Policy Brief

Economic Policy Series – May 2009

Canadian Energy: A Valuable Resource

Introduction

The International Energy Agency (IEA)[1] predicts world energy demand will rise 1.6 percent a year (on average) between 2006 and 2030, and that by 2030 the world will consume 45 percent more energy than it does today. Most of the demand growth (87 percent) will come from non-OECD countries reflecting more rapid economic expansion and population growth.

It is projected that North America will consume 20-25 percent more energy by 2030. With global demand projected to grow more rapidly, securing energy supplies is more important and desirable than ever. Meeting this challenge will require sound management and strategic planning. To this end, the Canadian Chamber of Commerce is bringing together energy producers, large end-users and energy service/product providers to develop a comprehensive energy strategy that promotes a diverse supply of reliable, affordable and environmentally sound energy; provides for the most efficient and economical use of energy; helps stimulate the development and deployment of new energy technologies; and recognizes that we live in a world of energy interdependence. The consultations will culminate in a paper containing key policy recommendations slated for release in the fall of 2009.

As a lead-up to the energy strategy paper, this report provides an overview of currently available energy sources in Canada and highlights the energy sector's importance to the economy.[2]

1 International Energy Agency. *World Energy Outlook 2008*. November 12, 2008.

2 Various sources were used in preparing this report including the private sector, international organizations, industry associations, and government agencies and departments. Every effort is made to present the most recent available data; however, there are lags in data collection and reporting.

The Canadian Chamber is committed to fostering a strong, competitive, and profitable economic environment that benefits all Canadians. This paper is one of a series of independent research reports covering key public policy issues facing Canada today.

We hope this analysis will raise public understanding and help decision-makers make informed choices. The papers are designed not to recommend specific policy solutions, but to stimulate public discussion and debate about the nation's challenges.

Energy Overview: A Statistical Portrait

Canada is a nation blessed with a rich endowment of energy resources that help meet domestic demand and supply the world. According to the IEA[3], Canada is the world's fifth largest producer of energy. Only China, the United States, Russia, and Saudi Arabia produce more energy than Canada.

Canada is the world's largest producer of uranium fuel for nuclear power generation, second largest producer of hydroelectricity, third largest producer of natural gas, seventh largest producer of oil, and seventh largest producer of electricity.

The energy sector contributes significantly to Canada's economy. In 2007, it accounted for 5.6 percent of Canadian GDP (almost $70 billion), spent $68.9 billion on capital repair and replacement (representing 35 percent of total private sector investment), and directly employed 372,200 people (2.2 percent of total employment in Canada) and many more in related industries.[4]

Between 1980 and 2007, energy production in Canada almost doubled. In 2007, natural gas and crude oil accounted for 41.3 percent and 36.3 percent, respectively, of total Canadian primary energy production. Coal accounted for 8.7 percent, gas plant natural gas liquids (NGLs) 4.0 percent and primary electricity (hydro, nuclear, wind, tidal and solar) 9.6 percent.[5]

About 40.1 percent of all energy consumed in Canada is refined petroleum, followed by natural gas (31.4 percent) and electricity (24.4 percent). The transportation sector is the largest end-user of energy accounting for 31.3 percent of final demand, followed closely by the industrial sector (30.9 percent). Residential customers account for 16.9 percent of energy demand, commercial and other institutional customers 16.7 percent, the agriculture sector 2.7 percent and public administration 1.5 percent. Of total industrial demand, manufacturing accounts for 70.7 percent, mining and oil & gas extraction 26.0 percent, construction 2.5 percent and forestry 0.8 percent.[6]

By region, Ontario is the largest consumer of energy in Canada accounting for 32.3 percent of total energy use, followed by Quebec (20.6 percent) and Alberta (19.9 percent).[7]

In 2007, almost 55 percent of total energy produced in Canada was exported.[8] Exports totaled $91.6 billion and accounted for 19.8 percent of Canada's total merchandise exports. Crude petroleum exports were valued at $41.0 billion, natural gas $28.4 billion and other energy products $22.3 billion. Imports were valued at $36.6 billion and accounted for 8.8 percent of total imports. Of this, $23.7 billion was crude petroleum and about $3.5 billion natural gas. In 2007, Canada had a trade surplus in energy products of $55.0 billion. [9]

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3 International Energy Agency. *Key World Energy Statistics*. 2008

4 National Energy Board. *Canadian Energy Overview 2007*. May 2008.

5 Statistics Canada. *Report on Energy Supply and Demand in Canada – 2007*. Catalogue no. 57-003-X. February 2009. Crude oil includes pentanes plus, condensate, crude bitumen and synthetic crude as well as conventional crude. NGLs are liquid hydrocarbon products extracted from the natural gas stream. The component parts are further separated into marketable products like ethane, propane, butanes, pentanes plus, condensate and sulphur. In 2007, Canada exported 30.8 percent of NGL production and imported small quantities.

6 Statistics Canada. *Energy Statistics Handbook*. Catalogue no. 57-601-X. January 2009.

7 Ibid.

8 Statistics Canada. "Energy Supply and Demand." The Daily. November 18, 2008.

9 Statistics Canada. *Canada at a Glance – Foreign Trade*. April 5, 2009.

Energy sources have a number of characteristics which influence their usefulness for end-users. First, is flexibility – the ability to use an energy source for different applications. Second, is reliability – some energy sources are available when needed or can be stored for future use; others are unpredictable and difficult to store. Third, is controllability – some energy supplies can be more readily increased or decreased as needs change. Fourth, is portability – the easier it is to transport or dispatch, the more attractive the energy source. Fifth, is longevity – some energy sources are renewable while others cannot be replenished. Sixth, is environmental impact – all energy sources, directly or indirectly, leave an environment footprint which varies in magnitude.

The Bottom Line: Canada has considerable energy resources and is one of the world's largest producers and exporters of energy. Investment by Canada's energy sector reaches across the entire country and provides benefits to many individuals and governments. Additionally, Canada's expertise in advanced recovery techniques and knowledge of complex resources are in demand around the world. Canada is also a large consumer of energy – energy consumption per capita in Canada is amongst the highest in the world. As an energy-reliant society we have an incentive to seek out better ways to source and produce our valuable resources, increase the share of renewables in the energy mix, and reduce the environmental footprint attributable to all energy production and consumption.

Crude Oil

Canada's established crude oil reserves are estimated at 179 billion barrels – second only to those of Saudi Arabia – of which 173 billion barrels are considered economically recoverable reserves found in Canada's oil sands (referred to as crude bitumen). The rest is conventional oil on land and offshore.[10]

In 2007, Canada was the world's seventh largest producer of crude oil, producing about 2.7 million barrels per day. This included about 1.2 million barrels per day of oil sands production (almost 44 percent of total crude oil and equivalent), 1.2 million barrels per day of conventional crude oil and equivalent from Western Canada (Alberta, British Columbia, Saskatchewan, Manitoba and Northwest Territories) and 369 thousand barrels per day from offshore production in Newfoundland and Labrador. A small amount of crude oil was produced in Nova Scotia and a trace in Ontario.[11]

More specifically, Alberta accounted for 67.6 percent of Canadian crude oil and equivalent production, Saskatchewan 15.3 percent, Newfoundland and Labrador 13.7 percent, British Columbia 1.3 percent, Manitoba 0.8 percent, the Northwest Territories 0.7 percent, and Nova Scotia 0.4 percent. [12]

Of total crude oil and equivalent production, 32.3 percent was light and medium crude oil, 25 percent crude bitumen, 18.2 percent synthetic crude oil, 18.1 percent heavy crude oil, 5.4 percent pentanes plus, and 1.0 percent condensate.[13]

Crude Oil - Production Trends

According to the Canadian Association of Petroleum Producers (CAPP), oil sands production has grown four-fold since 1990, and in 2007 exceeded 1.2 million barrels per day. It currently makes up about half of Western Canada's total crude oil production. CAPP projects that by 2020, oil sands production will total almost 3.3 million barrels per day. Today, oil sands production accounts for one out of every two barrels of production in Western Canada; by 2015 it is expected to rise to three out of four barrels.

In contrast, conventional crude oil production in Western Canada has been declining gradually since the late 1990s as a result of the maturity of the basin. CAPP predicts that by 2020, total conventional crude oil production from Western Canada will decline to 728 thousand barrels per day from about 1.0 million barrels per day in 2007.

Overall, Western Canada crude oil supply is projected to increase from 2.4 million barrels per day in 2007 to 4.1 million barrels per day in 2020.

Eastern Canada crude oil supply is expected to decline from 369 thousand barrels per day in 2007 to 75 thousand barrels per day in 2020.

10 Established oil reserves are the estimated quantities of crude oil that are recoverable under current technology and existing economic and geological conditions. Conventional crude oil is recovered from an underground reservoir through a well using standard production methods. It typically requires minimal processing prior to sale. Unconventional sources of crude oil require specialized extraction technology to produce, and the extracted petroleum may require significant processing prior to sale.

11 Canadian Association of Petroleum Producers. *Crude Oil Forecast, Markets & Pipeline Expansions*. June 2008. Equivalent refers to hydrocarbon mixtures similar to conventional crude oil, including pentanes plus and synthetic crude oil.

12 Statistics Canada. *Energy Statistics Handbook*. Catalogue no. 57-601-X. January 2009.

13 Ibid.

In 2007, Canada was the world's eighth largest exporter of crude oil. It exported approximately 66.0 percent of crude oil and equivalent production, virtually all to the United States (over 1.8 million barrels per day). Canada is the leading crude oil export country to the United States representing 18 percent of total U.S. demand for imported crude oil.

On a regional basis, Alberta accounted for 68.1 percent of total crude oil and equivalent exports, Saskatchewan 18.5 percent, Newfoundland and Labrador 11.7 percent, Manitoba 0.8 percent, Nova Scotia 0.5 percent and British Columbia 0.4 percent.[14]

Canada also imports sizable quantities of crude oil. In 2007, it imported over 900,000 barrels per day. Almost 21 percent of crude oil imports were sourced from Algeria, 20.2 percent from Norway, 16.7 percent from the United Kingdom, 8.7 percent from Iraq, 8.6 percent from Saudi Arabia, and the rest from 10 other countries.[15]

Refined Petroleum Products

Crude oil imports satisfy more than half of domestic refinery demand. The transportation costs associated with moving crude oil from Western Canada to Eastern Canada make it more cost effective for some refineries to import crude oil. Refineries in Quebec and the Eastern provinces run primarily imported crude oil. In 2007, 80 percent of Atlantic province's refining requirements were met by imports and 20 percent with Eastern Canadian production. Quebec remained the largest regional importer of crude oil with 92 percent of the Province's refining needs supplied from international sources. Refineries in Ontario run a mix of imported and domestically produced crude oil. Refineries in Western Canada run domestically produced crude oil.[16]

At the end of 2007, there were 19 refineries operating in Canada. Refinery runs of crude oil totaled 1.83 million barrels per day in 2007. Canada was the world's eighth largest producer of petroleum products generating revenue of $9.2 billion. About 75 percent of total available supply of petroleum products was sold to the domestic market. Exports of main petroleum products (about 448.7 million barrels per day) were destined primarily for the United States with two-thirds ending up in the U.S. East Coast. Canada imported about 271.0 million barrels per day of petroleum products in 2007. [17]

Canada's Oil Sands [18]

The oil sands are one of the world's largest hydrocarbon deposits, containing 1.7 trillion barrels of crude bitumen. Bitumen is heavy oil, too thick to flow or be pumped without being diluted or heated. It is oil mixed with sand, water and clay. Approximately 173 billion barrels is estimated to be recoverable using current technologies, with the potential to recover up to 315 billion barrels. The CAPP estimates the oil sands could sustain production of 3.0 million barrels per day for more than 150 years.

The Centre for the Study of Living Standards estimated the present value of oil sands reserves at $1,482.7 billion (2007) accounting for 18 percent of Canada's tangible wealth, making it a very valuable resource for Canadians.[19]

Twenty percent of the oil sands reserves are close enough to the surface (less than 75 metres) to be mined by hydraulic power shovels and dumped

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14 Statistics Canada. "Energy Supply and Demand." *The Daily*. November 18, 2008. Also, Statistics Canada. *Energy Statistics Handbook*. Catalogue no. 57-601-X. January 2009.

15 Statistics Canada. *Energy Statistics Handbook*. Catalogue no. 57-601-X. January 2009.

16 National Energy Board. *Canadian Energy Overview 2007*. May 2008.

17 Ibid. Petroleum products include motor gasoline, aviation turbo fuel, diesel fuel oil, light fuel oil, stove oil and kerosene, heavy fuel oil, and other petroleum products.

18 Information on the oil sands is largely sourced from the Canadian Association of Petroleum Producers unless otherwise indicated.

19 Sharpe, Andrew, Jean-Francois Arsenault, Alexander Murray and Sharon Qiao. "The Valuation of the Alberta Oil Sands." *CSLS Research Report No. 2008-7*. November 2008.

into heavy hauler trucks. The trucks transport the oil sand to a crusher unit that breaks it up, and then moves it by conveyor to the extraction plant. Hot water is added to separate the bitumen from the sand and clay. The bitumen is skimmed off and sent to an upgrading plant.

The 80 percent that is deeper (in situ) is recovered through advanced drilling techniques that permit steam or solvents to reach into the reservoir and mobilize the thick bitumen so it can be pumped up to the surface through recovery wells.

To transport it to refineries, it must be blended with diluent (any lighter hydrocarbon, like condensate and pentanes plus) to meet pipeline specifications for density and viscosity, and facilitate transport. To make it an acceptable feedstock for conventional refineries, it must be upgraded through the addition of hydrogen or the rejection of carbon.

Oil Sands Reassess Projects

According to the Canadian Association of Petroleum Producers (CAPP), oil sands capital investment totaled $18 billion in 2007, an estimated $20 billion in 2008 and a projected $10 billion in 2009. The recession, the sharp drop in the price of crude oil (from a record-high of US$147 per barrel in July 2008 to around US$50 at present) and the global credit crunch are having a material impact on near-term production and investment. A number of projects have been cancelled or delayed. The Canadian Energy Research Institute (CERI) believes oil prices have to recover above US$70 per barrel for the industry to resume a period of growth and expansion. [20]

Project delays and cancellations are having a negative impact on all parts of Canada, not just Alberta. Approximately 44 percent of the employment generated by oil sands investment is outside of Alberta – 16 percent in Ontario, 11 percent in the rest of Canada, and 17 percent in foreign jurisdictions.

Oil sands development is controlled by strict, government-approved environmental standards that are among the most comprehensive in the world. The industry recognizes that addressing environmental challenges is critical to business success and is responding to these concerns by meeting or exceeding regulatory requirements, reducing its environmental footprint through research and technology, and consulting with key stakeholders.

- **Greenhouse Gas (GHG) Emissions**

The oil sands account for 5 percent of Canada's total GHG emissions and 0.1 percent of global energy-related GHG emissions. By comparison, the transportation sector accounts for 25 percent of GHG emissions in Canada, oil and gas (excluding oil sands) 18 percent, electricity and heat generation 16 percent, agriculture 9 percent, buildings 10 percent, solvent and waste 4 percent, and other industry 14 percent.[21]

20 McColl, David. "The Eye of the Beholder: Oil Sands Calamity or Golden Opportunity." *Oil Sands Briefing ISBN: 1-896091-85-7*. Canadian Energy Research Institute. February 2009.

21 Environment Canada.

As of July 1, 2007, Alberta implemented a soft (intensity-based) cap-and-trade system. Facilities in Alberta (including those in the oil and gas sector) that emit more than 100,000 tonnes of greenhouse gases annually will have to reduce their annual emissions intensity by 12 percent from the average emissions levels of 2003, 2004 and 2005. Those unable to do so may purchase emissions permits at $15 per tonne of carbon dioxide (CO_2) emitted above the target. The money goes into an Alberta-based technology fund. Alternatively, large emitters can invest an equal amount in Alberta-based projects outside their operations that reduce (or offset) emissions on their behalf.

Sectors covered by Alberta's Climate Change Plan include oil sands, refining, electricity generation, gas, heavy oil, fertilizer, forest products, pipelines, cement, coal mining, lime, landfill and metal manufacturing. Figures released by the Government of Alberta show that as of March 31, 2008, companies had cut emissions by about 1.6 million tonnes through operational changes and practices, one million tonnes of offsets were purchased, and payments covering about 2.7 million tonnes (a total of $40 million) were made into the Provincial technology fund.

Since 1990, oil sands GHG intensity (i.e. GHG emissions per barrel of production) has been reduced by 38 percent. This has been achieved through efficiency, conservation, and the development and deployment of new technology.[22] For example, companies have been using lower temperature water for extraction in oil sands mining projects which requires less energy, thereby reducing GHG emissions. The industry is also evaluating how to capture CO_2 emitted during production, store it underground, and inject it into wells to help recover more oil and gas from wells with dwindling or ceased production. While carbon capture and storage hold promise, application on a broad scale will require significant investment in new technologies and transportation infrastructure. Also promising is the possibility of pumping water several kilometers below ground and exposing it to hot rocks in the earth's crust to heat it. Geothermal energy could provide a low-emissions alternative to the natural gas that is currently used to provide heat and steam in the oil sands production process.

- **Land Use**

Both oil sands surface mining and in situ oil production impact the land. All sites are required by governments to be fully reclaimed – i.e. to return the land to a sustainable landscape with productivity equal to, or greater to that prior to oil sands development – once extraction is complete.

The reclamation plan must be developed and approved by government as part of the overall project approval process even before the first shovel of earth is removed. It is modified as mine planning advances. Tailing ponds (which store a mixture of water, clay, sand and residual bitumen left over from bitumen extraction process) are also reclaimed. The industry is conducting ongoing research on new methods for accelerating separation of water and fine silts, on ways to recycle water faster, and on new reclamation methods. Research has led companies to use naturally occurring materials, like gypsum, to rapidly release water from the tailing mixture and speed up the reclamation process.

In situ deposits are developed underground with limited surface disturbance, similar to conventional oil development. Due to the more conventional drilling techniques and the smaller environmental footprint created, in situ operations are able to reclaim areas earlier than mining projects. The industry also works with other land users, like forestry, to develop an integrated approach to minimize the impact on the habitat. Existing clearings are used for staging sites to temporary store equipment.

22 Technology improvements accounts for about half of the overall improvement.

The industry recognizes the need to do more, and is developing and implementing new technologies and best practices.

- **Water Use**

As with conventional oil, water plays a critical role in the recovery of the oil sands resource. The most common in situ recovery methods use water to create steam which heats the bitumen underground allowing it to flow to the surface through wells. In situ projects are moving away from using fresh water opting for alternatives like deep non-portable water aquifers (blackish or brine not suitable for drinking) and enhanced recycling. After use, this water is treated and then re-injected back into these same aquifers so as not to impact the surface or groundwater systems. About 85 percent of the water used is recycled. There are several projects using, or experimenting with new lower water use technologies and alternative sources of water.

Alberta's *Water Act* requires a license before diverting and using surface water or ground water. Water-use permits are based on ensuring sustainable supply for all users. There is a specific limit on water use under the Province's *Water Management Framework for the Lower Athabasca River*, which is currently the source of fresh water for mining projects. The River Basin has one of the lowest allocation levels in the province, with 3.9 percent (2006) of the natural flow allocated for all users. The oil sands are currently using about 1 percent of the Athabasca's average flow. Going forward, all oil sands mining projects, including current and approved projects, are forecast to use about 2 percent of the natural flow of the river.

The provincial government continually monitors the oil sands industry's water withdrawals from the river to ensure sustainability. The industry participates in a number of initiatives that examine water use and impacts.

Natural Gas

In 2007, Canada had proved reserves (i.e. estimates of the quantities of gas in known reservoirs that are economic to produce and are connected, or can easily be connected, to pipelines and markets) of 58.2 trillion cubic feet (Tcf).[23] Canada's natural gas reserves rank 19th in the world.[24]

In 2007, Canada was the world's third largest producer of natural gas and second largest exporter.[25] Production totaled 5.9 Tcf and represented about one-quarter of combined Canada and U.S. natural gas production. Alberta accounted for 77.1 percent of marketable natural gas production, British Columbia 16.1 percent, Saskatchewan 4.0 percent, Nova Scotia 2.5 percent, Northwest Territories 0.1 percent, Ontario 0.1 percent and the Yukon less than 0.1 percent.[26] Natural Resources Canada predicts production will remain relatively stable at 5.9 Tcf by 2020.[27]

In 2007, domestic demand totaled 2.6 Tcf.[28] The industrial sector accounted for 40.1 percent of natural gas consumed in Canada, the residential sector 25.9 percent, the commercial sector 19.6 percent, electricity generation 13.5 percent, agriculture 0.9 percent and transportation 0.1 percent.[29] Natural Resources Canada predicts demand will rise to 3.9 Tcf by 2020.

Natural gas production is fairly constant throughout the year; however, demand varies widely depending on the season. To bridge the seasonal gap between supply and demand, natural gas is injected into storage in the summer and withdrawn in the winter. Canada has about 0.7 Tcf of storage capacity, the majority of which is located in Western Canada (424 billion cubic feet - Bcf), with Alberta having the greatest storage volume. There is smaller storage capacity in other producing provinces, namely British Columbia and Saskatchewan. Storage in Eastern Canada (253 Bcf) is located primarily in Ontario.[30]

Almost two-thirds of total Canadian natural gas marketable production is exported. Gross export volumes reached almost 3.8 Tcf in 2007, a record level, and generated $28.4 billion in revenue. Of this 24.1 percent was sent to the U.S. Pacific Northeast, 48.6 percent to the U.S. Midwest, and 27.3 percent to the U.S. Northeast.[31] Canadian natural gas accounts for 17 percent of total U.S. demand for natural gas. The United States relies on Canada for 82 percent of its natural gas imports.[32]

On a regional basis, Saskatchewan accounted for 32.2 percent of total natural gas exports by pipeline to the United States. British Columbia plus the Yukon and the Northwest Territories accounted for 25.7 percent, Ontario 22.7 percent, Manitoba 15.0 percent, Quebec 2.1 percent, New Brunswick 2.0 percent and Alberta 0.3 percent.[33]

Canadian imports of natural gas were at a record 466 Bcf in 2007, valued at about $3.5 billion. All of Canada's natural gas imports are sourced from the United States via pipelines located in Southern Ontario.[34]

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26 Statistics Canada. *Energy Statistics Handbook.* Catalogue no. 57-601-X. January 2009.
27 Natural Resources Canada. *Canadian Natural Gas Review of 2007/08 & Outlook to 2020.* December 2008.
28 Ibid.
29 Canadian Gas Association.
30 Ibid.
31 Ibid.
32 United States Energy Information Administration.
33 Statistics Canada. *Energy Statistics Handbook.* Catalogue no. 57-601-X. January 2009.
34 Natural Resources Canada. *Canadian Natural Gas Review of 2007/08 & Outlook to 2020.* December 2008.

Shale Gas

Share gas is natural gas within predominantly fine grained, organic rich rocks. Reservoirs are tight and require special drilling and completion to achieve economic production. Gas may also be contained in thin, porous silt, sand and beds interbedded in the shale.

There is large shale gas potential in Canada – greater than 1,300 Tcf – with the largest amount (more than 500 Tcf) in the Horn River Basin in British Columbia. Shale gas is also found in Alberta, Saskatchewan, Southern Ontario, the Quebec Lowlands and the Maritimes.[35]

While there is huge potential, shale gas production is in the early stages. Significant capital is required to bring shale gas to markets. Advances in technology such as horizontal drilling and multistage hydraulic fracture stimulation have unlocked the potential of shales to produce gas.

35 Heffernan, Kevin. "Shale Gas in North America: Energy Supply Opportunities." Canadian Society for Unconventional Gas. September 24, 2008.

Pipelines

According to the Canadian Energy Pipeline Association, there are approximately 580,000 kilometres of pipeline in Canada that transport energy products from the production facilities to refineries, distribution centres, homes and businesses. About 2.65 million barrels of crude oil and equivalent per day travel through Canada's crude oil pipeline network. Approximately 17.1 Bcf of natural gas per day travel through Canada's natural gas pipeline network. Offshore pipelines, such as those used for natural gas off the coast of Nova Scotia, are laid in trenches on the bottom of the ocean. A sizable portion of Canada's pipeline network carries NGLs (butane, propane, and ethylene).

Two new major pipeline projects have been proposed to transport natural gas – one from the Mackenzie Delta; the other from the Alaskan fields.

There are an estimated 9 Tcf proven gas reserves and an estimated 42 Tcf potential gas reserves in the Mackenzie Delta region in the Northwest Territories. The proposed $15 billion, 1220 kilometre Mackenzie Gas Pipeline will carry 1.2 Bcf per day to northern Alberta. The original goal was to have natural gas moving through the pipeline by 2010. The pipeline's expected completion date has now been pushed back to 2014.

The Mackenzie Delta Project faces one of the most stringent regulatory approval processes. It will require cooperation among several regulatory agencies – federal, territorial, provincial and settlement area – responsible for assessing and regulating energy development. These agencies will issue permits and authorizations, and set conditions on their approval.[36]

The Alaskan fields are estimated to have 35 Tcf proven natural gas reserves and an additional 126 Tcf potential gas reserves. The proposed $30 billion, 2,760 kilometre Alaska Gas Pipeline will stretch from Prudhoe Bay, Alaska through the Yukon and northeastern British Columbia to the BC/Alberta border linking into an existing pipeline network. The project is anticipated to be in service in 2018. When completed, it will deliver approximately 4 Bcf of natural gas per day to the North American market. Two commercial parties have pipeline proposals to move Alaskan gas through Canada – TransCanada/Foothills and ConocoPhillips/BP. Both project proposals must clear significant regulatory hurdles. Canada is committed to ensuring an efficient and effective regulatory review process and to seeing Canadians realize benefits in the development of the Alaska Pipeline Project. Canada-U.S. coordination will be required; Aboriginal support is critical.[37]

Regulation is increasingly focused on sustainable and community-oriented decision-making. New projects must contend with information gathering and public consultation requirements that are more detailed than ever before. Hearings are held where project proponents are required to explain their projects in great detail to interested parties. As a follow-up, project proponents must demonstrate compliance with consultation requirements.

Investors and pipeline project proponents are concerned about uncertain timelines and processes for regulatory review and approval. For example, the Mackenzie Gas Pipeline project continues to face a number of regulatory challenges as it slowly moves through the application approval process. Consultation and arrangements for regulatory coordination began four years before the relevant major permit applications were even filed with the National Energy Board.[38] Navigating through the regulatory project approval process has proved to be increasingly complex, inefficient and expensive. Thus, despite years of planning and rising costs, regulatory delays have increased the chances that the Mackenzie natural gas pipeline will not be built.

36 www.mackenziegasproject.com. See also hydrocarbons-technology.com.

37 Natural Resources Canada. "Alaska Natural Gas Pipeline Project: The Canadian Perspective." *Presentation to Interstate Oil and Gas Compact Commission*. May 5, 2008.

38 Smellie, James H. and Marie C. Rounding. "Canada: The Changing Face of Energy Regulation in Canada." Gowling Lafleur Henderson LLP. September 2008.

Coal[39]

According to the Coal Association of Canada, the coal industry contributes an estimated $5 billion annually to Canada's economy and directly employs about 5,000 people (2006). It is estimated that Canada has coal to last about 230 years at current consumption levels.

Coal is by no means a homogeneous commodity. A variety of coal types exist differing in terms of energy content, coking properties, sulfur, ash and moisture content. Energy content, which depends on the amount of carbon in coal, is the key determinant of price. High rank coals are high in carbon and; therefore, heat value, but low in hydrogen and oxygen. Low rank coals are low in carbon but high in hydrogen and oxygen content. The ranks of coals, from those with the least carbon to those with the most, are lignite, sub-bituminous, bituminous (coking) and anthracite. All four types are found in Canada.

Anthracite and bituminous coals can be used for metallurgical and thermal purposes (it is transformed into coke and fed with iron ore into blast furnaces for iron and steel production); sub-bituminous and lignite coals are used to generate electricity and are referred to as thermal coal.

In 2007, Canada had 8.7 billion tonnes of proven coal reserves. Of this 6.58 billion tonnes are deemed recoverable – 3.47 billion tonnes of anthracite and bituminous coal, and 3.11 billion tonnes of sub-bituminous coal and lignite. The largest known reserves are in Western Canada (British Columbia, Alberta and Saskatchewan). There are known coal reserves in Ontario that have yet to be developed due to the coal's high moisture content and low heating value. The Yukon and the Northwest Territories also contain modest deposits of coal that remain unexplored and undeveloped.

In 2007, coal production in Canada totaled 69.4 million tonnes – 32.8 million tonnes of bituminous coal, 26 million tonnes of sub-bituminous and 10.5 million tonnes of lignite. Alberta accounted for 47.2 percent of total production, British Columbia 37.4 percent and Saskatchewan 15.2 percent. Small amounts of coal are mined in Nova Scotia and New Brunswick. There were 22 coal mines operating in Canada at the end of 2007; 17 were in British Columbia and Alberta. Over 90 percent of coal was used to generate electricity; the rest consumed by Canada's steel, cement, and other industries.

Canada is the world's eighth largest exporter of hard coal. In 2007, Canada exported 30.1 million tonnes (44.5 percent of domestic production) valued at $2.9 billion. Metallurgical coal accounted for about 90 percent of Canada's coal exports. British Columbia exported 23.5 million tonnes and Alberta 6.5 million tonnes.

Generally speaking, all of Canada's metallurgical coal (i.e. all coal produced in British Columbia and some in Alberta) is exported. Almost all thermal coal (i.e. all of Saskatchewan's, New Brunswick's, and Nova Scotia's and most of Alberta's) is consumed domestically for coal-fired power generation.

Canada exports coal to 21 countries. Asia takes in more than half of Canada's coal exports with Japan importing the most. Canada also exports significant volumes of coal to a number of European countries, the United States, Mexico and Latin America.

In 2007, Canada imported 22.6 million tonnes of coal. Of this, 80.4 percent was imported by Ontario, 10.5 percent by Nova Scotia and 4.3 percent by New Brunswick. Coal is imported into central and eastern Canada for cost reasons (it is cheaper to obtain coal from the east and central regions of the United States than it is from the Western Canada), but also to ensure adequate supplies of the type of coal required. About 80 percent of coal imports are thermal coal for electricity generation in Ontario, Nova Scotia, and New Brunswick. The largest quantities were sourced from the United States, with smaller

39 Data sourced primarily from Statistics Canada. *Energy Statistics Handbook*. Catalogue no. 57-601-X. January 2009. See also Coal Association of Canada.

Uranium [40]

volumes from Colombia, Venezuela and Russia.

Canada has the world's largest uranium reserves and is the world's leading producer of high-grade, low-cost uranium (23 percent of total world total production) from its Saskatchewan mines. In 2007, Canada produced 9,476 tonnes of uranium worth approximately $835 million. The industry (i.e. mining and milling) directly employees over 1,000 people.

In 2007, nearly 85 percent of Canada's uranium production was exported totalling approximately $710 million. Exports were chiefly to the United States, the European Union and Japan. What is not exported is used to fuel CANDU reactors in Canada.

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

Electricity [41]

Canada is the world's seventh largest producer of electricity. In 2007, electric utilities and industry generated 615.3 billion kilowatt-hours. About 25,000 people are employed in the generation of electricity, and may more in activities associated with transmission and distribution.

Canadians today consume about 20 percent more power than 15 years ago, and projections call for a 25 percent increase in generation capacity by 2025.

Electricity is generated from a diversified mix of sources. In 2007, moving water (hydropower) generated 60.1 percent of electricity in Canada, coal 20.7 percent, nuclear 14.6 percent, oil and gas combined 4.0 percent, and internal combustion and renewables 0.6 percent. The predominant non-hydro renewable source is biomass. Emerging sources such as wind, solar, and ocean power provide a small but an increasing amount of electricity.

In 2007, 31.0 percent of electricity in Canada was generated in Quebec, 26.2 percent in Ontario, 12.0 percent in British Columbia and 10.0 percent in Alberta.

A certain amount of trading takes place in electricity – between provinces and across the border. Producers sell electricity that might otherwise go to waste to buyers who want to ensure adequate supplies to meet periods of

40 This section is largely sourced from Natural Resources Canada. "Energy Sources." www.nrcan.gc.ca.

41 Data largely sourced from Statistics Canada. *Energy Statistics Handbook*. Catalogue no. 57-601-X. January 2009. See also Canadian Electricity Association. "Electricity 08." Volume 79 – Number 1. 2008

high demand. Some trading reflects seasonal circumstances – electricity demand peaks during the winter in Canada and during the summer in the United States. As well, hydroelectric utilities with water reservoirs may boost production during daily peak demand periods in order to export electricity at advantageous prices, and reduce production (and refill the reservoirs) during off-peak periods while importing electricity at lower prices.

In recent years, Canada has been a net exporter of electricity to the United States. In 2007, export sales south of border amounted to 49.8 billion kilowatt-hours, less than 10 percent of total Canadian production. Of total electricity exported to the United States, Quebec accounted for 31.5 percent, Manitoba 22.5 percent, British Columbia 20.4 percent, Ontario 19.6 percent, New Brunswick 4.0 percent and Saskatchewan 1.5 percent. In total, Canada exported approximately $3.1 billion in electricity in 2007.

Import purchases from the United States amounted to 20.3 billion kilowatt-hours or $1.0 billion. Ontario accounted for 36.0 percent of total imports, British Columbia 35.8 percent, Quebec 16.5 percent, New Brunswick 3.2 percent, Saskatchewan 2.9 percent, Alberta 2.7 percent and Manitoba 2.6 percent. Overall, imports from the United States account for less than 3.0 percent of Canadian electricity consumption.

The industrial sector accounts for the largest share of electricity demand (44.3 percent) driven by a number of energy-intensive industrial activities in mining, oil and gas extraction and manufacturing. The residential and commercial-institutional sectors also consume large quantities of electricity (accounting for 28.7 percent and 22.9 percent, respectively of end-use demand). Smaller quantities were consumed by the agriculture sector (1.7 percent), public administration (2.6 percent) and transportation (0.7 percent).

A Smart Electricity Power Grid [42]

- Canada faces the need to replace a significant amount of its aging electricity infrastructure. According to the IEA, Canada will need to invest in excess of $185 billion by 2030 to replace and built new generation transmission and distribution infrastructure.

- Because of inefficiencies in the system, the grid is unnecessary wasteful. If Canada's grid was just five percent more efficient, it would be like eliminating the fuel and greenhouse gas emissions from four million cars.[43]

- Modernizing Canada's power grid infrastructure through the use of two-way communication, sensors, monitoring, and advanced information technology would create an intelligent power grid that would allow for more efficient, flexible and reliable delivery of power, and would reduce the environmental footprint of the electricity sector.

42 Further information on a smart grid system can be obtained from the Independent Electricity System Operator (IESO). "Enabling Tomorrow's Electricity System: Report of the Ontario Smart Grid Forum." February 4, 2009

43 IBM. "Smart power for a smarter planet."

- Utilities would utilize real-time data from sensors and advanced meters incorporated in the power grid to better understand specific supply and demand requirements, spot problem areas, and better manage resources. Utilities would be able to automate functions such as meter reading, and connecting and disconnecting service.

- A smart grid would enable the use of new technologies including plug-in hybrid electric vehicles, distribution generation, and energy storage solutions. It would include diverse and dispersed energy resources.

- An advanced energy-metering infrastructure would enable consumers to determine their energy usage based on dynamic price signals that fluctuate throughout the day in response to energy supply and demand conditions. By responding to price signals, consumers would help reduce peak demand and energy costs. Smart grids are already enabling consumers to save 10 percent on their bills and reduce peak demand by 15 percent.[44]

- In short, a smart grip would bring all elements of the electricity system – production, delivery and consumption – closer together to improve overall system operation and efficiency for the benefit of consumers and the environment.

Hydro[45]

Hydropower (hydroelectricity) is produced by the fall of water turning the blades of a turbine. The turbine is connected to a generator that converts the energy into electricity. The amount of electricity a hydropower facility can produce depends on the quantity of water passing through a turbine and the height from which the water falls.

Hydropower is Canada's number one renewable energy generation source accounting for 60.6 percent of Canada's electricity generation capacity and about 97 percent of existing renewable energy. Canada is also the second largest producer of hydroelectricity in the world (after China). Quebec has about half of Canada's installed hydroelectricity capacity. Other areas producing large quantities of hydroelectricity include British Columbia, Ontario, Newfoundland and Labrador, and Manitoba. Hydroelectric stations currently provide some of the lowest-cost electricity in Canada.

To replace the electricity produced by hydropower in Canada would require annually 560 million barrels of oil.

A number of hydropower projects are being considered, are in the planning stage or under construction. Over the next ten years, these projects will involve over $50 billion in capital investment. Hydropower produces no air pollutants, no polluting or toxic waste by-products, and a very small amount of GHG emissions – 60 times less

44 Ibid.

45 Canadian Hydropower Association. "Hydropower in Canada: Past Present and Future." 2008. Also, Fortin, Pierre. "Hydropower, green in more ways than one." Canadian Hydropower Association Op-ed. *Winnipeg Free Press, Edmonton Journal*. January 29, 2009.

than those from coal-fired plants and 18-30 times less than natural gas power plants. However, construction and operation of hydropower dams can significantly affect mature river systems as well as fish and wildlife populations.

On average, a large hydropower project requires 8 to 12 years of preparation – from the beginning of feasibility studies to its commissioning. In comparison, a fossil-fuel power plant can be operational in 4 years. The environmental assessment process is lengthy for hydroelectric projects due to its large emphasis on local impacts.

Thermal[46]

Thermal electric power plants burn coal, natural gas and petroleum products to generate steam which is used to turn the turbines that power generators producing electricity. Coal is the predominant source of fuel for thermal electric power production in Canada accounting for 20.7 percent of net electricity generation in 2007. Oil and gas combined accounted for 4 percent.

Coal is used to produce about 74 percent of the electricity in Alberta, 63 percent in Saskatchewan, 60 percent in Nova Scotia and 18 percent in Ontario. Most oil-fired generation takes place in the Maritimes. The majority of gas-fired generation takes place in Ontario. The generating capacity from fossil-fired plants is about 32,000 megawatts.

The coal-fired Nanticoke generating station in Ontario is Canada's largest thermal power plant (and one of the largest in the world) with installed capacity of 3,964 megawatts. The facility produces enough electricity to meet the needs of nearly 2.5 million households for a year.

Ontario's four coal-fueled power stations have been set to stop production by 2014 as part of the Provincial government's strategy for combating climate change. In the meantime, Ontario Power Generation will have to reduce the plants' combined emissions from 34.5 megatonnes (the level in 2003) to 11.5 megatonnes by 2011. This reduction in emissions is equivalent to removing 700,000 cars from the roads.

Ontario Power Generation is determining the commercial viability of replacing coal with biomass at existing coal-fuelled generating stations. Several successful test burns have been conducted.

Nuclear[47]

Canada is the world's six largest producer of electricity using nuclear power. In 2007, there were 22 CANDU reactors of which 18 were in service generating 14.6 percent of the country's electricity. Regionally, they generated 51 percent of Ontario's electricity, 30 percent of New Brunswick's and 3 percent of Quebec's.

Nuclear energy produces virtually none of the pollutants that contribute to smog and acid rain. Nuclear energy produces virtually no GHGs. It is estimated that the use of nuclear energy to produce electricity in Canada avoids emissions of about 90 million tonnes of GHGs per year, or about 12 percent of Canada's total emissions. In Canada, the use of CANDU reactors has avoided 2.3 billion tonnes of emissions since 1972.

Nuclear energy is a $6.6 billion per year industry, generating 21,000 direct and 10,000 indirect jobs, and $1.2 billion in exports. The industry is involved in refining and conversion of uranium; producing reactor fuel; manufacturing equipment and providing services for nuclear power plants in

46 Data sourced from Statistics Canada. *Energy Statistics Handbook.* Catalogue no. 57-601-X. January 2009.

47 his section is largely sourced from the Canadian Nuclear Association. "An Overview of Nuclear Power in Canada." February 19, 2009; and the Canadian Nuclear Association. "Innovating Today for a Brighter Future." 2008.

Canada and abroad; producing radioactive isotopes for use in medicine, industry and agriculture; and developing improved materials through nuclear-related research and development.

According to Atomic Energy of Canada Ltd. (AECL), about $6 billion was invested in Canada's nuclear program from 1952 to 2006. This investment has generated more than $160 billion in GDP benefits from power production, research and development, CANDU exports, uranium, nuclear radioisotopes and professional services. AECL's research and development programs keep Canada at the leading edge of nuclear technology.

Biomass[48]

Biomass, as a renewable energy source, refers to plant and animal matter that can be used as fuel or to generate electricity. It is the second largest source of renewable energy after hydroelectricity.

Wood remains the world's largest source of biomass. Other biomass fuel sources include wastes from forestry and sawmill operations (bark, wood chips, sawdust and logging debris); urban wood wastes (shipping pallets, packing and leftover construction wood); agricultural wastes (such as crop residues), fast-growing trees and crops (such as poplar, willow, straw and peat), organic wastes (such as animal manure and food processing wastes) and organic portions of municipal solid waste (found in municipal sewage and landfills).

There are several ways of turning biomass into electricity and heat. The simplest way is to burn it (direct combustion). High pressure steam is produced that turns a turbine connected to a generator producing electricity. Most of the world's biomass power plants use direct combustion.

One of the most economic ways to produce electricity from biomass is by burning it along with coal (co-firing) in traditional power plant boilers. This technique can help reduce the use of coal, thereby lowering emissions of carbon dioxide, sulphur dioxide and nitrogen oxides.

New technologies have been developed to heat solid biomass at high temperatures in an oxygen-deprived environment to produce a fuel gas that contains between 20 and 50 percent the heat content of natural gas. This gas can be used to drive highly efficient combined cycle systems to generate electricity.

City dumps or landfill sites containing organic waste produce biogas (landfill gas) rich in methane. This gas can be collected and used to heat buildings, run engines or generate electricity. Methane is a much more potent GHG than CO_2 having approximately 21 times the Global Warming Potential as CO_2 and is responsible for 15 percent of GHG emissions in Canada.

Biomass can also be used to produce biofuels, like ethanol and biodiesel. Ethanol is an alcohol made by fermenting organic matter rich in sugars, starch or cellulose. It is mostly used as a fuel additive, mixed with gasoline, to enhance vehicle performance and reduce emissions. It can also be used to fuel engines or fuel cells for electricity generation. Canada produces about 175 million litres of ethanol each year, mainly from corn and wheat. Biodiesel is produced by combining animal fats, waste vegetable oils and crops (soybean, canola, corn and sunflowers) with alcohol and a catalyzing agent. This clean-burning fuel can be used to reduce vehicle emissions. Canada produces approximately five million litres of biodiesel fuels per year. In 2008, there were 16 ethanol plants and four biodiesel plants operating or under construction in Canada, with a total capacity of 1.9 billion litres per year.[49]

48 Centre for Energy Information unless otherwise indicated.

49 Canadian Renewable Fuels Association.

Prairie grain crops produce about 32 million tonnes of straw residue each year. About 85 percent of this is put back into the soil leaving about five million tonnes per year to produce liquid biofuels.

In 2006, the federal government announced a regulation requiring a five percent average renewable content in Canadian gasoline by 2010 and two percent average renewable content for diesel fuel and heating oil by 2012.

According to Pollution Probe, Canada has more than 1,600 megawatts of installed biomass power capacity concentrated in the forestry and pulp and paper industries. Another 85 megawatts uses biogas from municipal landfill sites. Several independent power producers also generate electricity from the burning of wood wastes and other biomass materials. On a smaller scale, the burning of biomass, particularly firewood, continues to supply space heating in many Canadian homes. According to Natural Resources Canada, about 1.5 million Canadians use wood for home heating. This is most prevalent in Atlantic Canada.

When considering the economic and technical feasibility of this renewable energy source, collection, transportation and handling costs are primary obstacles. Some biomass is considered to be "carbon neutral" meaning the amount of carbon released when burned is equal to the amount removed from the atmosphere when the plant is growing.

Wind[50]

In 2006, the wind industry contributed $1.6 billion to Canada's GDP and employed 3,785 people. In addition to providing employment in the development, installation and service sectors, Canada manufactures most wind farm steel towers.

Wind energy is a clean, sustainable form of energy production that requires no fuel and produces no GHGs. However, as wind farms are generally situated in remote areas, they may cause land impacts when new transmission lines are connected to power plants.

Year-end 2007, Canada had 1,400 wind turbines operating on 85 wind farms for a total installed capacity of 1,846 megawatts, up from 137 megawatts in 2000. As of January 2009 this had risen to 2,369 megawatts, enough to power 680,000 homes. The provincial leaders in wind power capacity are Ontario (with installed wind energy capacity of 781 megawatts), Quebec (535 megawatts) and Alberta (524 megawatts).

Canada has tremendous potential to be a world leader in wind energy. Geographically, the country has large areas with excellent wind resources offshore and along coastlines. There are also high quality areas inland including the southern Prairies and the Gulf of St. Lawrence. Ultimately, how much electricity is produced depends on the availability of sufficient wind.

Canada's largest wind farm is slated for development in southern Manitoba. The project would generate 300 megawatts of electricity from 130 turbines and would bring the province one step closer to achieving its goal of developing 1,000 megawatts of wind power. Environmental benefits include displacing 800,000 tonnes of greenhouse gas emissions, the equivalent of taking 145,000 cars off the road.

50 Canada Wind Energy Association.

Solar[51]

The sun can be used effectively to provide energy for many applications, particularly to sparsely populated and remote areas that are off the electricity grid. Solar electric systems (photovoltaic cells - PV cells) are used to provide energy to telecommunications equipment, water pumps, navigational devices, oil and pipeline monitoring stations, and cottages and homes in remote areas. Non-electricity active solar system applications include space heating, water heating and drying crops and lumber. Solar energy is a clean, non-polluting source of power.

Canada's use of solar energy has increased in recent years; however, market penetration remains relatively low. The amount of solar energy available across the country varies with the season, latitude, weather conditions and the time of day. In 2001, there were more than 12,000 residential solar water heating systems in homes and 300 commercial and industrial solar hot water systems in use.

In early 2003, Canada's installed capacity of PV systems was about 10 megawatts, compared with one megawatt in 1992.

Drake Landing Solar Community

The Drake Landing Solar Community is a master planned neighbourhood in the town of Okotoks, Alberta. The first of its kind in North America, it is designed to store abundant solar energy underground during the summer months and distribute the energy to each home for space heating needs during winter months. The system is unprecedented in the world, fulfilling 90 percent of each home's space heating requirements from solar energy.

51 Centre for Energy Information.

Tidal[52]

Tidal power is created by using the ebb and flow of tides to run turbines to produce electricity. Due to the lunar cycle and gravity, tidal currents, although variable, are reliable and predictable and their power can make a valuable contribution to an electrical system which has a variety of sources.

Tidal energy can be exploited by building semi-permeable barrages across estuaries with a high tidal range or by harnessing offshore tidal streams. Like hydroelectric power, it is a renewable energy source that does not directly result in the emission of GHGs or acid rain. Damming or barring estuaries to run turbines can have environmental consequences that vary with the site.

Technology required for tidal power is well developed. The main barrier to increased use of the tides is construction costs. The construction period of a tidal energy project can be as lengthy as 10 years.

Canada has significant potential to develop a major presence in tidal energy. At present, Canada is home to one of three tidal power plants in the world and the only one in the Western Hemisphere. The tidal power plant in Nova Scotia (Annapolis) has generating capacity of 20 megawatts of electricity. Each day, 100 billion tonnes of seawater flows in and out of the Bay of Fundy where the tidal range reaches more than 50 feet. The U.S.-based Electric Power Research Institute identifies the Bay of Fundy as perhaps the most potent site for tidal power generation in North America. When fully developed, new in-stream tidal technology has the potential to generate 300 megawatts of energy in the Bay of Fundy - enough to power close to 100,000 homes.

Canada's West coast also has exceptional energy-producing potential. The first site with a potential of 800 megawatts (enough to provide electrical energy for 140,000 homes) will be Discovery Passage between Vancouver Island and the mainland. It is located at Campbell River.

Geothermal[53]

Geothermal energy can be captured from naturally occurring underground steam and be used to produce electricity. Drilling at the South Meager geothermal reservoir in British Columbia had demonstrated potential to become Canada's first commercial geothermal power facility with capacity of 100 megawatts of electrical generation. The focus is now on securing the funding and permitting necessary to complete the drilling program and prepare a feasibility report on the project.[54]

Geothermal projects can generate significant downstream benefits by providing energy for residential and commercial heating systems, greenhouses, land-based fish farms, and spas.

Capital costs for the construction of geothermal power plants are much higher than coal-fired plants or new natural gas turbine technologies. However, geothermal plants have relatively minor operation and maintenance costs, and bear no fuel costs or associated transportation costs.

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52 See Ocean Energy Council at www.oceanenergycouncil.com; Nova Scotia Power at www.nspower.ca; Government of Nova Scotia at www.gov.ns.ca/energy/renewables/public-education/tidal.asp; and Tidal Stream Energy at www.tidalstreamenergy.com - a company created to harness the kinetic energy in tidal currents off the coast of British Columbia.

53 Centre for Energy Information unless otherwise indicated. See also Canadian Geothermal Energy Association.

54 Western GeoPower Corporation. 2008. "South Meager Testing Demonstrates Potentially Commercial Permeability." *Press Release*. April 22, 2009.

Geothermal energy results in small air emissions. The disposal of water and wastewater is the principal pollution concern. However, geothermal fluids can be collected and re-injected allowing for recycling and reuse. Geothermal plants, while taking up relatively little land, can have a significant land impact when new transmission lines are connected to power plants.

The principal use of geothermal energy in Canada is to heat and cool residences and commercial and institutional buildings. In the most common application, heat pumps extract near-surface thermal energy from buried pipes or coils and distribute it through the building. The heat pumps, which operate on the same principle as a compressor in a refrigerator, can also reverse the process to provide cooling. The capital costs associated with geothermal energy are generally somewhat higher than conventional heating systems; however, the operating costs are usually much lower.

Summary

Canada is a world energy leader due to its hydropower potential, proven nuclear power technology, vast natural gas supplies, and large quantities of uranium and hydrocarbon reserves, including coal, oil sands bitumen, and conventional oil. Canada also has substantial renewable resources – moving water, biomass, wind, solar, geothermal and ocean energy – that can be used to produce energy.

The energy industry remains a cornerstone of the Canadian economy as demonstrated by its contributions to GDP, capital investment, employment and export earnings.

While the recession has led to a downturn in capital investment and reduced demand for many energy commodities, it has also served as an impetus for the industry to prepare for the next cycle of growth. Prices rise and fall in response to market forces, but one basic constant remains: the continuously growing demand for energy in a world where population and development are increasing.

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