined-Cycle Generation:

(Production d'électricité par cycle combiné) The production of electricity using simultaneously combustion turbine and steam turbine generating units.

Condensate:

(Condensat) A mixture comprised mainly of pentanes and heavier hydrocarbons recovered as a liquid from field separators, scrubbers or other gathering facilities or at the inlet of a processing plant before the gas is processed in a plant.

Conventional Crude Oil:

(Pétrole brut classique) A liquid mixture mainly of hydrocarbons heavier than pentanes that can be produced through a well using normal production practices.

Conventional Natural Gas:

(Gaz naturel classique) Natural gas occurring in a normal porous and permeable reservoir which, at a particular point in time, can be technically and economically produced using normal production practices.

Cumulative Production:

(Production cumulative) The total amount of hydrocarbons produced to a given date.

Cyclic Steam Stimulation (CSS):

(Stimulation cyclique par la vapeur) A method of recovering bitumen from a reservoir using steam injection to heat the reservoir to reduce the viscosity of the oil and provide pressure support for production. Oil production occurs in cycles, each of which begins with a period of steam injection followed by the same well used as a producer.

Deliverability:

(Productibilité) See Productive Capacity.

Diluent:

(Diluant) Any lighter hydrocarbon, usually pentane plus, added to heavy crude oil or bitumen in order to facilitate its transport on crude oil pipelines.

Disposable Income:

(Revenu disponible) The amount of income available to a household or person after the deduction of federal and provincial income taxes.

Electricity Generation:

(Production d'électricité) The amount of electric energy, usually expressed in terawatt hours (TW.hrs), produced in a given period.

End Use Demand:

(Demande pour utilisation finale) Energy used by consumers for residential, commercial, industrial and transportation purposes, and hydrocarbons used for non-energy purposes.

Energy Intensity:

(Intensité énergétique) For the overall economy and for industrial and commercial sectors, it is defined as the amount of energy used per unit of real GDP. In the residential sector, it is energy use per household.

Ethylene Plant:

(Usine d'éthylène) A petrochemical plant that cracks ethane to produce ethylene – the building block for other chemical derivatives.

Feedstock:

(Charge d'alimentation) Natural gas or other hydrocarbons used as an essential component of a process for the production of a product (e.g. fertilizer and ethylene).

Fossil Fuels:

(Combustibles fossiles) Hydrocarbon-based fuel sources such as coal, natural gas, natural gas liquids and oil.

Frontier Areas:

(Régions pionnières) Generally, the northern and offshore areas of Canada.

Fuel Cell:

(Pile à combustible) Fuel cells are batteries which convert fuel directly into electricity. Most fuel cells take in hydrogen and oxygen, and produce electricity, heat and water.

Fuel Economy:

(Économie de carburant) The average amount of fuel consumed by a vehicle to travel a certain distance (measured in L/100km).

Fuel Efficiency:

(Rendement du combustible) The ratio of useful energy produced when a fuel is burned to the theoretical energy content of the fuel.

Fuel-switching:

(Commutation de combustible) The ability to substitute one fuel for another. It is generally based on price and availability.

Greenhouse Effect:

(Effet de serre) An atmospheric phenomenon through which incoming solar short-wave radiation passes through the atmosphere relatively unimpeded, but long-wave radiation emitted from the warm surface of the earth is partially absorbed, adding net energy to the lower atmosphere and underlying surface, thereby increasing their temperatures.

Greenhouse Gases (GHG):

(Gaz à effet de serre [GES]) Gases which actively contribute to the atmospheric greenhouse effect. These include naturally occurring gases such as: carbon vapour, carbon dioxide, methane, nitrous oxide and ozone. It also includes three gases that are generated through industrial processes: hydroflurocarbons, perflurocarbons and sulphur hexafluoride.

Gross Domestic Product (GDP):

(Produit intérieur brut [PIB]) Market value of all goods and services produced in a year within Canada's borders.

Heavy Crude Oil:

(Pétrole brut lourd) Generally, a crude oil having a density greater than 900 kg/m^3.

Heavy Fuel Oil (HFO):

(Mazout lourd) In this report, it refers to No. 6 fuel oil.

Hog Fuel:

(Déchets de bois) Fuel consisting of pulverized bark, shavings, sawdust, low grade lumber and lumber rejects from the operation of pulp mills, saw mills and plywood mills.

Horizontal Well:

(Puits horizontal) A well which deviates from the vertical and is drilled horizontally along the pay zone. In an horizontal well, the horizontal extension is that part of the wellbore beyond the point where it first deviates by 80 degrees or more form vertical.

Integrated Coal Gasification Combined Cycle (IGCC):

(Gazéification intégrée à cycle combiné [GICC]) It is a relatively new technology used in power generation. IGCC system, coal is converted into a gaseous fuel that after cleaning is comparable to natural gas. The gas is then forwarded to a gas turbine. The exhaust heat from the gas turbine is used to produce steam for a conventional steam turbine.

Integrated Mining/Upgrading Plant:

(Exploitation minière et valorisation intégrée) A combined mining and upgrading operation where oil sands are mined from open pits. The bitumen is then separated from the sand and upgraded by a refining process.

in situ Recovery:

(Récupération in situ) The process of recovering crude bitumen from oil sands other than by surface mining.

Light Crude Oil:

(Pétrole brut léger) Generally, crude oil having a density of less than 900 kg/m^3. Also, a collective term used to refer to conventional light crude oil, upgraded crude oil and pentanes plus.

Light Fuel Oil (LFO):

(Mazout léger) In this report, it refers to furnace fuel oil (No. 2 fuel oil).

Liquefied Petroleum Gases (LPG):

(Gaz de pétrole liquéfié [GPL]) A mixture of hydrocarbons typically propane and butanes derived from refinery processes.

Marginal Cost (or Incremental)

(Coût marginal) It is the cost of the last unit of energy produced.

Marketable Natural Gas:

(Gaz naturel commercialisable) Natural gas which meets specifications for end use. It excludes field and plant fuel and losses. Its heating value may vary depending upon its composition.

Natural Gas Liquids (NGL):

(Liquides de gaz naturel [LGN]) Hydrocarbon components recovered from raw natural gas as liquids. These liquids include, but are not limited to, ethane, propane, butanes, and pentanes plus.

NYMEX:

(NYMEX) The largest physical commodity futures exchange traded on the New York Mercantile Exchange for delivery of natural gas at the Sabine Pipe Line Co's Henry Hub in Louisiana.

Oil Sands:

(Sables bitumineux) Deposits of sand or sandstone, or other sedimentary rocks containing bitumen.

PADD:

(PADD) Petroleum Administration for Defence Districts which define market areas for crude oil in the U.S.

Peak Demand:

(Demande de pointe) The maximum level of demand over a stated period of time.

Peak Capacity:

(Capacité de pointe) Electricity generating equipment which is available to meet peak demand.

Pentanes Plus:

(Pentanes plus) A mixture mainly of pentanes and some heavier hydrocarbons obtained from the processing of raw gas, condensate or crude oil.

Price Volatility:

(Volatilité des prix) The range of movement in commodity market prices.

Primary Energy Demand:

(Demande d'énergie primaire) The total requirement for all uses of energy, including energy used by the final consumer, intermediate uses of energy in transforming one energy form to another, and energy used by suppliers in providing energy to the market.

Productive Capacity (or Deliverability):

(Capacité de production [or productibilité]) The estimated rate at which natural gas, crude oil or bitumen can be produced, unrestricted by demand but constrained by costs and transportation infrastructure.

Pulping Liquor:

(Liqueur de cuisson) A by-product of the manufacture of chemical pulp which can be used as a fuel.

Real Price:

(Prix réel) The price of a commodity after adjusting for inflation. In this report, most real prices are expressed in 1986 dollars.

Reclamation:

(Remise en état) Returning disturbed land to a stable, biologically-productive state.

Recovery - Improved (or Enhanced):

(Récupération assistée) Recovery through a production process other than primary recovery.

Recovery – Primary:

(Récupération primaire) The extraction of crude oil or raw natural gas from a reservoir utilizing only its natural energy.

Regional Transmission Organization (RTO):

(Organisation de transport régionale [OTR]) A voluntary organization of transmission owners, users and other entities approved by the U.S. Federal Energy Regulatory Commission to efficiently coordinate transmission planning, expansion, operation and use of a regional basis.

Reliability:

(Fiabilité) The degree of performance of any element of an electricity system that results in electricity being delivered to customers within acceptable standards and in the amount desired. Reliability may be measured by the frequency, duration, and magnitude of adverse affects on the electricity supply.

Renewable Fuels:

(Combustibles renouvelables) Energy sources that are capable of being renewed by the natural ecological system (e.g. wind, biomass, solar and small hydro).

Reserves – Additions:

(Additions aux réserves) Incremental changes to established reserves resulting from the discovery of new pools and revisions to existing pools.

Reserves – Established:

(Réserves établies) The sum of proven reserves and half of the probable reserves.

Reserves – Initial:

(Réserves initiales) Reserves prior to deduction of any production.

Reserves – Probable:

(Réserves probables) The portion of reserves contiguous with proven reserves that are interpreted to exist with reasonable certainty.

Reserves – Proven:

(Réserves prouvées) Reserves recoverable under current technology and present and anticipated economic conditions, specifically demonstrated by drilling, testing or production.

Reserves – Remaining:

(Réserves restantes) Initial reserves less cumulative production at a given time.

Reserves to Production Ratio:

(Ratio réserves/production) Remaining reserves divided by annual production.

Reservoir (or Pool):

(Gisement [or réservoir]) A porous and permeable underground rock formation containing a natural accumulation of crude oil or raw natural gas that is confined by impermeable rock or water barriers.

Resources – Discovered:

(Ressources découvertes) Resources that are estimated to be recoverable using known technology but that have not yet been recognized as established reserves because of uncertain economic viability.

Resources – In Place:

(Ressources en place) The gross volume of crude oil or raw natural gas estimated to be initially contained in a reservoir, before any volume has been produced and without regard for the extent to which such volumes will be recovered.

Resources – Recoverable:

(Ressources récupérables) That portion of the ultimate resources potential recoverable under expected economic and technical conditions.

Resources – Ultimate Potential:

(Potentiel ultime de ressources) An estimate of all the resources that may become recoverable or marketable, having regard for the geological prospects and anticipated technology. It consists of cumulative production, remaining established reserves, discovered resources and undiscovered resources.

Resources – Undiscovered:

(Ressources non découvertes) Resources that are estimated to be recoverable from accumulations that are believed to exist on the basis of available geological and geophysical evidence but which have not yet been shown to exist by drilling, testing or production.

Shale Gas:

(Gaz de schiste) A continuous, low-grade accumulation of natural gas in marine shales.

Shrinkage:

(Pertes en cours de traitement) The quantity of raw natural gas removed at field processing plants for recovery of liquids and by-products, removal of impurities, or used as fuel.

Smog:

(Smog) Photochemical reaction of sunlight with volatile hydrocarbons and nitrogen oxides that have been released into the atmosphere, especially by automobile emissions.

Solar Energy:

(Énergie solaire) Includes active and passive solar heat collection systems and photovoltaics.

Stand Alone Upgrader:

(Usine de valorisation indépendante) An upgrading facility that is not associated with a mining plant or a refinery.

Steam-Assisted Gravity Drainage (SAGD)

(Drainage par gravité au moyen de la vapeur [DGMV]) Steam stimulation technique using horizontal wells in which the bitumen drains, by gravity, into the producing wellbore. In contrast to cyclic steam stimulation, steam injection and oil production are continuous and simultaneous.

Straddle Plant:

(Usine de chevauchement) A natural gas processing plant, located on a main gas transmission system, which extracts NGL from the gas stream.

Sulphur:

(Soufre) A natural occurring element found in most crude oils and natural gas. It is considered an impurity of particular concern when found in refined petroleum products like gasoline and diesel fuel.

Supply Cost:

(Coût de l'offre) Expresses all costs associated with resource exploitation as an average cost per unit of production over the project life. It includes capital costs associated with exploration, development, and production, operating costs, taxes, royalties, and producer return.

Thermal Generation:

(Production thermique) Energy conversion in which fuel is consumed to generate heat energy which is converted to mechanical energy and then to electricity.

Tight Gas:

(Gaz de réservoir étanche) Natural gas contained in low permeability reservoirs.

Toe-to-Heel Air Injection (THAI):

(Injection d'air par la méthode THAI) A new experimental version of in situ combustion that uses specifically placed vertical air injection wells and horizontal producing wells to promote a controllable combustion front in an oil reservoir. The process holds promise in achieving high recovery factors and partial upgrading of oil in situ.

Triple Bottom Line:

(Bénéfice net à trois niveaux) A framework for measuring and reporting corporate performance against economic, social and environmental parameters.

Unconventional Crude Oil:

(Pétrole brut non classique) Crude oil which is not classified as conventional crude oil (e.g., bitumen).

Unconventional Natural Gas:

(Gaz naturel non classique) Natural gas which is not classified as conventional natural gas (e.g., coal bed methane).

Upgraded Crude Oil (or Synthetic):

(Pétrole brut valorisé [or synthétique]) A mixture of hydrocarbons similar to light crude oil derived by upgrading oil sands bitumen or heavy fuel oil.

Upgrading:

(Valorisation) The process of converting bitumen or heavy crude oil into a higher quality crude oil either by the removal of carbon (coking) or the addition of hydrogen (hydrotreating).

Vapourized Extraction (or VAPEX):

(Injection de vapeur de solvants [or VAPEX]) Process similar to SAGD but using a vapourized hydrocarbon solvent, rather than steam, to reduce the viscosity of crude oil in the reservoir.

West Texas Intermediate (or WTI):

(West Texas Intermediate [or WTI]) A commonly used benchmark price for light-sweet crude oil produced in the US and used in North America. WTI refers to the price of a particular grade of crude oil for delivery at Cushing, Oklahoma.

Appendix A1: Conversion Tables

Energy Content Table

Energy measures		Energy content
GJ	gigajoule	0.95 million btu
PJ	petajoule	

Electricity		Energy content
MW	megawatt	
GW.h	gigawatt hour	3 600 GJ
TW.h	terawatt hour	3.6 PJ

Natural Gas		Energy content
Mcf	thousand cubic feet	1.05 GJ
Bcf	billion cubic feet	1.05 PJ
Tcf	trillion cubic feet	1.05 EJ

Natural Gas Liquids		Energy content
m^3	Ethane	18.36 GJ
m^3	Propane	25.53 GJ
m^3	Butanes	28.62 GJ

Crude Oil		Energy content
m^3	Light	38.51 GJ
m^3	Heavy	40.90 GJ
m^3	Pentanes Plus	35.17 GJ

Coal		Energy content
t	Anthracite	27.70 GJ
t	Bituminous	27.60 GJ
t	Subbituminous	18.80 GJ
t	Lignite	14.40 GJ

Petroleum Products		Energy content
m^3	Aviation Gasoline	33.52 GJ
m^3	Motor Gasoline	34.66 GJ
m^3	Petrochemical Feedstock	35.17 GJ
m^3	Naphtha Specialties	35.17 GJ
m^3	Aviation Turbo Fuel	35.93 GJ
m^3	Kerosene	37.68 GJ
m^3	Diesel	38.68 GJ
m^3	Light Fuel Oil	38.68 GJ
m^3	Lubes and Greases	39.16 GJ
m^3	Heavy Fuel Oil	41.73 GJ
m^3	Still Gas	41.73 GJ
m^3	Asphalt	44.46 GJ
m^3	Petroleum Coke	42.38 GJ
m^3	Other Products	39.82 GJ

Other Fuels		Energy Content
m^3	methanol	15.60 GJ
m^3	ethanol	23.60 GJ
m^3	hydrogen	0.12 GJ

ABBREVIATION TABLE

Prefixes		Equivalent
k	kilo	10^3
M	mega	10^6
G	giga	10^9
T	tera	10^{12}
P	peta	10^{15}
E	exa	10^{18}

IMPERIAL/METRIC CONVERSIONS

Physical Units		Equivalent
m	metre	3.28 feet
m^3	cubic metres	6.3 barrels (oil/ LPG) 35.3 cubic feet (gas)
L	litre	0.22 imperial Gallon
t	metric tonne	2 200 pounds
bbl	barrel (oil, LPG)	0.159 m^3

Guide to Appendix A2 to Appendix A7

Appendix 2 to Appendix 7 are available on the Boards' Website under Energy Overview at www.neb-one.gc.ca as well as on CD-Rom.

Appendix A2: Economic Indicators

Table A2.1:	Economic Indicators, Canada
Table A2.2 to A2.11	Economic Indicators, Provinces

Appendix A3: Energy Demand

Table A3.1:	Demand, Supply Push, Canada
Table A3.2 to A3.8:	Demand, Supply Push, Provinces
Table A3.9:	End Use Demand by Fuel, Supply Push
Table A3.10:	Transportation Energy Demand, Supply Push, Canada
Table A3.11:	Demand, Techno-Vert, Canada
Table A3.12 to A3.18:	Demand, Techno-Vert, Provinces
Table A3.19:	End Use Demand by Fuel, Techno-Vert,
Table A3.20:	Transportation Energy Demand, Techno-Vert, Canada

Appendix A4: Electricity

Table A4.1.1 to A4.1.11:	Generating Capacity by Technology and Fuel Type (MW) – Supply Push, Provinces
Table A4.12:	Generating Capacity by Technology and Fuel Type (MW) – Supply Push, Canada
Table A4.2.1 to A4.2.11:	Generating Capacity by Technology and Fuel Type (MW) – Techno-Vert, Provinces
Table A4.2.12:	Generating Capacity by Technology and Fuel Type (MW) – Techno-Vert, Canada
Table A4.3.1 to A4.3.11:	Primary Energy for Electrical Generation (PJ), Provinces
Table A4.3.12:	Primary Energy for Electrical Generation (PJ), Canada

Appendix A5: Crude Oil & NGLs

Appendix A6: Natural Gas

Appendix A7: Coal

Canada