North American Cross-Border Electricity Trade

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EXECUTIVE SUMMARY

The extensive trade of goods and services between the United States and Canada includes electricity. In general, this trade involves the shipment of power in both directions across the national border. In recent years the United States has been the net importer. In 1994 the United States imported a net 43.7 billion kilowatthours from Canada. This represented about 9.6% of the total consumption in Canada, but only about 1% of the total generation in the U.S.

About 55% of the electricity imported from Canada was consumed in New York and the New England states. The 24.0 billion kilowatthours imported to New York and New England represented around 10% of the total demand in those regions. This is a significantly greater portion of the demand than could have been met by the nearly 1 million tons of Virginia sourced steam coal burnt in power plants in the northeastern portion of the United States.

As coal mining in the Commonwealth of Virginia begins a downturn, from peak production in 1990 of 46.5 million tons, the import of electrical power from Canada appears to have little impact on the production of steam coal in Virginia. The longer term future of coal mining in Virginia appears to be in the extraction of thin seams, more suitable for the metallurgical than the steam market. The higher mining costs, in the thinner seams, is offset by the higher sales prices on the metallurgical market.

INTRODUCTION

This report investigates the role that imported electricity from Canada may have on the future trend of electrical generation from coal in the United States. The impetus for the creation of this document was a question raised during the October 7, 1997, meeting of the Virginia Coal and Energy Commission, in Roanoke, Virginia.

Based upon the World Energy database assembled by the Energy Information Administration, U.S. Department of Energy, Office of Energy Markets and End Use, several initial facts can be observed regarding the generation and distribution of electric power in North America. Most noticeable is that, although there is trade of electricity in both directions across both the U.S.–Canada and U.S.–Mexico borders, the United States is a net importer of electric power from both of these contiguous nations. Reasons for the trade of electricity across the borders of nations, states, and utilities include cost reduction, revenue maximization, and emergency mitigation.[1] Another reason for using foreign electrical power arises in areas where those transmission lines are physically closer to the client[2].

The electric power production growth rate in the United States has been fairly constant at about 2.7% percent per year since 1990. In the most recent year (1995), the sources of this electricity were: hydroelectric (9.0%), nuclear (18.8%), geothermal and other (2.2%), and thermal (70.1%). The thermal section includes coal, petroleum, and natural gas. The use of coal accounts for over half (56%) of all the electricity generated in the United States.

For the period 1990-1995, electricity generation in Canada grew in step with the United States, at about 2.6% per year. In the most recent year reported (1995), Canadian electricity production was from the following sources: hydroelectric (62.8%), nuclear (14.7%), geothermal and other (<0.1%), and thermal (22.5%). It is evident that, whereas the United States relies on coal fired electrical power plants, Canada relies, primarily, on hydroelectric power generation. In 1995, Canada exported a net of about 36.5 billion kilowatthours of electric power to the United States, about 1% of U.S. generation.

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[1] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review,* Organisation for Economic Co-operation and Development, Paris, France, p. 85.

[2] Energy Information Administration, *Electric Power Annual 1995*, Volume II, Department of Energy, publication DOE/EIA-0348(95)/2, December 1996, p.59.

Through the period of 1990 to 1995 the nation of Mexico increased electric power generation at a rate of 4.6% per year. In 1995 Mexican electricity production was from the following sources: hydroelectric (18.8%), nuclear (5.5%), geothermal and other (3.7%), and thermal (72.1%). In 1995, Mexico was a net exporter of electricity to the United States, sending about 1.1 billion kilowatthours to the U.S. From this information, Mexico accounts for about 3% of the electricity imported to the United States; therefore, for the purposes of this document, the effect of Mexico will be assumed negligible in comparison to Canada.

Current world trends regarding the generation of electricity by means of renewable resources suggest that only Canada and Japan will continue to grow. In both of these cases that growth is expected to be in the form of hydroelectric plants through the exploitation of untapped resources[3]. The projection for Canada appears to be made in spite of the 1994 cancellation of the Great Whale hydroelectric project in the province of Quebec[4]. Further development of large hydroelectric projects in the United States, as in the remainder of the industrialized nations, is likely to be inhibited by environmental pressures. U.S. Department of Energy (DOE) projections are that total renewable sourced power generation will remain essentially flat, as decommissioned hydro plants are replaced by alternate renewable sources[5]. Figure 1 illustrates the historical and projected growth of renewable electricity generation for all industrialized nations and for the world as a whole. By 2015, hydroelectric power is projected to account for more than 70% of Canadian generation[6].

This report investigates the role that electricity generated in Canada will have on the power market in the United States by first evaluating the current growth trends in capacity in both countries. The next factor to consider will be the consumption trends, which will be followed by a look at the projected energy balance between these two nations. Some brief comments will be provided concerning Mexico; however, the general assumption is that

[3] Energy Information Administration, *International Energy Outlook 1997*, Dept. of Energy, publication DOE/EIA-0484(97), p. 98.
[4] U.S. Energy Information Administration, "Canada," *Country Analysis Brief*, October 1996, http://www.eia.doe.gov/emeu/cabs/canada.html, October 9, 1997.
[5] Energy Information Administration, *International Energy Outlook 1997*, Dept. of Energy, publication DOE/EIA-0484(97), p. 98.
[6] Energy Information Administration, *International Energy Outlook 1997*, Dept. of Energy, publication DOE/EIA-0484(97), p. 100.

growth in Mexican electric capacity will be used to support growth within the Mexican economy, rather than exported to the United States.

While the initial question posed related to the increase in hydroelectric capacity in Canada, which could be directed to the U.S. market, it is not practical to assign specific power consumption to a specific source. Rather, what is more reasonable is to compare electric consumption on the basis of the proportion of power generated by sources of interest. This will, then, be the form of the conclusions.

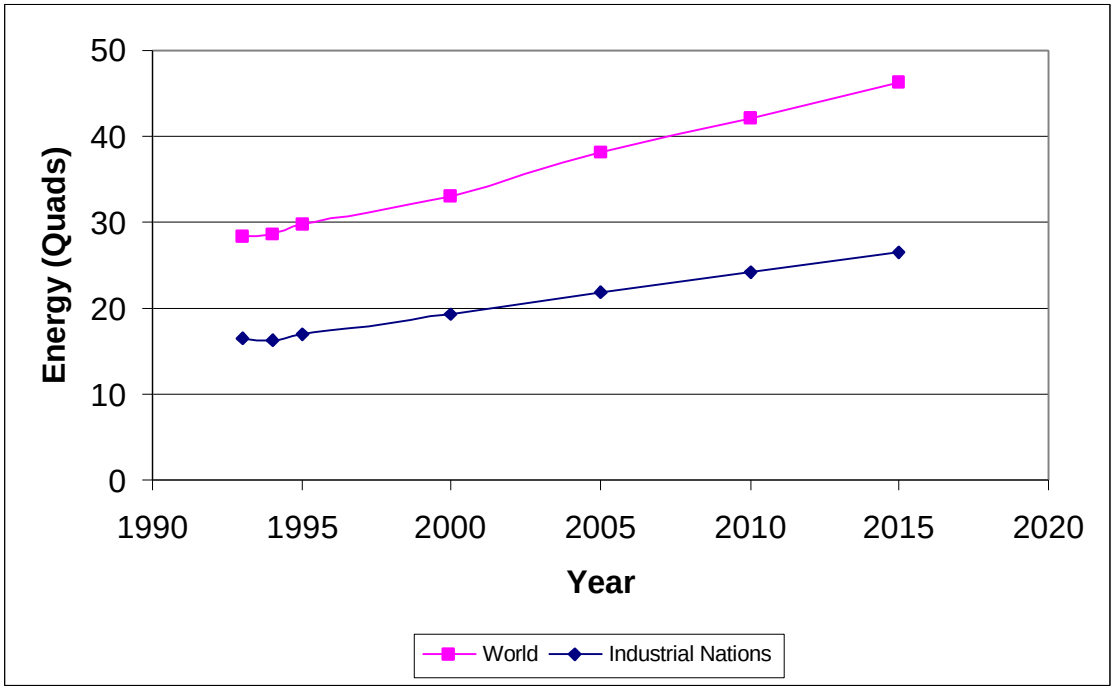

Figure 1: Projections of Renewable Electric Energy Generation

ELECTRICITY GENERATION TRENDS

Generation of electricity in North America is growing at a rate of about 2.5% per year, from 3,724.1 billion kilowatthours in 1990 to 4,263.0 billion kilowatthours in 1995. Primary fuel sources and national energy policies vary between the United States, Canada, and Mexico. This section addresses application of the primary fuels in these three nations, as well as current concerns surrounding growth in those fuel sources and countries.

United States

The United States of America, as the world's leading industrialized nation is also the largest generator of electric power, producing some 3,459.8 billion kilowatthours, 28.0% of the world electricity generation, in 1994[7]. Even with such vast generation capability, the United States is a net importer of electric power. The primary source of the import is from Canada, although a small fraction is imported from Mexico. Consumption of electricity follows a similar trend. Electrical power consumption by the United States has varied between 25.9 and 26.4% of the world total since 1986[8].

Primary Fuels

The primary fuel sources used for electric power generation in the United States are coal, petroleum, natural gas, nuclear, hydro sources, and renewables[9]. For convenience, these are lumped into three major elemental blocks: thermal, which includes coal, petroleum, and natural gas; hydroelectric and renewable, which includes hydro sources and the renewables; and nuclear. As appropriate to the available data, these segments will be reviewed separately, and the individual fuels broken out as possible. The trend in annual electric production since 1970, in the United States, is illustrated in figure 2. Figure 3 shows the trend in the proportion of electricity generated by the various primary fuels. In both of these graphs hydroelectric production has been combined with the renewables since the latter account for less than 1% of the total.

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[7] Energy Information Administration, *International Energy Annual 1995*, Department of Energy, publication EIA/DOE-0484(95), pp. 91-93.
[8] Energy Information Administration, *International Energy Annual 1995*, Department of Energy, publication EIA/DOE-0484(95), pp. 91-93.
[9] Includes: geothermal, solar, wind, waste, and wood.

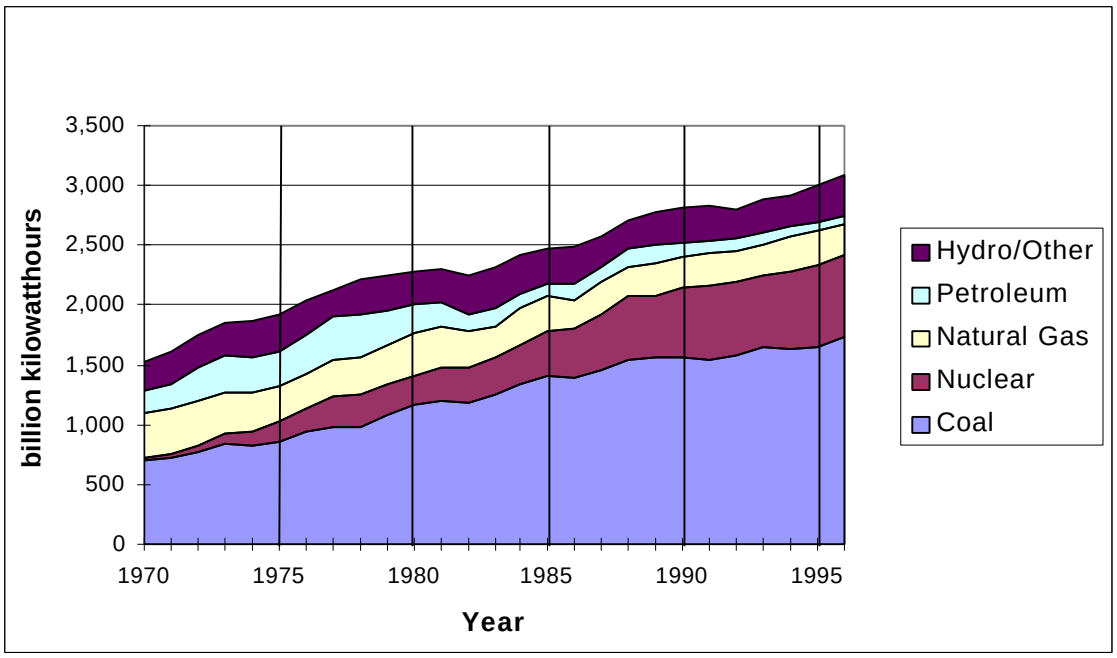

Figure 2: Annual Electric Power Production Trend in the United States

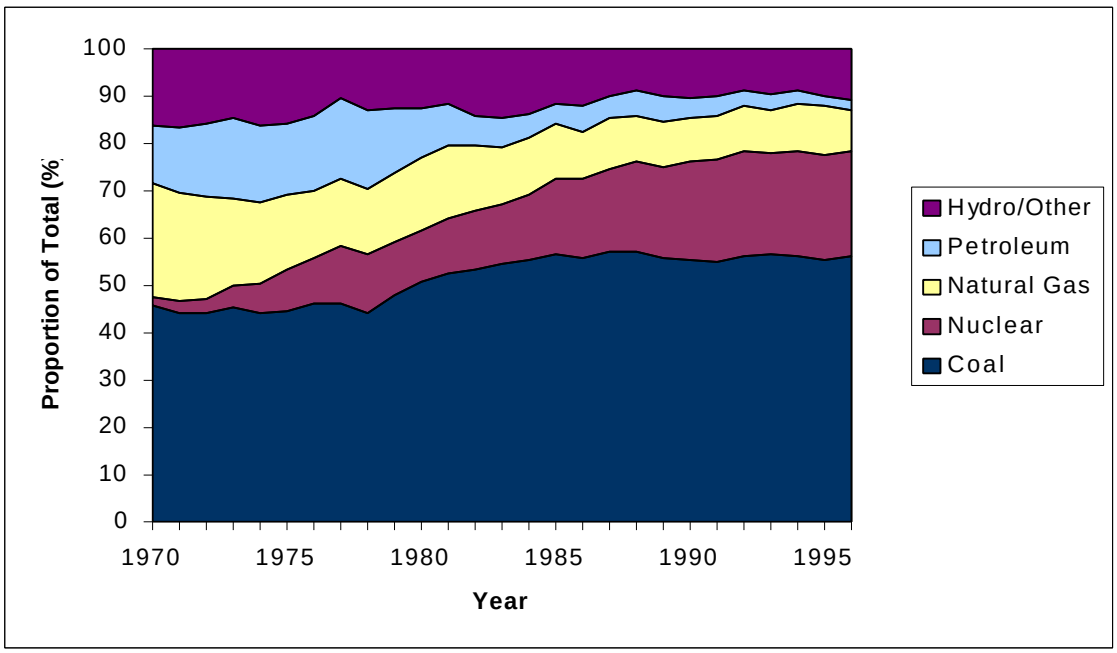

Figure 3: Electricity Production Proportion Trend by Source in the United States

Thermal. Unquestionably the primary fuel used in the United States for the generation of electricity has been, and is expected to continue to be, coal. Over the last 25 years, the fraction of electricity generated in the United States from the combustion of coal has varied between 44 and 57%. The other two fossil fuels, petroleum and gas, have seen a steady decline in electricity production. Petroleum accounted for only 2.2% of electricity production in 1996. Its peak in the last 25 years was in 1977 at 16.9%. Natural gas, in 1996 accounted for 8.5% of the electricity generation. In the previous 25 years its peak was 23.2% in 1971.

Hydroelectric and other renewable sources have seen a slow but steady decline from 16.6% of electricity generation in 1971 to 10.9% of generation in 1996. This decline has not, however, been monotonic. Hydroelectric sources represent the greatest proportion of the category, and this generation is affected by the annual precipitation into the source watersheds. Hence, in years of lower precipitation the magnitude of hydroelectric generation is also lower.

The future of hydroelectric generation appears to be relatively stable, or declining, over the next twenty years. The Energy Information Administration (EIA) projects that by the year 2015 the share of electricity generated by hydroelectric sources will account for about 7% of the total, down from about 9% in 1995[10]. Two factors are involved: the number of hydroelectric plants is likely to increase as new, small plants and upgrades to existing facilities come on line. Great gains in total available power will be offset, however, by loss of existing facilities that have licenses up for renewal over the next several years. The fate of these plants is in the hands of the priorities associated with water use, primarily in the American west. Electric power production from these existing hydroelectric plants may be curtailed or ceased by the Federal Energy Regulatory Commission (FERC) in preference to water-use and environmental priorities.

Nuclear. The gap in generation that exists between thermal and renewables has been filled by nuclear reactor generation facilities. The proportion of electricity generated at these plants has exhibited nearly continuous growth over the last 25 years, from 2.5% in 1971 to 21.9% in 1996. The peak, in that time frame was 22.5% in 1995.

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[10] Energy Information Administration, *Annual Energy Outlook* 1997, Washington D.C., publication DOE/EIA-0383(97), January, p. 56.

The EIA does not project any significant growth in the supply of electricity from nuclear fueled sources. In their 1995 energy projections to the year 2010, the EIA projected only two additional nuclear power plants coming on line in the United States, namely the Tennessee Valley Authority's (TVA) 1170 MWe Watts Bar 1 (1995)[11] and Watts Bar 2 (1997)[12]. Furthermore, the EIA discounts the likelihood that any other, as yet unfinished, nuclear plants would be on line prior to 2010 on the basis of these four points:

- Concerns about the disposal of radioactive waste
- Public concerns about safety
- Concern about the economic and financial risk
- Uncertainty in the licensing and regulatory processes[13].

More recent predictions by the EIA express the same expectations, that, by the year 2015, 59 nuclear power plants will supply on the order of 10% of the total electricity generated in the United States. This fraction of production is about half of the total fraction of 20% recorded for 1995. An additional factor noted against the construction of new nuclear power plants is the economics in favor of natural gas and coal-fired power plants[14].

Growth Policy

The growth policy of the United States, regarding additional electrical power generation, appears to be hypocritical. As has been addressed in the above paragraphs, the United States relies very heavily on coal fired power plants, with a secondary reliance on nuclear power. In 1996 fossil fuels accounted for more than 67% of electrical generation; however, fossil fuel plants emit gaseous air pollutants, including sulfur dioxide and oxides of nitrogen, compounds believed to be associated with "acid rain," as well carbon, principally in the form of carbon dioxide. Great strides have been made in the abatement of sulfur emissions from

[11] Tennessee Valley Authority Watts Bar 1 actually became operational in February 1996, having been ordered in 1970. Energy Information Administration, *Nuclear Power Generation and Fuel Cycle Report 1997*, Publication DOE/EIA-0436(97), p. 68.
[12] The 1170 MWe Watts Bar 2 has been indefinitely deferred. Of the three 1212 MWe Bellefonte plants ordered in 1970, 1 and 2 are also in a state of indefinite deferral. There are currently (1997) 110 operable nuclear reactor plants in the United States; 3, already mentioned, on indefinite deferral; 13 which have been shut-down, and 123 that were cancelled after orders were placed. Energy Information Administration, *Nuclear Power Generation and Fuel Cycle Report 1997*, Publication DOE/EIA-0436(97), pp. 61, 68.
[13] ibid., p. 166.
[14] Energy Information Administration, *Annual Energy Outlook 1997*, Washington D.C., publication DOE/EIA-0383(97), January, p. 52.

U.S. coal fired boilers, so much so that the emission credits, which the U.S. Environmental Protection Agency (EPA) had predicted would rise in cost and lead to a reliance on low-sulfur coals, have in fact decreased in price, without reliance on low-sulfur coal.

The greatest environmental concern now appears to be the concept of "global warming" in which the gaseous carbon compounds contained in the atmosphere lead to a greenhouse effect, wherein the mean global temperature rises. While there continues to be debate in the scientific community as to the true nature of the global warming phenomenon, international policy appears based on the assumption that a global warming trend does indeed exist. To that end, a number of treaties are in the works that would attempt to limit or curtail the emission of carbon into the atmosphere by industrialized nations. The nation which would be most affected by ratification of such treaties is the United States. This is due to compounding factors of the high level of industrialization (electric power consumption) and the high degree of reliance on fossil fuel electrical generation. It is necessary, also, to keep in mind that consumption of fossil fuels for other purposes (domestic, commercial, industrial, transportation, etc.) also results in emissions of the so called "greenhouse gases."

Alternative sources of electrical power generation are available, which do not directly emit the gases presumed to be associated with global warming. Based on the number of operational units, most of these (photovoltaic, geothermal, wind, etc.) are of negligible consequence for any purpose in the foreseeable future. Two, however, do standout as fairly viable alternatives to fossil fuel electricity: hydroelectric and nuclear.

The U.S. does have some untapped conventional hydroelectric resources, that are free of known limitations associated with wild and scenic river legislation. These represent a proportion of the total generation capacity that is not insignificant. In 1994 the estimated untapped conventional hydroelectric capacity in the U.S. was 73.5 million kilowatts[15]. This is equal to about 10.7% of the total installed capacity (699,971 MW) in that year[16].

Nuclear power represents the most significant alternative to the continued reliance on fossil fuels for the generation of electricity. Based on installed capacity and production, the U.S. leads the world in nuclear power. In 1993, the United States produced 610 billion

[15] U.S. Census Bureau, *1996 Statistical Abstract of the United States*, Washington, D.C., p. 595.
[16] Energy Information Administration, *Electric Power Annual 1996, Volume 1*, Publication DOE/EIA-0348(96)/1, p. 12.

kilowatthours at nuclear power plants, this represented just over 21% of the total 2,882 billion kilowatthours of net electrical generation that year[17]. This can be compared with France, a nation that depends on nuclear power plants to supply a massive 75% of its electrical power needs. Yet, French generation from nuclear plants, in 1993, was only 367 billion kilowatts[18], or 57% of U.S. nuclear production.

Canada

Canadian electric power generation is dominated by provincial/territorial electric power utilities (called "Crown" companies), which, in 1994, accounted for about 84% of all of Canada's power generation capacity and produced about 78% of the generated electricity.[19] Only in the provinces of Nova Scotia and New Brunswick are the primary electric companies in private hands; although, private and municipal electric companies have a presence in Newfoundland, Manitoba, and Alberta[20]. Under the Canadian constitution, the federal government is limited in its ability to affect the electrical power generation companies at the provincial level. The Canadian federal government is limited to dealings with "interprovincial and international trade, and works extending beyond the limits of a province."[21] Federal control is also exercised over the generation of nuclear power and the nuclear fuel cycle.

While there is some move nationally to privatize the provincial electric utilities, this is expected to be a slow process, particularly in Ontario, Quebec, and Newfoundland. This is based on the very large debt owed on the vast hydroelectric projects in the provinces. The presence of the debt is compounded by the fact that these projects are still at a phase of over-capacity for their markets.[22] A primary consideration for reforming the power generation and transmission structure in the Canadian market away from a monopolized

[17] Energy Information Administration, *Electric Power Annual 1996, Volume 1*, Publication DOE/EIA-0348(96)/1, p. 18.
[18] U.S. Census Bureau, *1996 Statistical Abstract of the United States*, Washington, D.C., p. 576.
[19] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 77.
[20] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 78.
[21] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 79.
[22] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 87.

system is the requirement for reciprocity in transmission access required to gain direct access to markets in the United States[23,24].

In 1994 Canada generated nearly 535 billion kilowatthours of electricity. This is about 17.8 thousand kilowatthours per person in this nation of nearly 30 million people. Of the total, 44 billion kilowatthours were exported to the United States, about 8.2% of the total production. The trend in net generation and net export from Canada is illustrated in figures 4 and 5, respectively. In 1995, the electricity trade with the United States was similar. The overall import and export of electricity between these two nations is illustrated in Table I and figure 6.

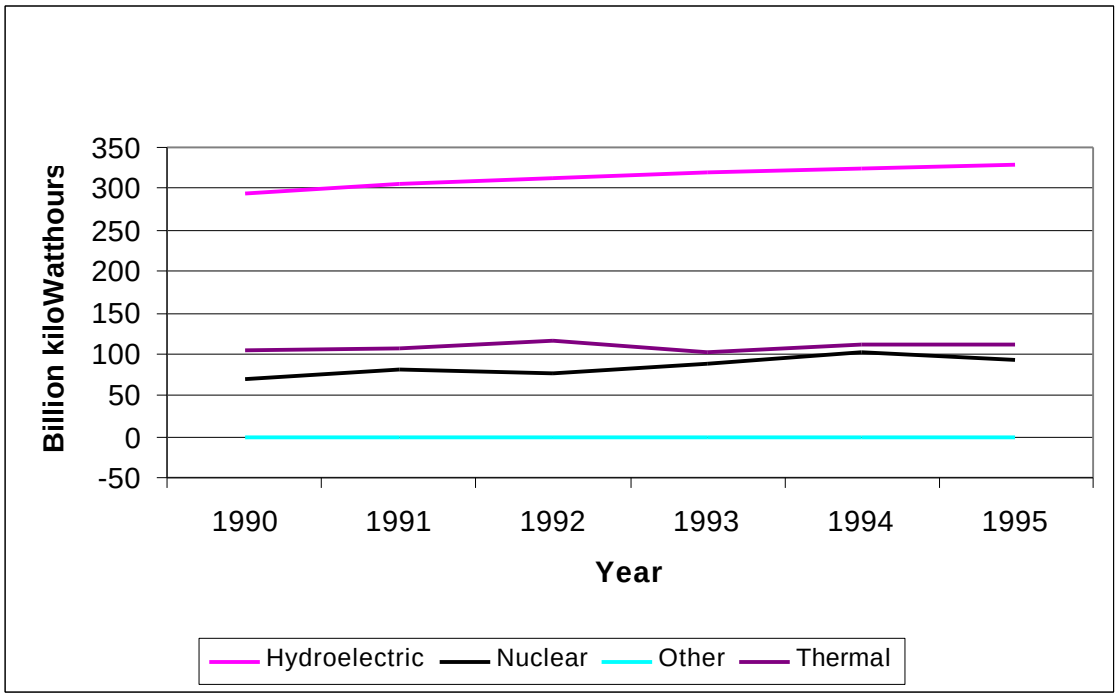

Figure 4: Trend in the Generation of Electricity in Canada

[23] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review,* Organisation for Economic Co-operation and Development, Paris, France, p. 87.

[24] A Canada NewsWire release at web site www.newswire.ca/releases/May1997/12/c2525.html cites that the U.S. Federal Energy [Regulatory] Commission rejected an application submitted by Hydro-Quebec to be a "power marketer" in the United States. The rejection was based in part on necessity for "free market competition" within Quebec. From the Canadian side, their National Energy Board has granted permission for Ontario Hydro to trade "with purchasers in the United States not directly connected with their system," see "Restructuring the Electric Power Industry in North America," Energy Information Administration, *International Energy Outlook 1995*, at web site: www.eia.doe.gov/oiaf/ieo95/box4.html.

Table I: Electricity Trade Balance between Canada and United States

Year	USA	Canada		
	Total Exports to Canada/Mexico	Import from USA	Export to USA	Net Export to USA
	billion -kWhr	billion kWhr	billion kWhr	billion kWhr
1990	20.50	19.38	20.08	.70
1991	8.54	7.92	28.70	20.77
1992	8.86	7.87	35.18	27.32
1993	10.65	9.80	37.09	27.28
1994	7.59	6.52	50.22	43.70
1995	9.15	7.99	44.50	36.51

The provincial electric utility of Quebec, Hydro-Quebec, was dealt a significant blow to its plans for future electric power production when, on November 18, 1994, the provincial Premier, Jacques Parizeau, cancelled the $10 billion (U.S.) Great Whale hydroelectric project. This project represented the second of a three phase project, by Hydro-Quebec, to exploit the vast water resources of Quebec, which flow into the James Bay. The first phase of this, the James Bay hydroelectric project, consisted of building four dams, which affected the La Grande, Eastmain, and Caniapiscau rivers and was completed in 1985. The maximum capacity of Phase I is 10,340 megawatts.

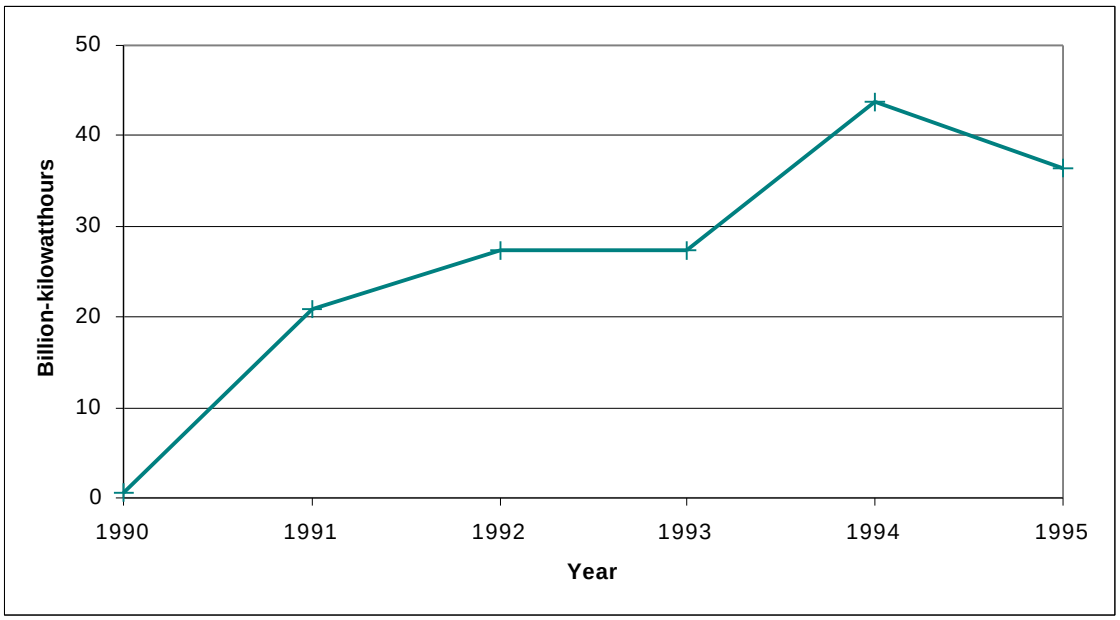

Figure 5: Net Electricity Export from Canada to the USA

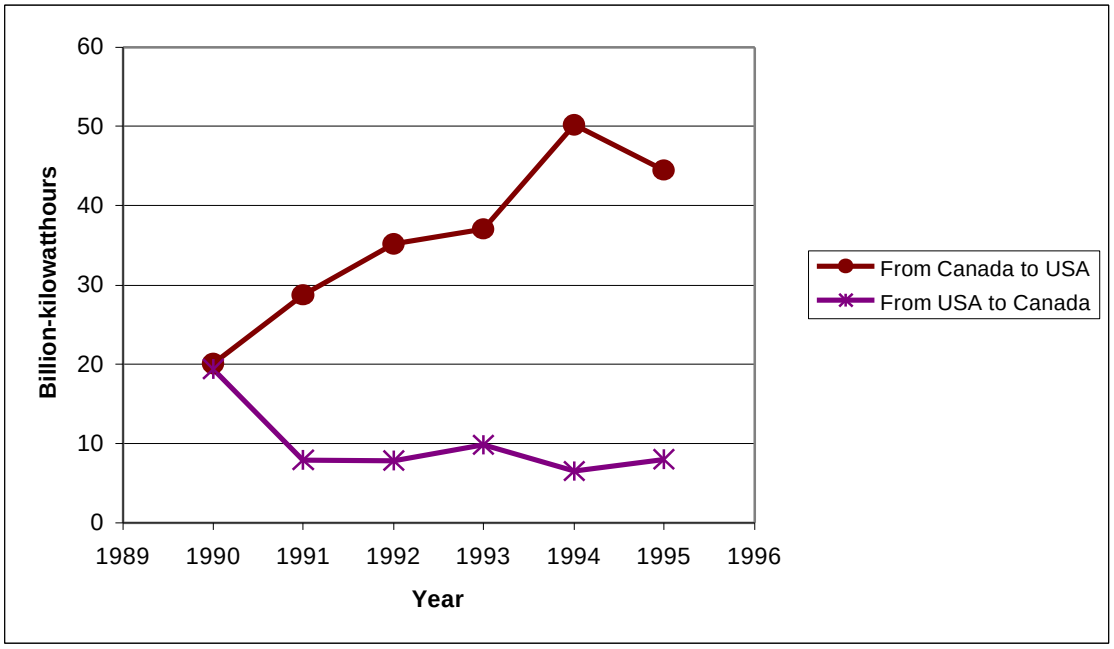

Figure 6: Electricity Trade between the USA and Canada

Primary Fuels

Combined, the provinces of Ontario and Quebec produce over half of all the electricity generated in Canada. The primary fuels used within these two provinces are, however, different. In Quebec hydroelectric power generation accounts for at least 97% of all of the electricity generated. Nuclear power provided about 64.7% of the 1994 electrical generation in Ontario[25].

Thermal. Generation of electricity from Canadian thermal plants accounted for about 20.5% of total electricity generation in 1994. The breakdown of thermal electrical power generation (from the total generation) is coal 16.0%, natural gas 2.8%, and oil 1.7%[26].

Hydroelectric and Renewable. The vast natural resource of water in Canada lends itself quite well to the generation of electricity. This is evident in the electric power generation trends of Canada, which produces about half of its electricity from the movement of water. The use of hydroelectric sources in Canada ensures that a stable supply of

[25] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review,* Organisation for Economic Co-operation and Development, Paris, France, p. 92.
[26] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review,* Organisation for Economic Co-operation and Development, Paris, France, p. 84.

electricity is available for the people in that nation. The EIA notes that in the province of Quebec nearly two-thirds of all homes rely on electricity for all their power needs[27]. The overwhelming majority of this power is from hydroelectric sources. It is interesting to note that 11 of the 12 provinces and territories in Canada produce at least some hydroelectric power. The exception is Prince Edward Island. In 1994, nearly 56% of the electricity generated in Canada was from hydroelectric plants.

The generation of hydro electricity is expected to continue to be the primary source of electric power in Canada. However, the outcome of two separate projects may attest to the trend in future hydro-generation plants. In 1994, the $10 billion (U.S.) Great Whale hydroelectric project was cancelled[28]. Nearing completion (1997), is the 100-megawatt Le Nordais, wind generation project on the Gaspe Peninsula[29]. This project has a long term sales contract with Hydro Quebec[30].

Besides the extensive hydroelectric production in Quebec, the province of Newfoundland/Labrador produces excess electricity from hydroelectric facilities. These plants are located in the Churchill Falls developments in central Labrador. The capacity of the Churchill Falls plants exceeds 5,428 Megawatts[31]. In 1995, Labrador exported 26.7 billion kilowatthours of electricity to Quebec.[32] This accounts for nearly 63% of the Canadian interprovincial transfer of electricity, Table II.

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[27] Energy Information Administration, *International Energy Outlook 1995*, at web site www.eia.doe.gov/oiaf95/hydro.html, November 4, 1997.
[28] U.S. Energy Information Administration, "Canada," *Country Analysis Brief*, October 1996, http://www.eia.doe.gov/emeu/cabs/canada.html, October 9, 1997.
[29] No further information on this project was available. In any event 100-megawatts is a small fraction of the entire Quebec electricity potential.
[30] Energy Information Administration, *International Energy Outlook 1997*, Publication DOE/EIA-0484(97), p. 87.
[31] "The Lower Churchill Dam and the Innu Nation," at web site: www.web.apc.org/~innu/dam.html, November 4, 1997. The root site of this article is operated by an organization with a distinct political agenda, "Global Communications for Environment, Human Rights, Development and Peace." The capacity listed does not seem unreasonable, however, because it would represent an ability to generate 47.55 gigawatthours per year. Based on the 1995 export figure, the capacity factor would be on the order of 56.2%.
[32] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 85.

Table II: Interprovincial Electricity Trade, Including Imports/Exports with United States (million kilowatthours)[33]

from \ to	USA	B.C.	Alta.	Sask.	Man.	Ont.	Que.	Nfld.	N.B.	PEI	N.S.	Export
USA	-	4,738	2	73	56	1,659	838	62	0	0	0	7,428
B.C.	3,484	-	487	0	0	0	0	0	0	0	0	3,971
Alta.	0	1,646	-	58	0	0	0	0	0	0	0	1,704
Sask.	155	0	239	-	1,107	0	0	0	0	0	0	1,501
Man.	9,033	0	0	1,226	-	600	0	0	0	0	0	10,859
Ont.	10,210	0	0	0	22	-	837	0	0	0	0	11,069
Que.	16,854	0	0	0	0	1,515	-	0	6,644	0	0	25,013
Nfld.	0	0	0	0	0	0	26,721	-	0	0	0	26,721
N.B.	3,585	0	0	0	0	0	0	0	-	815	528	4,928
PEI	0	0	0	0	0	0	0	0	0	-	0	0
N.S.	0	0	0	0	0	0	0	0	47	0	-	47
Import	43,321	6,384	728	1,357	1,185	3,774	28,396	62	6,691	815	528	93,241

Nuclear. The generation of nuclear electricity, as a proportion of the total, in Canada is about two-thirds of that in the United States. Ontario is the largest producer of nuclear power in Canada, with a capacity of some 13.4 giga-watts. The provincial utility, Ontario Hydro, does not expect to build any new nuclear power facilities in the foreseeable future[34].

The dominant role that Ontario Hydro plays in the generation of nuclear power plants in Canada is evident in suggestions, made in 1994, that this utility's nuclear arm be combined with Atomic Energy of Canada Limited (AECL). AECL's role is in nuclear research and reactor design and technical support. In addition to the combination of the nuclear element of Ontario Hydro and AECL, the suggestion included that the nuclear reactors operated by Hydro Quebec (1 unit) and New Brunswick Power (1 unit) be a part of the realignment[35].

[33] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review,* Organisation for Economic Co-operation and Development, Paris, France, p. 85.
[34] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review,* Organisation for Economic Co-operation and Development, Paris, France, p. 92.
[35] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review,* Organisation for Economic Co-operation and Development, Paris, France, p. 91.

A report, late in 1997, indicates that Ontario Hydro plans to take 5 of its nuclear plants off line for overhauls and upgrades[36]. The projected shut-down of the Bruce A and Pickering A stations will account for a loss of about 5.4 Giga-Watts (or 40% of Ontario Hydro's capacity). The remaining plants, Bruce B, Pickering B, and Darlington, account for the remaining 8.0 Giga-Watts electric capacity. Overall, these five facilities account for about 40 percent of the total capacity of Ontario Hydro. Curtailment of these facilities is likely to have significant effect on the overall distribution of electrical power within Canada, and subsequently with the U.S.–Canada electricity trade balance. The deficit of capacity in Ontario may be made up from excess capacity in the United States or in the Canadian Atlantic provinces.

Growth Policy

Early in the 1990s it appeared that the growth in electrical power generation capacity in Canada would be provided by the extension of the mega-hydroelectric projects in Quebec and Newfoundland. In general the tide appears to have turned against such large scale projects. This is evidenced by the action of Quebec Premier Parizeau in canceling the 3,200 megawatt Great Whale project of Quebec Hydro[37]. This cancellation appears to have been affected by a number of factors; concern and opposition over the true need for the project expressed by the people of Quebec, concern over the environmental impact to the native peoples of the region (primarily the Cree and Innu), and opposition generated by international environmental organizations such as the Sierra Club and others such as the Massachusetts Save James Bay Foundation. Similar concern and opposition has also affected the extension of the 5,284 megawatt Churchill Dam complex in Labrador.

Overall, the future of growth in electrical generation capacity lies at the provincial level, due to the nature of the Canadian industry. Currently, it appears that there is a concerted effort for the traditional Crown corporations to divide into private corporations. The nature

[36] Atomic Energy Control Board (Canada), "Shutdown of Ontario Hydro Reactors: The Regulatory Perspective," August 15, 1997, http://www.ulysses.srv.gc.ca/aecb/docs/announce/eng/hydro3_e.htm, December 4, 1997.

[37] The Multinational Monitor, "Behind the Lines: Great Whale on Ice," *Corporate Hall of Shame*, December 1994, http://essential.org/monitor/hyper/mm1294.html, February 1998. According to this article, power from the Great Whale project was "primarily for export to the U.S. markets." Hydro Quebec is quoted, in regards to the government's cancellation of this project, as stating that they will "exclude the Great Whale project from the strategic plan on which the corporation is currently conducting public consultations."

of this trend will probably have a significant impact on growth. The IEA reports that both Quebec Hydro and Hydro Ontario, the primary suppliers of electricity exported to the United States, are carrying substantial debt, owing to the mega-projects that have encumbered these utilities[38]. Major new entrances into the U.S. electrical distribution market appear to have been suspended until a free market electrical distribution system is in place in Canada. Future large scale electrical power generation facilities have likely been placed on hold until such a time as the present glut in capacity has been brought to a more reasonable level. In 1994, Canadian capacity exceeded 110 million kilowatts. Generation that year was 535 billion kilowatthours, representing a capacity factor[39] of only 55%. In the same year Canadian domestic consumption was 491 billion kilowatthours[40]. A capacity factor of 60% would provide the Canadian market with some 578 billion kilowatthours of generation.

Mexico

Many remote towns and villages in Mexico are not connected to the electrical distribution network; however, many of these locales are served by stand alone electrical power generation systems. The Mexican national electric utility estimates that nearly $22.1 billion must be invested through the year 2004 to increase the 1996 capacity by 9 million kilowatts (1994 capacity was 35 million kilowatts). Electrification of rural areas of Mexico is a high priority of that nation's government. This is one of the bases of attracting foreign capital investment into Mexico, to generate electricity in competition with the Mexican national utility[41].

Primary Fuels

The nation of Mexico has extensive hydrocarbon resources, including both oil and natural gas. Independent studies of reserves in the Bay of Campeche have reduced the total proven oil reserves to less than 49.8 billion barrels.

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[38] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 82.

[39] Capacity factor represents the actual gross generation as a fraction of the total available generation at rated capacity. In the same year, the U.S. capacity factor was approximately 47.3% of net summer capability [U.S. Census Bureau, *1996 Statistical Abstract of the United States*, Washington, D.C., p. 592.]

[40] Derived from net generation minus net exports; actual sales would be expected to be 7 to 10% lower than figure to account for utility use as well as transmission and other losses.

[41] Energy Information Administration, *International Energy Outlook 1997*, U.S. Department of Energy, Publication EIA/DOE-0484(97), p. 102.

Thermal. Electricity generation in Mexico from the combustion of fuels accounts for nearly 70 percent of the total. The primary fossil fuel used is fuel oil. The current energy policy in Mexico is seeking to convert a major portion of the thermal plants owned by the Comission Federal de Electricidad (CFE) to natural gas by the year 2005. Coal represents a very small portion of the total energy balance in Mexico, about 4 percent of the total.

Hydroelectric and Renewables. Generation of electricity from hydroelectric and renewable sources accounts for about 6 percent of Mexico's total. About two-thirds of this (4% of the total) is from hydroelectric plants, the remainder is from geothermal and other sources. Mexico operates a single wind-powered generation station.

Nuclear. The single nuclear power plant in Mexico accounts for about 4% of the total electrical generation.

Growth Policy

Mexico is a nation with a fairly high level of fossil fuel resources, primarily petroleum and natural gas. The policy exhibited towards increasing their domestic generation capacity appears to be directed to the utilization of those resources.

While Mexico, no doubt, has some degree of environmental awareness and an environmental movement, it is still a developing nation. This creates a condition wherein the general concern is economic development.

ENERGY BALANCE

The three primary nations in North America exchange numerous products across their mutual borders. Included with these, is energy; that is coal, petroleum, natural gas, uranium, and electricity, to cite the most obvious.

United States and Canada

While there is transportation of electric power in both directions across the United States–Canada border, the U.S. is the net importer. The ability to transfer power between the U.S. and Canada is illustrated by the IEA. They note that there are "36 major interprovincial connection points with a total transfer capacity of 10.1 gigawatts. Whereas, they note, between Canada and the U.S. there are over 100 interconnections. Of these, 37 are rated for service in excess of 69 kV[42], total transfer capacity exceeds 18.9 gigawatts.[43]

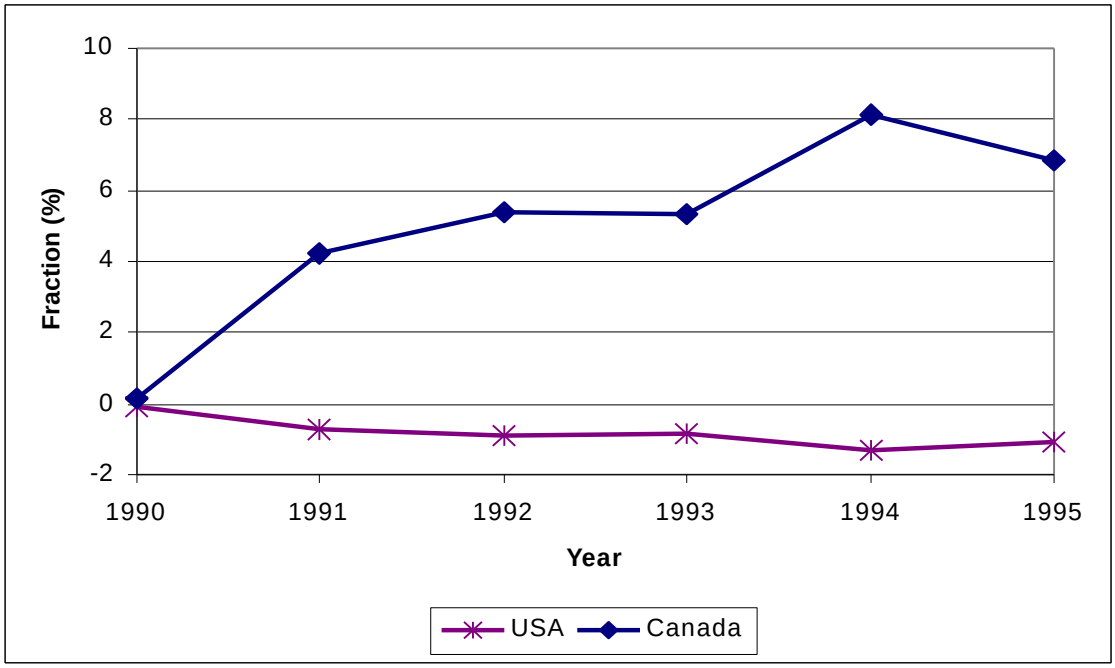

Figure 7: Electricity Export as a Fraction of Domestic Consumption in USA and Canada

[42] The intended duty of electric power distribution systems can be assessed based on the voltage rating of the lines. Main transmission lines general exceed 115 kV (kilovolts), sub-transmission is carried on systems rated between 69 and 138 kV. Retail distribution supplying electricity to consumers are usually less than 69 kV. See: Fuldner, A. H., "Upgrading Transmission Capacity for Wholesale Electric Power Trade," Energy Information Administration, Feature Article, April 9, 1997, www.eia.doe.gov/cneaf/pubs_html/feat_trans_capacity/w_sale.html, October 9, 1997.

Labrador and Quebec have electrical power transmission lines in excess of 600 kV connecting Labrador's Churchill Falls and Quebec's James Bay hydroelectric projects to customers in Montreal and in the northeastern United States.[44] The import/export trend, over the last several years is illustrated in figure 7. Based upon this trend, it is likely that the United States will continue to obtain electric power generated in Canada for the foreseeable future.

The gross electricity trade balance between the United States and Canada is largely in favor of the northern nation. Several parameters allow the meaning of the apparent deficit to be assessed. The proportion of electricity imported/exported based on the total generation in each nation is show in figure 7. As this figure illustrates, the U.S. imports a quantity of electricity from Canada, equal to just over 1% of the entire domestic production. On the other hand, nearly 7% (1995) of Canadian electricity production was exported to the United States. Based on the 1995 figures, the transmission capacity between the United States and Canada would be about 5% of the U.S. consumption.[45]

Since electricity is delivered to the consumer in the same form, regardless of the source of its generation, it is of little real consequence to the consumer as to the nature of the generation. The nature of generation is important, however, when the ability to exploit available resources is considered. At this time, Canada continues to hold vast resources of untapped hydroelectric capacity. Under the proper conditions, these resources could be used to generate power to meet the needs of the Canadian populace, as well as for export to the United States.

United States and Mexico

As with Canada, the United States and Mexico exchange electric power in both directions, yet here again, the U.S. is the net importer. The trend, over the last several years is shown in figure 8.

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[43] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 85.
[44] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 84.
[45] This factor is based on 100 percent capacity of the inter-connecting transmission lines operating from Canada to the United States. In 1995, the use of capacity towards the U.S. was about 26.3%, and towards Canada about 4.5% of the overall transfer capacity.

As a nation, Mexico appears to be undergoing growth in its economy. With this growth, it is expected that the need for electric power will also grow. The state of the electric energy trade with the United States will depend on the ability of Mexico to maintain generation capacity at the level of power requirements. In any foreseeable event, there is no projected change in the magnitude of the future trade of electricity between Mexico and the United States. The amount of electric power imported from Mexico is a very small to insignificant fraction of the total generation and consumption in the U.S., such that no threat to the U.S. energy market is perceivable from this source.

Northeastern United States

Much of the electricity generated from hydroelectric sources in Quebec, that is imported into the United States, is sold to states in the northeast, principally, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and New York. To a small degree, Pennsylvania can be considered on this list. The primary fuel distribution for electricity generation in these states is shown in Table III. As is further illustrated in Table III, these seven (or eight) states are net importers of electric power. That is, they do not meet their electric power requirements from in-region sources. Only Pennsylvania and New Hampshire produce more electricity than they consume.

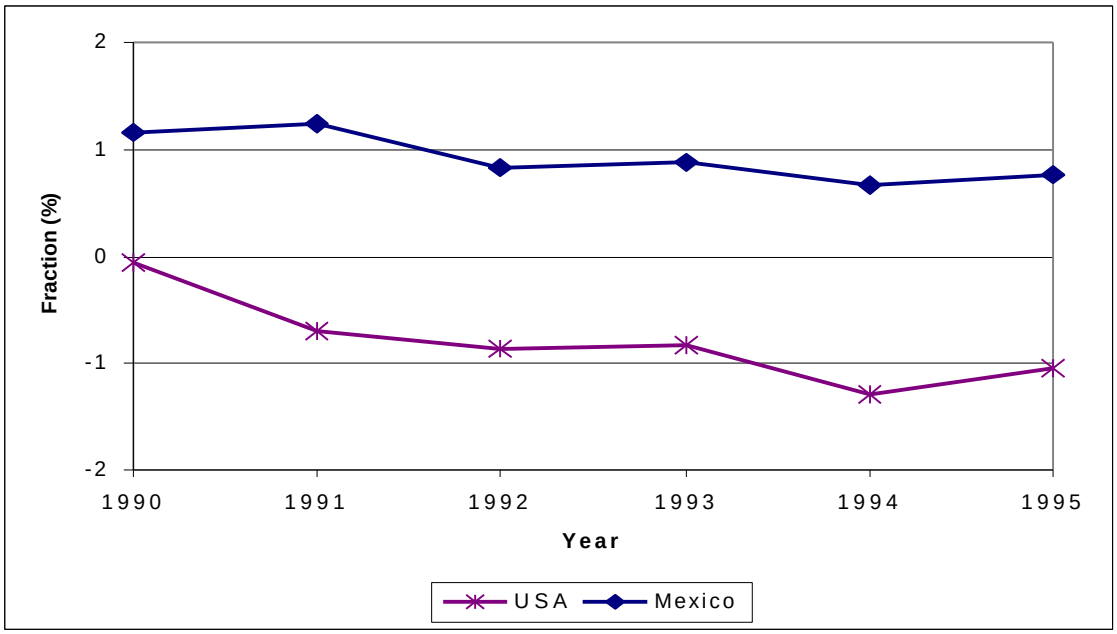

Figure 8: Electricity Export as a Fraction of Domestic Consumption in USA and Mexico

Table III: Electricity Generation and Sales in the Northeastern United States, 1995[46]

State	Coal	Petro.	Gas	Nuclear	Hydro.	Renew.	**Total**	Sales	Net
	(Million kilowatthours)								
Connecticut	2,269	3,397	1,820	18,749	293	404	**26,932**	27,850	-918
Maine	-	812	-	198	1,658	-	**2,668**	11,386	-8,718
Massachusetts	10,587	5,869	6,206	4,486	-156	-	**26,992**	46,750	-19,758
New Hampshire	3,367	1,004	201	8,379	984	-	**13,935**	8,914	5,021
Rhode Island	-	50	603	-	-	-	**653**	6,547	-5,894
Vermont	-	13	7	3,859	834	127	**4,840**	5,109	-269
New York	19,943	7,835	23,414	26,336	23,620	12	**101,160**	129,995	-28,835
Pennsylvania	96,800	3,072	2,165	66,462	444	-	**168,943**	125,605	43,338
Total	**132,966**	**22,052**	**34,416**	**128,469**	**27,677**	**543**	**346,123**	362,156	-16,033
Percent of Total	38.4	6.4	9.9	37.1	8.0	0.2	100.0		

It is into these states that the transfer of electricity generated by Quebec hydroelectric projects, versus coal fired plants in the United States, should primarily be considered. This hypothesis is supported by several observations:

> In 1994, New York State was the largest single importer of electricity from Canada, followed by the New England states. New York consumed 29% [approximately 12.7 billion kilowatthours] of these imports and New England 26% [approximately 11.4 billion kilowatthours].[47]
>
> In March of 1994, the New York Power Authority canceled a $5 billion contract that it held with Hydro-Quebec, under which it was to receive energy from the James Bay complex over a twenty year period beginning in 1995[48].
>
> Electricity consumption in Massachusetts, in 1995[49], from Canadian sources, accounted for over $70 million (U.S.). (Approximated at 2.45 billion kilowatthours, or about 5.4% of that state's total[50].)

[46] Energy Information Administration, *Electric Power Annual, 1996*, Volume I, Department of Energy, Publication DOE/EIA-0348(96)/1, pp. 19-21, 38.

[47] International Energy Agency, *Energy Policies of IEA Countries, Canada 1996 Review*, Organisation for Economic Co-operation and Development, Paris, France, p. 85.

[48] "James Bay Project," http://arachnid.colgate.edu/jeffo/dams/jamesbay.html, October 17, 1997. This information is supported by several other sources, including the Energy Information Administration country profile on Canada.

[49] This year is presumed, the source (Massachusetts Save James Bay Foundation) does not carry a year in the citation. The referenced article appears to mid to late April 1996. If this is the case, then the most recent year for which reliable compiled data would be generally available is 1994. The actual calendar year is not really significant, on the assumption that the technical details are reasonably accurate to give an overall picture.

[50] Massachusetts Save James Bay Foundation, web site: http://web.maxwell.syr.edu/nativeworldgeography/northam/canada/jamesbay.html. The conclusion

Role of the Commonwealth of Virginia

Virginia produces energy in several forms. These include primary sources: coal, petroleum, natural gas, and stored water, and the secondary source, electrical power. The generation of electricity comes from coal, petroleum, and natural gas fired plants, nuclear reactors, and both conventional and pumped storage hydroelectric facilities. Despite the natural resource wealth of Virginia, the Commonwealth is a net importer of energy. The only key energy resource that is exported from Virginia is coal. This coal is exported for both steam and metallurgical purposes, on both the domestic and foreign markets. This section briefly looks at the state of the energy industry within the Commonwealth of Virginia; dealing primarily with the extracted energy sources.

Coal Production

Coal production from Virginia appears to have peaked in 1990, with a total production that year of some 46.5 million tons. In subsequent years, production fell to 35.9 million tons in 1995. A slight increase in production is noted in 1996, at 36.8 million tons. Projections are that 1997 production will show a slight increase over 1996 levels. While it is still too early for a comprehensive analysis, the increase in production in 1996 and 1997 appears to be related to the Virginia Coalfield Employment Enhancement Tax Credit Legislation. This behavior was predicted in a 1996 report prepared by the Virginia Center for Coal and Energy Research[51].

The coal that is mined in Virginia predominately serves two markets[52]: steam coal and metallurgical coal. Figures for 1995 indicate that U.S. market distribution was about 14.5 million tons to the steam market, 6.5 million tons to the metallurgical market, and 3.5 million tons to "other" markets. Since 1989, the quantity of coal shipped to the steam markets in

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reached in this source (assuming 1995), i.e. cost, power, and proportion, is generally supported by the EIA. Based on the DOE figures for Massachusetts (1995) the total electrical sales were 47.3 billion kilowatt-hours, of which the 2.45 billion kilowatt-hours reported in this source represents 5.2 percent. The $70 million dollar figure would represent a fee paid to the supplier of less than 3 cents per kilowatt-hour, and therefore may be somewhat underestimated.

[51] Zipper, C. E. and S. M. Kambhampaty, "Effects of Virginia Employment Enhancement Tax Credit Legislation," Virginia Center for Coal and Energy Research, Report Number 96-01, 55 pp. In this report, the authors note that the predicted increase in coal production associated with the tax credit is temporary. Ultimately, coal production in Virginia must decline as readily accessible reserves become depleted. The net effect of the tax credit legislation is to delay the onset of the decline in total production, not to stop it completely.

the northeastern United States has been falling. In 1995, steam coal deliveries to the northeast were about 1 million tons, less than 3% of the total coal mined in Virginia that year, and about 7% of the coal delivered to the electric generator market. In the same year, slightly less than 10 million tons were exported overseas and to Canada, of which about 90% was metallurgical coal.

On the market, coal mined in Virginia receives a higher price than average in the U.S. This is affected by two factors: the higher fees paid for metallurgical coal with respect to steam coal, and the slightly higher fees paid for low sulfur coal on the steam market. The average price of coal in the U.S. has been falling steadily in constant dollars, although the current year, or nominal, price for coal has remained fairly constant.

Natural Gas and Petroleum Production

Both natural gas and crude oil are produced from wells in Virginia. Based on the annual gas and oil reports from the Division of Gas and Oil, crude oil production is limited to two counties, Lee and Wise, with total production of around 13.4 thousand barrels[53]. Overall, crude oil production is statistically insignificant to the energy balance of Virginia.

Natural gas production is derived from two sources, conventional wells[54] and coalbed methane[55]. The production of natural gas from conventional wells occurs in seven Virginia counties (Buchanan, Dickenson, Lee, Russell, Scott, Tazewell, and Wise). Over the past eight years (1989 – 1996) conventional gas production has varied between 13.8 (1991) and 21.9 (1994) billion cubic feet.

Virginia production of natural gas from coalbed sources began in the late 1980s. In 1991 this gas source accounted for 7.4% of production; in 1992 it was 24.3%; and in 1993 it was

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[52] Other markets for coal include: industrial, residential, and commercial uses, which include petrochemical production and heat generation.

[53] Division of Gas and Oil, Commonwealth of Virginia, Department of Mines, Minerals and Energy, 1996 Gas and Oil Report, June 1997. Previous years production; (1995: 12.6 thousand barrels (Mbbl); 1994: 16.7; 1993: 12.1; 1992: 12.9; 1991: 12.1).

[54] Conventional natural gas wells are those drilled into what are considered traditional gas reservoirs, such as sandstone and shale, and may or may not be associated with the production of liquid petroleum. In these types of wells, the gas is generally in a compressed gas state.

[55] Coalbed methane wells extract natural gas directly from the coal seams and/or their surrounding strata. This type of production can be associated with "de-gassing" coal prior to extraction, or with coal seams which for one reason or another are not conducive to being mined. Methane is held in to coal seams in an adsorbed state. That is, rather than existing as a compressed gas in the formation, it is physically held to the coal surfaces by molecular attraction.

56.4%. This gas is produced from four counties (Buchanan, Dickenson, Russell, and Wise). In 1996 coalbed methane production was 34.2 billion cubic feet, or 62.9% of Virginia sourced natural gas.

Electricity Production

The Commonwealth of Virginia has the capacity to generate some 14,733 megawatts from 189 electric utility generators[56]. The total electric power generated in 1996 was nearly 56.5 billion kilowatthours[57], whereas the total electric sales, in the same year, was 87.5 billion kilowatthours[58]. This indicates that Virginia imported some 31.0 billion kilowatthours, not including losses.

Virginia's generation, in 1995, was separated into following proportions: coal 46.4%, nuclear 47.7%, petroleum 2.1%, natural gas 3.6%, and hydroelectric/other 0.3%.

[56] Energy Information Administration, *Electric Power Annual 1996*, Volume I, U.S. Department of Energy, publication DOE/EIA-0348(96)/1, p. 13.
[57] Energy Information Administration, *Electric Power Annual 1996*, Volume I, U.S. Department of Energy, publication DOE/EIA-0348(96)/1, p. 19.
[58] Energy Information Administration, *Electric Power Annual 1996*, Volume I, U.S. Department of Energy, publication DOE/EIA-0348(96)/1, p. 38.

CONCLUSIONS

Overall, the effect of steam coal mined in Virginia and consumed for the electric power market of the northeastern United States represents a small fraction of the total electric energy in that market. The future of electric trade in this region will be affected by the North American Free Trade Agreement (NAFTA) and the current electric power trade situation in the Northeast and New England regions. Furthermore, given the current declining phase of the Virginia coal mining industry, particularly related to steam coal, it appears unlikely that any significant gains in total production or sales could be made for the coal producers in the Commonwealth.

Impact of NAFTA

The EIA notes that the trade in electricity between Canada, the United States, and Mexico represents only a small fraction of the overall trade of energy in North America. Furthermore, the electricity trade has, historically, been open between the nations. The primary effects appear to be in the areas of "pricing of international transactions," and slightly improving access to markets in California for the electric utilities of western Canada[59].

Impact on the Northeastern USA

It appears that, given a free and open market for electrical power transmission within and between the United States and Canada, the northeastern states will become increasingly dependent on electricitdy generated in Quebec. The magnitude of this dependency will be determined by the ability of the Canadian generators to provide electrical power and service at a competitive price.

The environmental savvy of customers in the northeastern states may also have a role in the growth of electrical power generated in Canada and consumed in the United States. The future will show whether the consumers in the northeast will chose the environmental impacts associated with flooding large tracts of land in Canada, the impacts associated with coal and petroleum production and combustion, or the impacts of the nuclear fuel cycle.

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[59] Energy Information Administration, *International Energy Outlook 1995*, July 6, 1995, http://www.eia.doe.gov/oiaf/ieo95/elect.html, November 4, 1997.

Value of Trade

In the end, the impact of the energy trade between the Canadian provinces of Ontario and Quebec, and the northeastern United States, and the role of coal mined in the Commonwealth of Virginia can be assessed in the dollar value of the products. As a point of reference, the total cost of generation and the revenue of sales of electric power in the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont will be considered. These costs and sales will be compared to the estimated value of the cost of power imported from Canada and the price of coal paid by power plants in those states.

In 1994, about one million tons of coal mined in Virginia were delivered to the northeastern U.S. electrical generation market. These northeastern states consumed 14.3 million tons of coal at their electrical utilities. For this coal the average delivered cost was $39.55 per ton (1994 constant dollars)[60]. Thus, the total price paid for coal in this market was about $567.1 million. The power generated from coal was 36.35 billion kilowatthours, which corresponds to a fuel cost of about $0.0156 per kilowatthour. (U.S. average fuel cost, at electrical utilities, for fossil fuel steam plants was $0.01667 per kilowatthour, with a total plant cost of $0.0218 per kilowatthour[61].)

If one assumes that all of the coal shipped from Virginia to the northeastern states was consumed in the seven under consideration, then slightly more than 2.5 billion kilowatthours were generated from Virginia coal[62]. Recalling that between New England and New York, 24.1 billion kilowatthours were imported from Canada, it can be estimated that the energy imports from Virginia to the northeast were about 10% of the imports from Canada.

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[60] Energy Information Administration, *Electric Power Annual 1996*, Volume I, U.S. Department of Energy, publication DOE/EIA-0348(96)/1, pp. 32, 33. Average is based on 5,945 million tons delivered to New England states at an average of $43.34 per ton and 8,395 million tons delivered to New York state at average $36.86 per ton.

[61] Energy Information Administration, *Electric Power Annual 1995*, Volume II, U.S. Department of Energy, publication DOE/EIA-0348(95)/2, p. 35. Note: Fossil steam includes coal, petroleum, and natural gas fired boilers. It does not include gas turbine generators.

[62] Based on the following assumptions, 1 million tons of Virginia coal consumed in the northeastern electricity generation market, 14.3 million tons coal total consumed in that market, 36.35 billion kilowatthours generated. Thus (36.35 / 14.3) = 2.54 billion kilowatthours per million tons coal. There are obvious limitations to this assumptions: (a) that most of the Virginia coal shipped to the northeastern market goes to New Jersey for combustion in generators there and the electricity is then shipped to the consumer; (b) that the Virginia coal burned in New Jersey has about a 7% higher BTU/lb. heat content than the coal from other sources, Kentucky and West Virginia. Energy Information Administration, *Cost and Quality 1994*, Publication DOE/EIA-0191(94)

At best, the import of coal from Virginia to the northeastern states' electrical power generators fulfills 7% of their coal consumption, and is used to produce no more than 1.4% of that region's total electrical generation. Comparing generation to sales, the 2.5 billion kilowatthours attributable to Virginia coal represents a mere 1% of the electrical sales in the seven states under consideration. Given the current distribution, it is doubtful that more coal from Virginia could be supplied to the northeastern market. Two factors affect this observation. First, based on estimates published by the DOE/EIA, current recoverable reserves of 188,344,000 tons (1996) are only 5.3 times the production level of 35,590,000 tons for that year[63]. The second factor is that Virginia coal mines operated at a fairly high utilization of capacity, compared to both the neighboring states, as well as against the national average. Table IV shows that, in the last four years, compared to the nearby major coal producing states, Virginia has had the highest utilization of capacity in 1993 and 1996. In 1994 and 1995 Virginia was less than one-half of one percent behind West Virginia, which had the highest value.

Table IV: Utilization of Coal Production Capacity in Virginia, Nearby States and the United States Overall (%)[64]

	YEAR			
State	1996	1995	1994	1993
Virginia	**85.34**	79.07	79.62	**77.07**
Kentucky	80.38	75.49	75.54	76.11
Ohio	75.88	76.55	67.87	67.94
Pennsylvania	82.53	78.81	75.89	71.79
West Virginia	78.32	**79.50**	**80.07**	67.91
United States	*80.21*	*79.40*	*78.11*	*74.77*

Future of Coal Mining in Virginia

Despite the fairly low recoverable reserves figure in Virginia, presented by the DOE as 188.3 million tons (1996)[65], there appears the possibility for a continued coal mining presence in the economy of the Commonwealth. Based upon various estimates, there may

[63] Energy Information Administration, *Coal Industry Annual 1996*, Publication DOE/EIA-0584(96), p. 208.
[64] Energy Information Administration, *Coal Industry Annual 1996*, Publication DOE/EIA-0584(96), pp. 200 ff.
[65] Energy Information Administration, *Coal Industry Annual 1996*, Publication DOE/EIA-0584(96), p. 208.

yet be some 5 billion tons of coal not currently classified as recoverable, but not beyond the scope of emergent technologies. This coal is in seams less than 28 inches thick. The high cost of mining seams of this nature will, in all likelihood, render it un-competitive against very low cost coal from the western states. However, the metallurgical qualities of coal from Virginia are well known on both the domestic and foreign markets. A concerted effort made by the Virginia coal owners, mining companies, transporters, equipment manufacturers, and the legislature, acting on behalf of the people of the Commonwealth, could go a long way to ensuring that this important portion of our heritage continues amidst changing demand and market environments.