Canada – U.S. Electricity Trade and GHG Emissions Policies: The Situation in the North East

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Summary

Canada has ratified the Kyoto Protocol while the United States, its main trading partner, has not. A major concern of Canadian industrial producers is the negative impact on competitiveness of programs designed to reduce greenhouse gas emissions (GHG). To alleviate this concern, the Government of Canada is proposing an approach that puts a ceiling on the price of emission permits paid by industrial users and that allocate emission permits on the base of output. We analyze how such a scheme would affect electricity production and trade among three Canadian provinces (Ontario, Québec and New Brunswick) and two U.S. regions (New England and New York), which are linked by large interconnections and which exchange electricity on other wholesale markets. We find that the Canadian government approach has almost no effect on electricity production and trade flows; so it is very effective at protecting the competitive position of electricity producers. However, it does little to reduce GHG emissions.

Introduction

After a protracted consultation process which lasted more than four years and which revealed conflicting regional and industry positions, Canada finally ratified the Kyoto Protocol in December 2002. Now Canada is committed to a 6% reduction of its greenhouse gas (GHG) emissions below the 1990 level over the first commitment period, from 2008 to 2012. According to Government of Canada estimates, this means that CO_2 eq. emissions[1] will have to decrease by 240 Mt or by 30% relative to the business-as-usual (BAU) scenario over the test period. In order to make explicit its intention to reduce GHG emissions, the Government of Canada published a plan that sets the guiding principles, the policy instruments and the specific targets by sector.[2] It claims that the measures that have already been launched will cause CO_2 eq. emissions to fall by 80 Mt.[3] The plan released in November 2002 presents policy actions and programs to lower further CO_2 eq. emissions by 100 Mt.[4] 55 Mt of this reduction are supposed to be realized by the large industrial emitters which are oil and natural gas production, electricity generation from fossil fuels (oil products, natural gas and coal) and a small group of heterogeneous industries,[5] According to BAU emission projection, the power generators share is about 20 Mt.

A major concern expressed by the Canadian industrial producers is the negative impact of such a policy on their competitive position in international markets. A cause of this concern comes from the fact that the Bush administration has decided not to ratify the Kyoto Protocol and that more than 80% of the international trade of Canada takes place with the United States. To address this concern, the Canadian plan contains measures to alleviate the burden that industries would bear. Two measures are of particular significance: first, no measure that costs more than \$15/tonne of CO_2 eq. should be undertaken by industries[6]. This sets a ceiling on the price of emission permits to be paid by the Canadian industrial users. Second, Canadian industries are not going to be asked to make CO_2 eq. emissions reduction that exceeds 15% of their emissions associated with the BAU scenario in 2010[7]. This means that the Canadian industries will receive free of charge 85% of the permits associated with their specific emission target.

The fact that the Bush administration has decided not to sign the Kyoto Protocol and that there is no plan in the United States as in signatory countries, does not mean that there will be no government program that makes a contribution to the objective of the Protocol. For instance, the New England states governors are committed to stabilize GHG emissions to their 1990 level in 2010 and to reduce them by 10% in 2020; New York State is considering the development of a regional GHG emission permit market for electricity producers that will encompass also the New England states and the PJM area.[8] Furthermore, it is possible that some standards will be set for electricity production from renewable sources. At this stage it is unclear what will be the end results of these policy initiatives; however, the time lag required to change the mix of electricity generation equipments leads to believe that their real effects around 2010 are likely to be minor.

The U.S. wholesale electricity market has been open to competition since January 1997 through FERC Order 888 which allows producers, local distribution utilities or any FERC licenced marketers to exchange electricity at market prices. Canadian electric utilities satisfied the reciprocity conditions imposed by FERC upon foreign applicants and obtained their FERC licences to participate in this new open wholesale market. Now there are wholesale electricity markets operating in New York and New England.[9] There were already significant electricity exchanges between the United States and Canada before 1997, mostly through long-term contracts; the structural change has tilted the balance in favour of instantaneous direct competition. In 2002, Canada exported 34.1 terawatt-hours (TWh) and the share of interruptible sales was 77.0%; it imported 20.8TWh and the share of interruptible sales is close to 100%. In value terms, exports were worth \$1837 million and imports \$1370 million[1.0] The provinces of Ontario, Québec and New Brunswick (N.B.) accounted for 59.0% of the exports and 96.0% of the imports.[10] The bulk of the exchanges of these three provinces is with New York and New England.

The purpose of this paper is to analyze the effects of the implementation of the Kyoto Protocol by Canada on the electricity production and exchanges between the three aforementioned provinces and their southern neighbors in

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[1] See footntoes at end of text.

the United States, i.e., New York and New England. Because of the time lag required to bring in service, new generating equipments, existing power plants are going to be a major factor in the implementation of the Kyoto Protocol at least toward the first commitment period, i.e., around 2010. Our aim is to analyze how interfuel substitution and trade could foster or impair the realization of the objective of the Kyoto Protocol, what are the effects on the output of Canadian electricity producers and what are the likely costs of implementing the Protocol.

The order of the presentation is as follows: in the first section, we describe the underlying analytical framework and we single out key features of the data that enter into the cost minimization problem which is assumed to represent the operations of the open wholesale electricity market. In the second section, we present and discuss the results. Toward this end, we build two scenarios: in the first scenario, which is considered to be our base case, we have free trade and no regulation on GHG emissions. The second scenario embodies the main features of the output base allocation of emission permits as currently proposed by the federal government, i.e., the $15/tonne price ceiling on emission permits and the 85% share born by the government.

Here is our finding: the Canadian government approach, which imposes a price ceiling on emission permits and which allocates emission permits on the base of production, has almost no effect on production and trade flows; it has also no effect on GHG emissions.

The Analytical Framework and Electricity Market Information

In order to study the effects of limiting CO_2 eq. emissions on electricity production and exchanges between the five regions, we use the 1998 data on load, available generating capacities, average fuel costs by type of generating equipment and interconnection capacities between the five regions. The year is divided into four uneven periods: Winter peak (300 hours), Spring (3930 hours), Summer peak (600 hours), and Fall (3930 hours). The stepwise representation of the load curve allows us to capture the specific role played by hydro power plants; although the latter can accommodate a fairly flexible production schedule, they are limited not only by their generating capacities like any other generating plants, but also by the amount of electricity that can be produced from the available water.

Under the two scenarios which are called respectively free trade and output base allocation of permits in Canada, we assume that all the available resources in the five regions are used to minimize the total fuel cost of serving the given seasonal load in each region, while taking into account the constraints related to generating capacities, interconnection capacities, available hydroelectricity and policies related to CO_2 eq. emission reduction. The results of the cost minimization problem of serving the given load yield the optimal use of the generating capacities in each region and the trade flows during the four periods of the year.

We now present a brief description of the data that enters into this cost minimization problem. Table 1 shows our stepwise representation of the load curve in MW within each of the five regions. Canadian regions have Winter peak demand due to electrical space heating while New York and New England have Summer peak load due to air conditioning. Altogether, the five regions have a Winter peak load.

Table 1
1998 Demand (MW)

Period	Québec[1]	Ontario	New Brunswick	New England	New York	Total
Winter (300 h)	34295	22330	3333	19800	24150	103908
Spring (3930 h)	20461	16087	1668	12428	16132	66776
Summer (600 h)	20461	21387	1668	22100	28960	94576
Fall (3930 h)	20461	16087	1668	12428	16132	66776

Estimated by the authors from North American Reliability Council (1998, 1999).

1 For Québec, we use the 1999 data due to the 1998 ice storm. 2300 MW of generation for own use by private companies are added to arrive at Québec total demand.

The upper part of Table 2 displays the available generating capacities by region. Hydro generating capacity represents 41.7% of the total; this is due mostly to Québec where hydro power plants form 94.1% of its total capacity. Most of its hydro power stations are backed by reservoirs which are filled by spring runoff and which provide water for the rest of the year until the next cycle starts. In terms of relative importance, hydro generating capacity is followed by oil (24.0%), nuclear (14.5%), coal (11.1%), natural gas (6.4%) and other (2.2%).[12] We assume other generating capacities to be must-run units and their utilization rates are based on recent experiences. The last line of Table 2 shows the total electricity (TWh) that can be produced by the hydro power stations.[13] The 262.3TWh of hydroelectricity represent 42.6% of the overall electricity demand (616.03TWh) of the five regions in 1998.

Table 2
1998 Available Generating Capacity (MW) and Hydroelectricity (TWh)

Type	Québec	Ontario	New Brunswick	New England	New York	Total
Hydro	37 996[1]	8 034	919	3 599	5 470	56 018
Nuclear	675	8 728[2]	680	4 365	4 981	19 429
Coal	--	7 797	570	3 311	3 262	14 940
Oil1	1596	2 302[3]	1 884	11 930	14 600	32 312
Natural Gas	37	1 803	--	1 858	4 959	8 657
Other[4]	90	334	511	1 599	469	3 003
Total	40 394	28 998	4 564	26 662	33 741	134 359
Hydroelectricity[5]	190.140[6]	39.818	3.000	4.380	24.930	262.268

Source (Québec, Ontario and New Brunswick) : Statistics Canada (1998a) and Statistics Canada (1994, 1995, 1996). (New England and New York) : U.S. Energy Information Administration (1994, 1995, 1996, 1998).

1 Due to a long term contract, 5 428 MW from Churchill Falls in Labrador are included in Québec capacity.

2 Total nuclear generating capacity is 13 864 MW. Bruce A (2 060 MW) and Pickering A (3 076 MW) nuclear power plants have been taken out of service. See Ontario Power Generation (2002).

3 Oil or natural gas can be used as fuel.

4 Geothermal, solar, wind and biomass.

5 Average hydroelectricity production (TWh) in 1994, 1995 and 1996.

6 26.649 TWh from Churchill Falls in Labrador are included.

Table 3 shows the average fuel costs associated with the generating capacities of each region. Here is the overall increasing order of costs by generation type: hydro, nuclear, coal, oil and natural gas. However, there are some exceptions: natural gas average costs are less than oil average costs in Québec and Ontario. Furthermore, oil in New Brunswick (1884MW) has a lower average cost than coal in New England (3311MW). The increasing order of the average fuel costs is the main factor behind cost minimization.

Table 3
1998 Average Fuel Costs (¢/kWh)

Type	Québec	Ontario	New Brunswick	New England	New York
Hydro	0.00	0.00	0.00	0.00	0.00
Nuclear	0.18	0.23	0.18	0.18[1]	0.18[1]
Coal	--	2.07	2.35	2.68	2.20
Oil	3.86	3.22	2.37	3.15	3.02
Natural Gas	1.86	3.09	--	4.23	3.93

Source (Québec, Ontario and New Brunswick) : Statistics Canada (1998b).
(New England and New York): U.S. Energy Information Administration (1998).
[1] No data are available. We use the Canadian information.

Interconnection capacities (MW) between the contiguous regions appear in Table 4. Figure 1 shows the geographical layout of the high voltage interconnections which link the power grids of the five regions. Québec occupies a pivotal position and it has fairly large interconnections with all its neighbors. In general, the north-south interconnections of the Canadian regions to the U.S. power grids are larger than the east-west interconnections between the Canadian provinces. This is expected due to the seasonal complementarity of the power grids along the north-south axis. The size of the interconnections between the five regions can be considered to be large when they are compared to what exists elsewhere in Canada and in the U.S. Nonetheless, if we set aside New Brunswick which has much smaller generating capacities than the other four regions, we see that the size of the interconnections is relatively small when interconnection capacities are compared to peak demand in each region. This limits the role that competition from outside sources can play in each region and the extent that marginal costs can be equalized in the new deregulated wholesale market.

Table 4
2000 Interconnection capacity (MW)

From/To	Québec	Ontario	New Brunswick	New England	New York	Total
Québec	--	1 195	1 200	2 303	2 695	7 393
Ontario	550	--	--	--	2 325	2 875
New Brunswick	785	--	--	815	--	1 600
New England	1 670	--	815	--	1 600	4 085
New York	1 000	1 300	--	1 425	--	3 725
Total	4 005	2 495	2 015	4 543	6 620	19 678

Source (Québec, Ontario and New Brunswick): Canadian electricity association and natural resources Canada (1999).
(New England and New York): New York Independent System Operator (2000).

In order to keep the problem at a manageable scale without limiting unduly the validity of the analysis, we take as given the exchanges with power grids other than the five regions included in our study and they are set at their pre-1997 level. Ontario is a net exporter to Michigan and Minnesota, New Brunswick to Nova Scotia and Prince Edward Island, and New York is a net importer from PJM. The trade of flows with power grids outside the five regions are much smaller than the trade flows within the five regions.[14] .

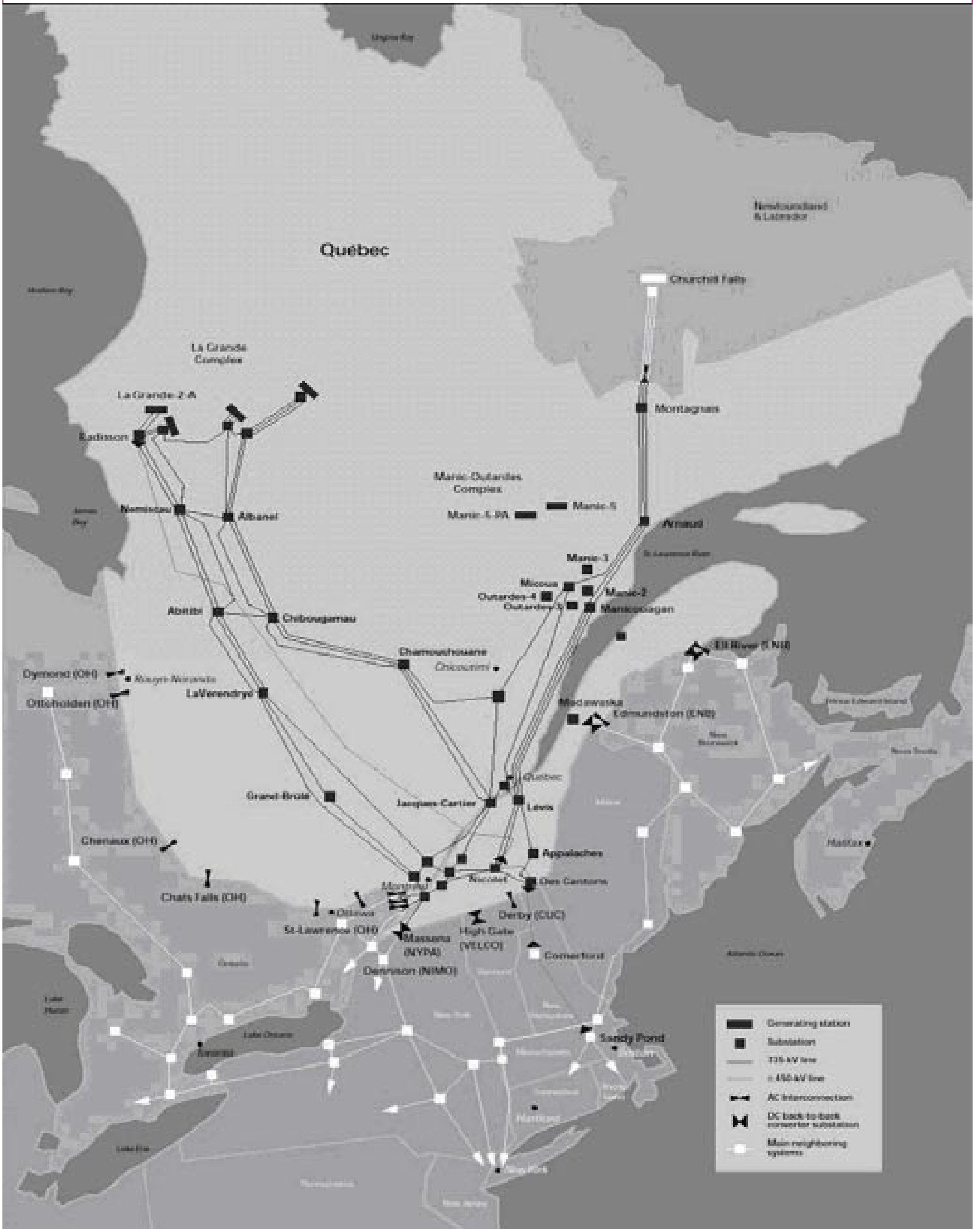
The commitment of the Government of Canada with respect to the Kyoto Protocol is to reduce the GHG emissions to the 1990 level minus 6%. Here are the CO_2 eq. emissions (Mt) that resulted from the 1990 electricity production of the three provinces: Ontario (27.4), Québec (1.1) and New Brunswick (6.5) for a total of 35.0.[15] In that year, electricity production emitted 40.8 Mt of CO_2 eq. in New England and 61.6 in New York for a total of 102.4.[16] In this study, we assume that the CO2 eq. emissions by fuel type (Mt/TWh) are: coal (0.974), oil products (0.778), and natural gas (0.511).[17]

Table 5
Production and CO_2 Emission: Free Trade

Region / Type	Winter (MW)	Spring (MW)	Summer (MW)	Fall (MW)	(TWh)	($MtCO_2eq$)
Québec						
Hydro	35 327	21 177	21 814	21 177	190.14	0
Nuclear	675[1]	675[1]	675[1]	675[1]	5.91	0
Coal	--	--	--	--	--	--
Oil	0	0	0	0	0.00	0
Natural Gas	37[1]	37[1]	37[1]	37[1]	0.32	0.2
Other[2]	60	60	60	60	0.53	--
Total	36 099	21 949	22 586	21 949	196.90	0.2
Ontario						
Hydro	8 034[1]	4 146	8 034[1]	4 146	39.82	0
Nuclear	8 728[1]	8 728[1]	8 728[1]	8 728[1]	76.46	0
Coal	7 797[1]	6 461	7 797[1]	6 461	57.80	56.3
Oil	0	0	0	0	0.00	0
Natural Gas	0	0	0	0	0.00	0
Other[2]	131	131	131	131	1.15	--
Total	24 690	19 466	24 690	19 466	175.23	56.3
New Brunswick						
Hydro	919[1]	302	583	302	3.00	0
Nuclear	680[1]	680[1]	680[1]	680[1]	5.96	0
Coal	570[1]	570[1]	570[1]	570[1]	4.99	4.9
Oil	1 884[1]	1 729	1 448	1 729	15.02	11.7
Natural Gas	--	--	--	--	--	--
Other[2]	104	104	104	104	0.91	--
Total	4 157	3 385	3 385	3 385	29.88	16.6
New England						
Hydro	3 599[1]	145	3 599[1]	145	4.38	0
Nuclear	4 365[1]	4 365[1]	4 365[1]	4 365[1]	38.24	0
Coal	3 311[1]	3 311[1]	3 311[1]	3 311[1]	29.00	28.3
Oil	2 827	0	5 127	0	3.92	3.1
Natural Gas	0	0	0	0	0.00	0
Other[2]	1 155	1 155	1 155	1 155	10.12	--
Total	15 257	8 976	17 557	8 976	85.66	31.4
New York						
Hydro	537	2 867	3 730	2 867	24.93	0
Nuclear	4 981[1]	4 981[1]	4 981[1]	4 981[1]	43.63	0
Coal	3 262[1]	3 262[1]	3 262[1]	3 262[1]	28.58	27.8
Oil	14 600[1]	1 917	14 600[1]	1 917	28.21	21.9
Natural Gas	0	0	0	0	0.00	0
Other[2]	343	343	343	343	3.00	--
Total	23 723	13 370	26 916	13 370	128.35	49.7
Total	**103 926**	**67 146**	**95 134**	**67 146**	**616.03**	**154.2**

[1] Maximum generating capacity.
[2] Geothermal, solar, wind and biomass

Figure 1
High Voltage Interconnections



Results and Discussion

Scenario 1: Free Trade

Table 5 shows the use of generating equipments under free trade which is considered to be our base case. As is expected, hydro and nuclear power, which have zero or low fuel costs, are used to their full extent in all regions. These two sources have zero emissions and their 100% use means that no further GHG emission reduction can be directly obtained from them. However, hydro generating facilities are not operating at full capacity (MW) most of the time even if all available water is used; therefore, hydro resources can still be reallocated from one period to another period to accommodate some substitution toward sources which have lower emissions and in this way, they can make an indirect contribution to GHG emission reduction. Ontario has large coal fired generating facilities which have low average costs relative to other regions; so they are used to the fullest extent which is compatible with the available interconnection capacities. This is also the case of oil facilities in New Brunswick. Coal generating power stations in New England and New York are used at full capacity while oil facilities are the marginal generating sources. Except for Québec, which is a minor exception in this respect, natural gas power plants have relatively high fuel costs and make no contribution to the load in any of the other four regions.

Table 6
Origin and Destination of Electricity: Free Trade

From/To		Winter (MW)	Spring (MW)	Summer (MW)	Fall (MW)	(TWh)
Québec	Québec	33 572	19 126	19 298	19 126	171.98
Ontario		378	550[1]	378	550[1]	4.66
New Brunswick		0	785[1]	785[1]	785[1]	6.64
New England		0	0	0	0	0.00
New-York		344	0	0	0	0.10
Total		34 295	20 461	20 461	20 461	183.39
Québec	Ontario	0	0	0	0	0.0
Ontario		22 515	16 591	22 275	16 591	150.52
New-York		0	0	0	0	0.00
Total		22 515	16 591	22 275	16 591	150.52
Québec	New Brunswick	224	0	0	0	0.07
New Brunswick		3 342	1 785	1 785	1 785	16.10
New England		0	0	0	0	0.00
Total		3 566	1 785	1 785	1 785	16.17
Québec	New England	2 303[1]	1 755	2 303[1]	755	15.86
New Brunswick		815[1]	815[1]	815[1]	815[1]	7.14
New England		15 257	8 976	17 557	8 976	85.66
New-York		1 425[1]	882	1 425[1]	882	8.22
Total		19 800	12 428	22 100	12 428	116.88
Québec	New-York	0	1 069	984	1 069	8.99
Ontario		1 797	2 325[1]	2 037	2 325[1]	20.04
New England		0	0	0	0	0.00
New-York		21 953	12 487	25 491	12 487	120.03
Total		23 750	15 881	28 513	15 881	149.06
Total		103 926	67 146	95 134	67 146	616.03

[1] Maximum generating capacity.

Overall CO_2 eq. emissions (Mt) under free trade are higher than the 1990 level, i.e. 154.2 versus 137.4.[18] They are much higher in Canada, 73.1 versus 35.0, while they are lower in the two U.S. regions, 81.1 versus 102.4. The shift of CO_2 eq. emissions from the United States to Canada is caused by the low costs of coal facilities in Ontario and New Brunswick, and the low cost of oil facilities in the latter province and by the fact that 5136 MW (Bruce A, 2060MW and Pickering A, 3076 MW) of nuclear power in Ontario have been taken out of service.

Table 6 shows that congestion interconnections is fairly widespread; however, congestion is mostly associated with moving power into New England, either directly or indirectly through Québec and New York. The three Canadian provinces are net exporters while the two U.S. regions are net importers.

The upper part of Table 7 shows the marginal costs in each region during the four periods of the year. We can see that free trade does not lead to the equalization of marginal costs in the five regions due to the limits imposed by the interconnections. Québec and New York, which are located at the centre and which are linked by large interconnections, are free of congestion and hence they share the same marginal costs, that is 3.02¢/kWh. However, the imports into New England are limited by the congested interconnections during the Winter and the Summer peak periods and as a result, New England makes use of its high cost oil facilities at 3.15¢/kWh. Exports from coal facilities in Ontario during Spring and Fall and from oil facilities in New Brunswick during Spring, Summer and Fall are limited by congestion and the two provinces have lower marginal costs than New York and Québec during these periods.

Table 7
Marginal Cost (¢ / kWh)

Scenario/Region		Winter	Spring	Summer	Fall
Free trade	Québec	3.02	3.02	3.02	3.02
	Ontario	3.02	2.07	3.02	2.07
	New Brunswick	3.02	2.37	2.37	2.37
	New England	3.15	3.02	3.15	3.02
	New York	3.02	3.02	3.02	3.02
Output base allocation of permits in Canada and no U.S. action					
	Québec	3.02	3.02	3.02	3.02
	Ontario	3.02	2.29	3.02	2.29
	New Brunswick	3.02	2.57	2.57	2.57
	New England	3.15	3.02	3.15	3.02
	New York	3.02	3.02	3.02	3.02

Table 8 shows the fuel costs and the value of net exports in each region under free trade. The marginal cost of the importing region is assumed to be the price of the electricity, which is exchanged between two regions: this is what is expected under free competition. We can observe that altogether the three Canadian provinces have net export revenues of $1572 million and the bulk is directed to New England that has imports which are close to a billion. In summary, Canadian electricity producers should perform well under unfettered free trade due to their low operating costs. However, the negative side is the increase in GHG emissions.

Scenario 2: Output Based Allocation of Permits in Canada and No U.S. Action

The plan which has been proposed by the Government

Table 8
Profit Change and its Components ($ million)

Scenario	Québec	Ontario	New Brunswick	New England	New York	Total
			Fuel cost			
1	16.7	1 372.3	484.1	969.8	1 559.1	4 401.9
2	16.7	1 372.3	484.4	969.8	1 559.1	4 402.2
			Permit purchase			
1	--	--	--	--	--	--
2	2.5	843.9	244.4	--	--	1090.8
3	2.5	730.3	5.2	--	--	738.0
4	2.5	164.2	0.0	--	--	166.7
			Permit allocation			
1	--	--	--	--	--	--
2	2.1	717.3	207.7	--	--	927.1
			Net exports			
1	411.0	745.9	415.1	- 948.2	-623.8	0.0
2	411.0	745.9	415.1	- 948.2	-623.8	0.0
			Profit change			
1 / 2	- 0.4	- 126.6	- 37.0	0.0	0.0	-164.0
			Profit change (¢ / kWh)			
1 / 2	~ 0.0	- 0.1	- 0.2	0.0	0.0	--
			Relative to 1998 average price (%)			
1 / 2	0.0	1.0	3.5	0.0	0.0	--

[1] Free trade.
[2] Output base allocation of permits in Canada and no U.S. action.

of Canada to reduce the GHG emission in the industrial sector came out of the consultation process that led to the ratification of the Kyoto Protocol and the main feature is the allocation of emission permits on the base of actual output according to the following formula:

Number of permits = Physical output
x GHG emission intensity per unit of output
x Reduction factor.

The reduction factor is applied to bring the level of GHG emissions to the level which is deemed appropriate for the sector by the Government of Canada. For the oil and natural gas sector, the reduction factor is 85%. If we combine such a permit allocation mechanism with the $15/tonne price ceiling of emission permits, this means that the cost of a permit to the purchaser is reduced to $15 x 0.15 = $2.25/tonne since the purchaser of a permit needs to buy only 0.15 of a permit; the remaining 0.85 is provided gratis by the government. Given the CO_2 eq. emission intensity that we have adopted for this study, the modified permit price adds the following amounts to fuel cost (¢/kWh) in Canada: coal (0.22), oil (0.17), and natural gas (0.11). If we add these numbers to the average fuel costs as they are presented in Table 3, we can see that there are very few changes in the ordering of the costs: now coal (2.57¢/kWh) is more expensive than oil (2.54¢/kWh) in New Brunswick and coal (2.29¢/kWh) in Ontario is more expensive that coal (2.20¢/kWh) in New York. Our aim in developing scenario 2 is to analyze the effects of such changes relative to unfettered free trade; we assume that no action is undertaken in the U.S. regions to reduce GHG emissions in the electricity sector.

There is no change of total production in each region that comes out ot the Canadian policy toward GHG emissions. There is only one relative change by fuel type: electricity generated from oil goes up in New Brunswick with a compensating decrease of coal. The fact that coal production in New York is now cheaper than coal production in Ontario does not induce any change since coal facilities in New York were already fully used under free trade. The small substitution of coal by oil in New Brunswick brings emission down by 0.4Mt of CO_2 eq.; this is a very small change. Since there is no change in the total production by fuel type in each region, there is no change in the pattern of trade relative to free trade.

Table 7 shows the impacts of the $2.25 permit price in Canada on the marginal costs. The only change occurs in the off peak marginal costs of Ontario and New Brunswick. Since exports out of these two provinces are limited by interconnection congestion during these periods, there is no influence on the neighbours. The same point can also be seen in Table 8 which shows no changes in the values of net exports in comparison to free trade.

Except for the small increase of fuel cost in New Brunswick, the only significant change is the purchase of emission permits by Canadian producers at the net price of $2.25/tonne. In order to show the significance of the resulting profit change, we present two indicators in Table 8. The first indicator is the profit change per unit of sale within each region. The second indicator is the first indicator divided by the average price of electricity in each region in 1998. The motivation behind the second indicator is to assess how the price paid by the final user would need to change so that the profits of the producers are brought back to the level under free trade. To illustrate the information transmitted by this second indicator, let us consider the case of Québec which experiences no change of marginal costs, and yet its cost goes up due to its small electricity generation from natural gas. This is an infra marginal change which is not reflected in prices in competitive market. However it has a negative impact on profitability. In this particular case, it turns out to be very small. The negative impacts are somewhat larger in Ontario (+1.0%) and New Brunswick (+3.5%).

It should be noticed that the two U.S. regions which take no action to reduce GHG emissions, emit 81.1Mt of CO_2 eq. This is less than their combined emission level in 1990 (102.4Mt). The latter emission ceiling would not be binding for the U.S. electricity producers.

In summary, the approach proposed by the Government of Canada to shield the competitive position of Canadian industrial producers may turn out to be very effective; however the counterpart of this positive effect is that there is almost no reduction of GHG emissions. Total emissions of electricity producers in the three Canadian provinces are 72.7Mt of CO_2 eq. Since 15% are covered by permit purchase, the uncovered part is 61.8Mt, which is well above the 1990 emission level minus 6%, i.e., 32.9Mt. This would be a rather unsatisfactory situation. There are two ways to solve this problem and both impinge upon the competitive position of Canadian electricity producers. First, the Canadian government could lower its share of the emission permit price below 85% and thus increase the price of emission permits to Canadian electricity producers; second, it could impose some ceiling on the overall emission level. This second approach gives rise to difficult implementation issues: for instance, how to reconcile an output base allocation approach with an overall emission ceiling?

Conclusion

Canada has ratified the Kyoto Protocol and the United States have not. This is raising some concerns among Canadian industrial producers with respect to their competitiveness on the world market. To alleviate these concerns, the Government of Canada is proposing to introduce some safeguards on the costs born by large industrial GHG emitters. Two such safeguards are the price ceiling on GHG emission permits at $15/tonne and a favourable allocation of emission permits based on actual output. In this paper, we analyze the effects of such measures on the electricity production and exchanges between three Canadian provinces (Ontario, Québec and New Brunswick) and two U.S. regions (New York and New England). Electricity presents an interesting case because competition on the base of marginal costs is already well developed since FERC deregulated the U.S. wholesale electricity market in 1997. Using cost minimization of satisfying the load in each region as a representation of the operations of the wholesale electricity market, we find that the two safeguards suggested by the Government of Canada to shield the competitive position of Canadian industrial producers, i.e., emission permit price cap at $15/tonne and output base allocation at 85% of emission intensity, are very effective indeed in this respect. There is no change in production and trade flows. However, there is also little change in GHG emissions, which is the primary objective of the whole exercise. This is an unsatisfactory outcome which will require attention by the Government of Canada in the near future. Otherwise, Canada tax payers will have to pay a huge bundle related to GHG emission permits on the world market.

Footnotes

[1] CO_2 eq. emissions = CO_2 equivalent of GHG emissions.

[2] Government of Canada (2002).

[3] Including 30 Mt of CO_2 eq. in the form of sinks which are forest and agriculture accepted by the other parties to the Kyoto Protocol.

[4] The 60 Mt remaining gap will be addressed in programs to be announced later on.

[5] Mining, pulp and papers, chemical products, iron and steel, non-ferrous metals, cement and glass.

[6] This is a commitment by the Government of Canada for the first commitment period only. It is still possible that some industries may adopt measures that are more expensive than $15/tonne if they expect the emission permit prices to be above that threshold in future periods.

[7] The oil and natural gas producers have been told by the Minister of natural resources, The Honourable H. Dhaliwal (2002), that their reduction target will not represent more than a 15% GHG intensity reduction compared to BAU scenario during the first commitment period. See Nguyen (2003).

[8] Pennsylvania, New Jersey and Maryland.

[9] Such a market is also operating in Ontario since May 2002.

[10] Values are expressed in Canadian dollars.

[11] For an analysis of the effects of wholesale electricity market deregulation on the exchanges between Ontario, Quebec, N.B., New England and New York, see Bernard, Clavet and Ondo (2003).

[12] Geothermal, solar, wind and biomass.

[13] In order to remove some of weather randomness, we use the average hydroelectricity production in 1994, 1995 and 1996 prior to wholesale electricity market deregulation.

[14] See Bernard, Clavet, and Ondo (2003).

[15] Canadian Electric association and Natural Resources Canada (1991)

[16] http://www.eia.doe.gov/cneaf/electricity/st_profiles (1990)

[17] Gagnon (2000).

[18] Bernard, Clavet and Ondo (2003) estimate that the wholesale electricity market deregulation adds 4.3Mt of CO_2 eq. emissions.

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