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UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

SUBSIDIARY BODY FOR SCIENTIFIC AND TECHNOLOGICAL ADVICE
Sixteenth session
Bonn, 5 - 14 June 2002
Item 10 (b) of the provisional agenda

PROPOSAL ON CLEANER OR LESS GREENHOUSE GAS-EMITTING ENERGY

Submissions from Parties

Note by the secretariat

Addendum

Submission from a Party

1. At its fifteenth session, the Subsidiary Body for Scientific and Technological Advice (SBSTA) requested the secretariat to organize a workshop under the guidance of its Chairman on the topic of cleaner or less greenhouse gas-emitting energy, if possible prior to its sixteenth session, and to prepare a report on the workshop. The SBSTA invited Parties to submit views on the structure and scope of the workshop by 15 February 2002, for compilation by the secretariat into a miscellaneous document (FCCC/SBSTA/2001/8). Nine such submissions were received by the secretariat (FCCC/SBSTA/2002/MISC.3).

2. The secretariat has received one additional submission from Canada.* In accordance with the procedure for miscellaneous documents, this submission is reproduced in the language in which it was received and without formal editing.

* In order to make this submission available on electronic systems, including the World Wide Web, it has been electronically imported. The secretariat has made every effort to ensure the correct reproduction of the text as submitted.

CONTENTS

Government of Canada / Gouvernement du Canada

Modalities for the Accounting of Assigned Amounts under Article 7, Paragraph 4 of the Kyoto Protocol in Relation to Cleaner Energy Exports

Notes for an Intervention
by
Paul Fauteux
Co-Head of the Canadian Delegation

SBSTA 16
Bonn, Germany
June 6, 2002

Canada

Mr. Chairman, allow me first to express Canada's gratitude to Mr. Dovland for his very balanced report and for his outstanding work in guiding our deliberations in Whistler. Thanks to his untiring efforts and wise counsel, the Whistler workshop allowed all participants to gain a better appreciation of their respective points of view on this complex issue, which I am sure will greatly assist the continuing work of all Parties here in Bonn as well as in New Delhi in October.

Mr. Chairman, in Whistler Canada indicated its intention to bring forward a draft decision to this session of the SBSTA. With your permission I would now like to do so.

First I would like to make a few general remarks and then I will speak briefly to the main elements of the decision.

As we all know, the objective of the Convention is to "stabilize concentrations of greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". Canada fully supports that objective and played an active role in the development of the Kyoto Protocol, which is a major step in that direction.

We all recognize that cleaner or less greenhouse gas emitting energy does create global environmental benefits. We also recognize that over the longer term, to achieve the objective of the Convention, we need to make the transition to a less GHG-emitting global economy. To facilitate this transition, we should optimize the uptake of cleaner or less-GHG emitting energy as of now.

The objective of the Convention is descriptive, not prescriptive. All efforts by all Parties to reduce emissions are important to all Parties and Canada believes that all efforts in this regard, including optimizing the uptake of cleaner or less GHG-emitting energy through cleaner energy trade, should be encouraged. If there is a way we can further reduce emissions now to maximize global environmental benefits and attain long-term sustainability at the lowest possible cost, we should do it.

Canada is also of the view that, in certain circumstances, the Protocol may not always promote the uptake of cleaner energy. The Canadian situation is one example of such circumstances. We have been raising this issue since prior to COP 3. We agreed to a target of minus 6% below 1990 levels on the basis that the US was going to minus 7%, and that we would be able to work with the US through the Protocol. There was, of course, no way that Canada could have foreseen in 1997 the events that led to the US withdrawal from the Protocol in 2001.

No other country is confronted with an economic relationship of such singular significance with an Annex B non-Party. No other Annex B Party has the same level of economic integration with the US as Canada. Over 85% of Canada's exports go to the US, and our competitive exposure is ten times greater than that of any other Party as a result of the US decision not to ratify the Protocol.

We need a decision to address the lack of parity of effort to address climate change between Canada and its largest trading partner, an Annex B non-Party, with whom such lack of parity was never envisioned.

Mr. Chairman, I now turn to the main elements of the decision, previewed in Whistler, that Canada is proposing:

- Canada is seeking credit for the global environmental benefits created by its exports of natural gas and hydro-electricity to the US. The decision is for the first commitment period only and applies only to Canada, based on its unique circumstances vis-à-vis the scale of its cleaner energy exports to an Annex B non-Party.

- We are seeking agreement on the Canadian methodology for estimating global environmental benefits, which would produce a “displacement factor” per unit of cleaner energy shipped.
- The decision would cap the amount of credits at 70 Mt of CO2 equivalent per year, based on actual reported cleaner energy export volumes and domestic emissions associated with those exports.
- The global environmental benefit created by Canada’s cleaner energy exports would be subject to review by an Expert Review Team.
- Canada would be authorized to issue assigned amount equivalent to the global environmental benefit created by its cleaner energy exports.

Mr. Chairman, these are the main elements of our draft decision, the basis for which has been presented in capitals to all Parties. The draft decision itself has been issued by the secretariat as part of document MISC. 3/Add.1. My delegation asks that the SBSTA recognize the importance of this issue to Canada and consider this draft decision with a view to forwarding it to COP 8 for adoption.

Draft Decision -/CP. 8

Modalities for the accounting of assigned amounts under Article 7, Paragraph 4 of the Kyoto Protocol in relation to cleaner energy exports

The Conference of the Parties,

Mindful of the objective of the Convention as set out in its Article 2,

Recalling its report on the second part of its sixth session,

Recognizing the potential of cleaner or less greenhouse gas-emitting energy to promote global environmental benefits to meet the objectives of the Convention and the Kyoto Protocol,

1. *Decides* that any Party that intends to avail itself of the provisions of decision -/CMP.1 (*Modalities for the accounting of assigned amounts in relation to cleaner energy exports)* shall so notify the Conference of the Parties prior to its ninth session,

2. *Recommends* that the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol, at its first session, adopt the draft decision below.

Draft Decision -/CMP. 1 (*Modalities for the accounting of assigned amounts in relation to cleaner energy exports)*

Modalities for the accounting of assigned amounts under Article 7, Paragraph 4 of the Kyoto Protocol in relation to cleaner energy exports

The Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol,

Mindful of the objective of the Convention as set out in its Article 2,

Recalling decision -/CP.8 adopted by the Conference of the Parties at its eighth session,

Mindful of the concept of additionality, as reflected in Articles 6.1 (b) and 12 (c) of the Kyoto Protocol,

Recalling the report on the second part of the sixth session of the Conference of the Parties (document FCCC/CP/2001/2, section II, sub-section A), in which it "recognized that cleaner or less greenhouse gas-emitting energy, emphasizing renewables, hydro, geothermal, and natural gas, could promote global environmental benefits to meet the objectives of the Convention and the Kyoto Protocol and optimize the uptake of cleaner or less greenhouse gas-emitting energy",

Recalling further that, at its seventh session, the Conference of the Parties took note of the conclusions of the Subsidiary Body for Scientific and Technological Advice in the report of its fifteenth session (document FCCC/SBSTA/2001/8, section X, Topic 1), taking note of the report by the Government of Canada on the meeting on the subject of cleaner or less greenhouse gas-emitting energy and requesting the secretariat to organize a workshop on that topic,

Bearing in mind Article 7.4 of the Kyoto Protocol,

1. *Decides* that, for the purposes of this decision, cleaner or less greenhouse gas-emitting energy shall refer to natural gas and hydro-electricity;

2. *Decides* that, for the first commitment period only, a Party included in Annex B that is a Party to the Protocol may issue assigned amount units equivalent to the global environmental benefit created by its exports of cleaner or less greenhouse gas-emitting energy, provided that:

(a) Those exports are to a Party included in Annex B of the Protocol that is not a Party to the Protocol; and

(b) The net annual exports, within the first commitment period, on average exceed 3 trillion cubic feet of natural gas or 10 terawatt/hours of hydro-electricity;

3. *Decides* that the global environmental benefit created by cleaner or less greenhouse gas-emitting energy exports shall be calculated as the difference between the estimate of global emissions in the absence of those exports and the emissions associated with the production and transportation of those exports in the exporting Party;

4. *Decides also* that the estimate of global emissions in the absence of those exports shall equal the actual volume of natural gas times 22.3 megatonnes of carbon dioxide-equivalent per trillion cubic feet plus the actual volume of hydro-electricity times 0.75 megatonnes of carbon dioxide-equivalent per terawatt/hour;

5. *Decides* that emissions associated with the production and transportation of those exports in the exporting Party shall be estimated in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and any additional good practice guidance adopted by the Conference of the Parties serving as the meeting of the Parties;

6. *Decides* that the information required in paragraphs 3, 4 and 5 above for the purpose of issuing assigned amount units in accordance with paragraph 2 above shall be annually reported separately under Article 7.1 and be subject to a review under Article 8;

7. *Decides also* that the total amount of assigned amount units issued by a Party pursuant to this decision shall not exceed 70 million tonnes of carbon dioxide-equivalent annually. Such assigned amount units shall only be issued following the review in accordance with Article 8 of the report submitted pursuant to Article 7.1 for the last year of the first commitment period, taking into account any adjustments applied under Article 5.2 and resolution of any questions of implementation related to the reported emissions associated with the production and transportation of cleaner or less greenhouse gas-emitting energy exports in the exporting Party and the reported net volumes of cleaner or less greenhouse gas-emitting energy exports;

8. *Decides further* that any assigned amount units issued pursuant to this decision cannot be transferred or acquired by another Party under Articles 6 or 17 of the Protocol, or carried over to the second commitment period.

Government of Canada Gouvernement du Canada

Cleaner Energy Exports and Global Environmental Benefits: Canada's Position

The North American economy is highly integrated. Approximately 85% of Canada's trade is with the United States. This figure increases to over 95% when energy trade alone is considered. Canada produces and exports substantial natural gas and hydro-electricity to the United States. Over 50% of the natural gas produced in Canada is shipped to US markets, providing a secure and competitively priced energy supply. Canada exports approximately 7% of its generated electricity to the United States, 93% of which is hydro-electric.

Canada took on a target of -6% below 1990 levels on the basis of US effort at -7%. The implications of the announcement by President Bush on February 14, 2002, are that US emissions may move upward by as much as 31% by 2010.

Canada's exports of cleaner energy, specifically hydro-electricity and natural gas, to the United States produce a significant global environmental benefit.

Global environmental benefit is equal to:

- ***what global emissions (outside of Canada)would be in the absence of Canadian cleaner energy exports, minus***
- ***emissions in Canada associated with those exports.***

To estimate the global environmental benefit from Canada's cleaner energy exports, we have analyzed a counter-factual scenario using conservative assumptions in which Canada's natural gas and hydro-electricity are not exported. The lack of Canadian cleaner energy would result in a new US energy market equilibrium. This new equilibrium would be characterized by higher coal-based electricity generation, higher natural gas production, higher liquid natural gas imports, higher consumption of coal and oil, and lower consumption of natural gas, leading to overall higher US and global emissions. To arrive at the global environmental benefit, emissions in Canada associated with the production and transportation of cleaner energy exports are subtracted from these higher emissions.

The annual global environmental benefit created by these exports in 2010 is estimated to be 82 Mt CO_2-equivalent, an increase of 69 Mt CO_2-equivalent relative to 1990.

The nature of the North American energy economy, the unparalleled integration of the Canadian and US economies and the disappearance of the expected parity of Canadian and US efforts to mitigate climate change have created a fundamental change of circumstances that places Canada in a unique situation vis-à-vis its goal to ratify the Kyoto Protocol and manage the economic impacts of implementation.

At SBSTA 16, Canada will be bringing forward a draft decision for consideration by CoP 8, requesting an accommodation to provide it with credit equivalent to the global environmental benefit created by its cleaner energy exports, i.e., 70 Mt CO_2-equivalent per year, for the first commitment period only.

May 2002

Canada

Impacts of

Canada's Cleaner Energy Exports

on

Global Greenhouse Gas Emissions

Whistler, B.C.
Canada

May 2002

1. Introduction

The North American economy is highly integrated. Canada and the United States (US) each constitute the other's largest trading partner. Approximately 85% of Canada's exports go to the US. Considering energy exports alone, this figure increases to over 95%. Over 50% of the natural gas produced in Canada is shipped to the US, providing a secure and competitively priced energy supply. While Canada exports[1] only about 7% of its generated electricity to the US, 93% is hydro-electric.

Canada estimates that its exports of cleaner energy, specifically hydro-electricity and natural gas, to the US produce a significant global environmental benefit. This paper presents Canada's estimate of the reduction in global greenhouse gas (GHG) emissions due to Canada's cleaner energy exports to the US.

Estimating the impact of cleaner energy exports on global GHG emissions is a relatively new concept and we do not know of any existing methodology that could permit such an exercise. Therefore, using US energy market analysis to inform our thinking, we developed a new methodology.

After defining cleaner energy, we briefly analyse the export market for Canada's cleaner energy. We then present our methodology and underlying assumptions to estimate "displaced" or "avoided" global GHG emissions due to Canada's cleaner energy exports. After presenting our estimates of emissions in Canada due to production, processing and transportation of these energy exports, and displaced emissions in the rest of the world, we compare these results with those of two studies undertaken by independent consultants. We conclude that the global environmental benefit created by Canada's cleaner energy exports depends on assumptions underlying the new energy market equilibrium in the US that would result from the absence of these exports. We then quantify that benefit based on independent studies and conservative assumptions.

2. Definition

On 27 July 2001, the second part of the Sixth Conference of the Parties (CoP 6 bis) recognized that "cleaner or less greenhouse-gas-emitting energy, emphasizing renewables, hydro, geothermal and natural gas, can promote global environmental benefits to meet the objectives of the Convention and the Kyoto Protocol and optimize the uptake of cleaner or less greenhouse-gas-emitting energy."

Natural gas and hydro-electricity are cleaner energy commodities that Canada exports which result in lower global GHG emissions. In accordance with the emphasis in the previously quoted CoP 6 bis conclusion, electricity exports from non-hydro sources (i.e., nuclear and fossil fuel based generation) are not considered and are not reflected in the estimates. In addition, and for similar reasons, crude oil, oil sands and coal exports are excluded.

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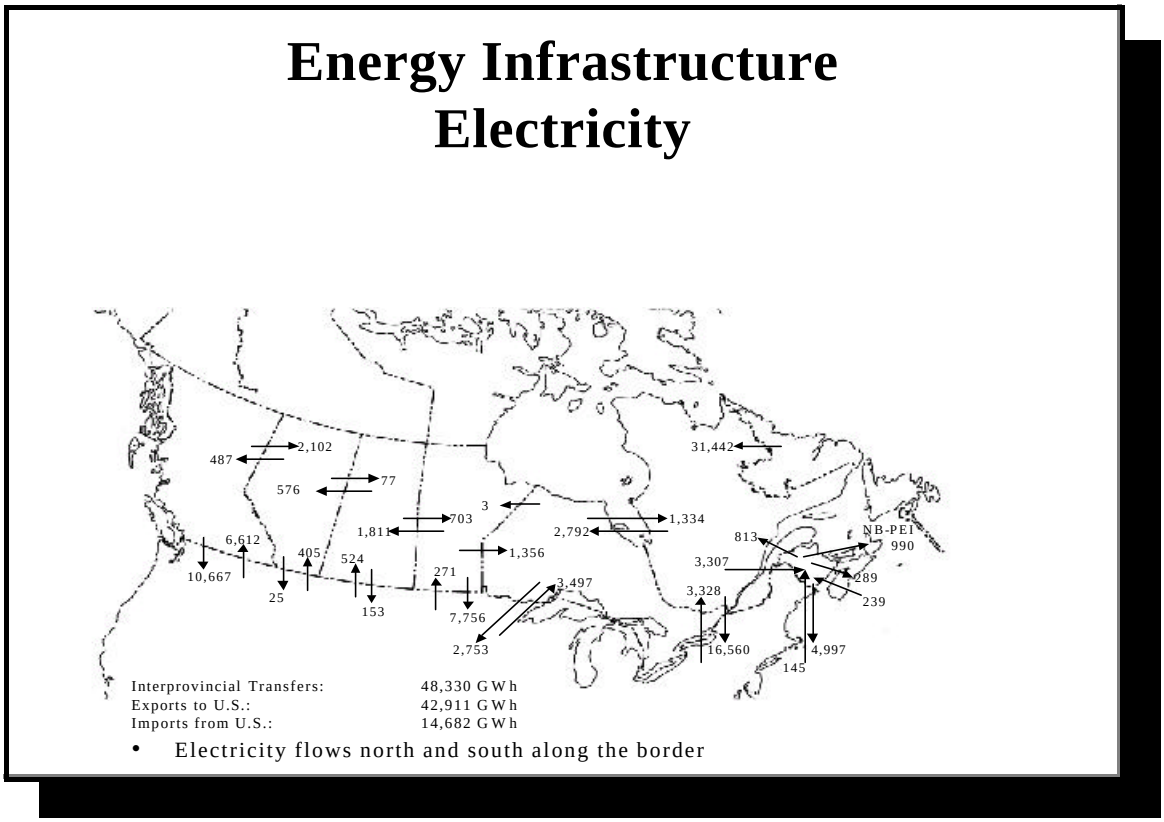
[1] In this document all exports and imports are defined as those occurring between two countries, and all emissions are in million tonnes of CO_2 equivalent (Mt)

3. Market for Canada's Cleaner Energy Exports

3.1 Electricity

There are strong electricity links between neighbouring Canadian provinces, between Canadian provinces and neighbouring US states and between most US states. In general Canada-US electricity trade is a two-way street (see map).
Most Canadian exports are hydro-based, while imports from the US are fossil fuel-based. Canada's



net electricity exports to the US depend on availability of power in Canada, in the US, and on water conditions in exporting provinces. These exports fluctuated from nearly zero in 1965 to a new record in 2000 of 45.9 TWh. Canada's official projections, assuming normal water conditions, call for these exports to be about 28.6 TWh by 2010. The vast majority of these exports are generated in the provinces whose electricity is nearly entirely from hydro power (see Table 1). In Ontario and New Brunswick non-hydro-electricity exports have been excluded.

Table 1: Projected Net Electricity Exports
2010
TWh

Exporting Provinces	**Total net exports**	**Net hydro-electricity exports**
New Brunswick	3.2	0.3
Quebec[2]	15.2	15.2
Ontario	-0.9	0
Manitoba	9.4	9.4
British Columbia	1.7	1.7
Canada Total	**28.6**	**26.6**

Canada's electricity exports account for less than 1% of total US consumption, but they play a much larger role in some regional markets of the US They are heavily concentrated in the Northeastern states, accounting for 5 to 6% of total electricity consumption in that region. Canada's electricity exports in other US regions represent less than 1 % of total regional consumption (see table 2).

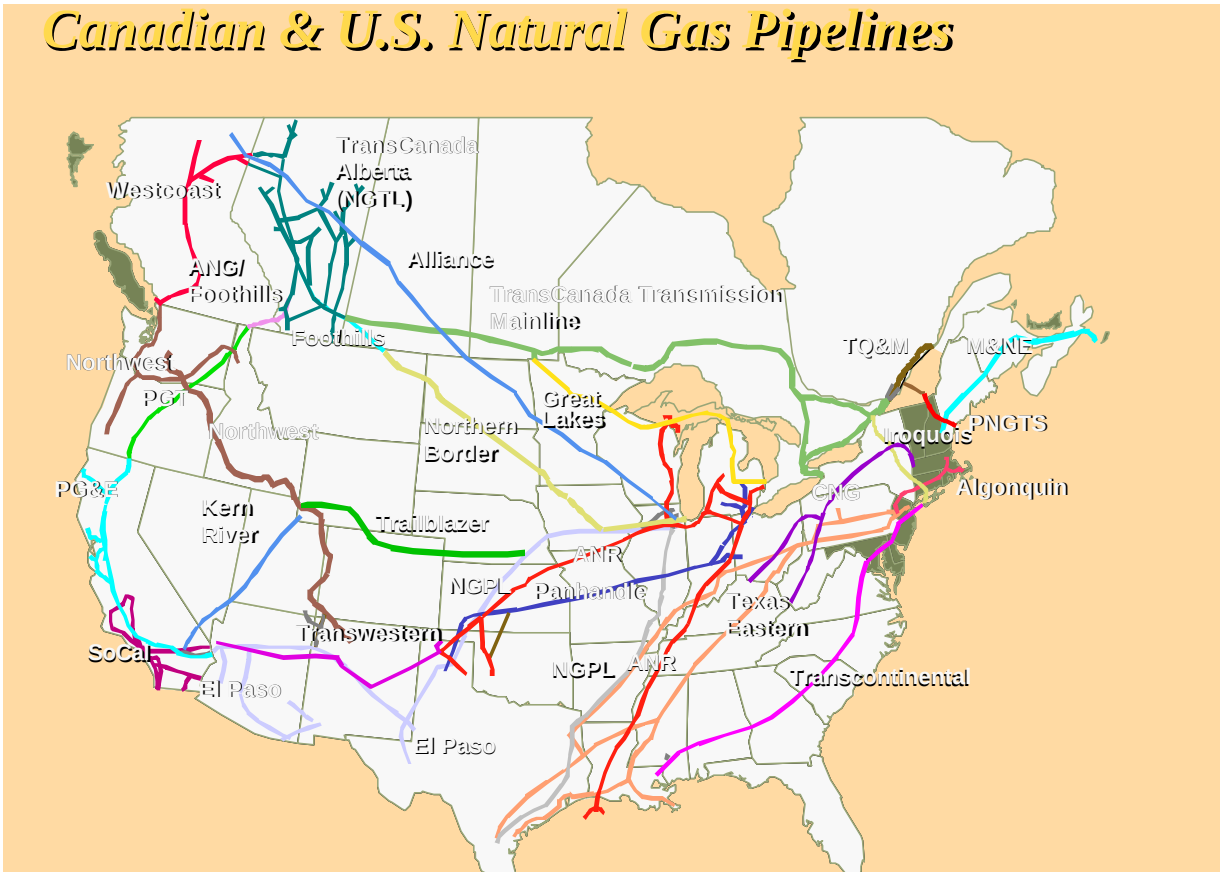
Table 2: Canadian Net Electricity Exports to the US
2000

US Destination	TWh	% of Supply
Northeast	22	5
Midwest	7	1
West, Other	5	1

[2] It should be noted that Quebec is a substantial importer of electricity from the Province of Newfoundland and Labrador.

3.2 Natural gas

Canada's natural gas exports increased by 130% between 1990 and 2000, from 1430 BCF to 3520 BCF, and are expected to increase by another 26%, to 4420 BCF by 2010. That would constitute more than 56% of Canada's total natural gas production. One of the largest and most technically sophisticated pipeline systems in the world connects Canadian natural gas producers with the US market (see map).



Canada's natural gas exports account for about 15% of total US consumption. Canadian exports provide almost 100 percent of supply in the Pacific Northwest, and account for about 30% of California, Midwest and Northeast supply. (Table 3)

Table 3: US Regional Natural Gas Supply

	California	Pacific Northwest	Midwest	Northeast	Rest of USA	Total USA
Total supply (bcf/d)	6	1.5	11	9	34	62
Canadian share of total supply	29%	almost 100%	30%	31%	0%	15%

4. Methodology

To estimate the global environmental benefit from Canada's cleaner energy exports to the US, we have considered a scenario in which Canadian natural gas and hydro-electricity are not produced and exported to the US.

The analysis considers the overall net emissions impact of this scenario. For example, if Canada does not produce and export natural gas and hydro-electricity to the United States, emissions in Canada will be lower. In the US, the lack of Canadian cleaner energy would result in a new energy market equilibrium. Several scenarios can be envisioned, each considering different combinations of US energy market reactions in response to the lack of Canadian imports.

Global environmental benefit is equal to:

- ***what global emissions (outside Canada) would be in the absence of Canadian cleaner energy exports, minus***
- ***emissions in Canada associated with those exports***.

One such scenario is assumed to occur for the purposes of this analysis. The emissions associated with this scenario in the US are then calculated. The difference between these emissions and the reference case (in which Canadian cleaner energy is available in the US) emissions constitutes the "displaced" emissions in the US. Detailed calculations involved in estimates of the global environmental benefit created by Canada's cleaner energy exports for 1990 and 2010 and the growth in that benefit between 1990 and 2010 are presented in Annex 1.

Although Canada is a net exporter of natural gas and hydro-electricity, in order to calculate the global environmental benefit created by these exports, emissions incurred in the production and transportation of any electricity imports to Canada are also included. Since the emissions in Canada would no longer

occur, they are subtracted from the total, producing an estimate of the global environmental benefit.

1. Absence of Canadian cleaner energy exports

Absence of Canadian cleaner energy exports reduces emissions in Canada but increases emissions elsewhere.

5.1 Emissions in Canada associated with cleaner energy exports

i) Electricity

This paper considers only hydro-electricity exports and assumes their emissions to be nil. Emissions from hydro reservoirs are not considered and are not reflected in the estimates. Like other countries, Canada currently neither monitors nor reports greenhouse gas (GHG) emissions from hydroelectric reservoirs as part of its annual GHG inventory. Existing scientific knowledge and data are inadequate and insufficient for estimating these emissions at the national level.

ii) Natural gas

Production, processing and transportation of Canadian natural gas exports to the US result in GHG emissions that are accounted for in Canada's official inventory estimates. The most recent available estimates indicate that Canadian natural gas exports to the US more than doubled between 1990 and 2000, increasing from 1.4 Tcf in 1990 to 3.5 Tcf in 2000. Due to growth in exports, and despite a 9% reduction in emissions intensity, emissions associated with Canada's natural gas exports in 2000 are estimated to be 32 million tonnes of CO_2 equivalent (Mt) or 130% above 1990 levels, and are projected to increase to 36.8 Mt in 2010 or 163% above 1990 levels. Emissions in 2010 incorporate the impact of all planned measures and initiatives announced by industry as of 2000. These measures and initiatives are expected to reduce the average emissions intensity of natural gas production and transportation by 18% between 1990 and 2010. In the absence of these measures and initiatives, emissions in Canada associated with Canadian natural gas exports would be 7 Mt more in 2010.

Table 4 summarizes natural gas emissions by greenhouse gases for 1990 and 2010.

Table 4: Emissions in Canada due to Natural Gas Exports

Mt

	1990				2010 (projected)			
	CO_2	CH_4	N_2O	Total GHGs	CO_2	CH_4	N_2O	Total GHGs
Production	3.4	2.3	0.1	5.8	8.4	5.3	0.1	13.8
Processing	1.8	1.8	0	3.6	4.9	4.3	0	9.2
Transportation	2.8	1.8	0	3.6	9.5	4.3	0	13.8
Total	8.0	5.9	0.1	14.0	22.8	13.9	0.1	36.8

5.2. New US Energy Market Equilibrium

Canada's cleaner energy exports constitute important supply sources for the US market and their absence would result in a new market equilibrium. Several considerations are used to formulate our assumptions in estimating that new equilibrium.

i) Electricity

There are many possible reactions to "missing" Canadian hydro-electricity, ranging between the following two extreme scenarios, presented solely to provide end points for the possible range of assumptions:

Extreme Scenario A

All "missing" Canadian hydro-electricity exports will be replaced by higher consumption of renewables and lower energy consumption. This scenario assumes no possibilities for producing electricity using locally available energy sources. The global environmental benefit created by Canadian hydro-electricity exports would be nil.

Extreme Scenario B

All "missing" Canadian hydro-electricity exports will be replaced by low-efficiency coal-based electricity generation. The global environmental benefit created by Canadian hydro-electricity exports would be 25 Mt.

Canada's Scenario

All "missing" Canadian hydro-electricity exports would be replaced by high-efficiency coal-based electricity generation.

- In the US Northeast, nuclear and coal-fired generation plants are almost fully utilized, while there is considerable surplus capacity of oil-fired generation plants. The fact that coal-fired plants are used at full capacity indicates that, for this region's power generators, coal, an indigenous source, is a preferred option.

- Electricity producers in this region may opt for new (high-efficiency) coal-fired generating plants to replace "missing" Canadian electricity, or they may increase the utilization rates of existing (low-efficiency) oil-fired generating plants. The net impact on emissions would be more or less the same, as the high efficiency of coal-fired generation as compared to low efficiency oil-fired generation compensates for higher emission factors associated with coal consumption.

- We assume that Canada's hydro-electricity exports displace high-efficiency coal-fired electricity generation (38% to 40% efficiency, as compared with the efficiency of existing coal plants - less than 33%).

ii Natural Gas

The absence of Canada's natural gas would decrease the supply of natural gas in the US and result in higher natural gas prices. As a result of higher natural gas prices, a chain of market reactions would result in a new market equilibrium.

This new market equilibrium would be characterized by higher coal-based electricity generation, higher US natural gas production, higher liquid natural gas imports, higher consumption of coal and oil, and lower consumption of natural gas, leading to overall higher US and global emissions. The impacts on US GHG emissions depend strongly on the assumptions underlying this new equilibrium.

The new market equilibrium depends on answers to the question "What adjustments would occur in the United States energy market if Canadian exports of natural gas were eliminated?" There are many possible answers to this question, ranging between the following two extreme scenarios, presented solely to provide end points for the possible range of assumptions:

Extreme Scenario A

Impacts on natural gas prices, as well as on other fuel prices, would be severe enough to induce large research and development (R&D) investments in energy efficiency and encourage finding new renewable energy sources to such a degree that "missing" Canadian natural gas, as well as hydro-electricity, will be replaced by lower energy consumption and higher consumption of renewable energy sources.

This scenario assumes no possibilities for the substitution of other fuels and/or for higher US natural gas production and higher LNG imports. The global environmental benefit created by cleaner energy exports would be negative (-140 Mt).

Extreme Scenario B

All "missing" Canadian natural gas will be replaced by indigenous coal.

This scenario assumes that all natural gas consumption can be replaced by coal. In reality some of the natural gas consumption (e.g., natural gas liquids) cannot easily be replaced by coal or oil. The global environmental benefit created by Canada's cleaner energy exports would be highly positive, in the order of 300 Mt.

Canada's Scenario

Canada's scenario, as described in this paper, involves a combination of market reactions. Based on data regarding US regional and sectoral consumption of natural gas, regional availability of indigenous resources, the possibility of increasing US natural gas production (including Alaskan gas) and importing liquid natural gas (LNG), we assume that "missing" Canadian natural gas in the US would be replaced by higher US natural gas production, higher liquid natural gas imports, higher consumption of coal and oil, and lower consumption of natural gas, as follows:

- 26% by higher US natural gas production;
- 6% by increased LNG imports;
- 30% by higher consumption of coal;
- 30% by higher consumption of oil; and
- 8% by lower energy consumption (higher energy efficiency).

6. Results

Table 5 summarizes the impacts of Canada's cleaner energy exports on global GHG emissions.

S As a result of Canada's hydro-electricity exports, in the first commitment period, annual global GHG emissions will be 20 Mt lower.

S As a result of Canada's natural gas exports during the same period, annual global GHG emissions will be 62 Mt lower.

S The total impact on annual global GHG emissions due to Canada's cleaner energy exports in the first commitment period is thus estimated to be 82 Mt.

S Comparing these estimates with those of 1990 (13 Mt), the change in the annual global GHG emissions from 1990 to 2010 due to Canada's cleaner energy exports would be 69 Mt.

This scenario, like all scenarios, is one possible future, but we believe it to be a fair assessment

of possible US energy market reaction to "missing" Canadian natural gas and hydro-electricity. The assumptions are based on a thorough US energy market assessment.

Table 5: Global Environmental Benefit

	Year	Natural Gas	Hydro-electricity	Total
Emissions in Canada associated with production/transportation	2010	37	0	37
	1990	14	0	14
	change between 1990 and 2010	23	0	23
Global environmental benefit created by Canada's cleaner energy exports (net of emissions in Canada and net of emissions in US from imports)	**2010**	**-62**	**-20**	**-82**
	1990	-17	4[3]	-13
	change between 1990 and 2010	**-45**	**-24**	**-69**

7- Other Studies/Estimates

Canada has commissioned two independent studies in addition to this paper. These independent studies, based on very different assumptions regarding the new US energy market equilibrium, indicate that this paper's estimates are at the lower end of the range of possible and defensible estimates of the global environmental benefit created by Canada's cleaner energy exports:

- McCann/Ziff[4]: assumes that LNG will replace Canadian cleaner energy (along with minor use of unused coal and nuclear generating capacity and return of major northwest US hydro-electricity). The study assumes an arbitrary 25% of new LNG from Alaska, and the rest from the Caribbean, Africa and the Far East. Total displaced emissions would range between 90 Mt and 145 Mt, for an average of 113 Mt. The growth in displaced emissions between 1990 and 2010 on average would be 100 Mt.

[3] In 1990, Canada displaced 5 Mt of emissions in the US, which partially offset the 9 Mt of emissions associated with imports of fossil fuel-generated electricity from the US.

[4] T.J. McCann and Associates, "Canadian Energy Vector Exports and Greenhouse Gases", 2001. McCann used analysis and results of a study by Ziff Energy, " Impacts of Canadian Electricity and Gas Exports in the United States ", 2001, to estimate the impacts of "missing" Canadian cleaner energy exports on global GHG emissions. We have adjusted the original McCann estimates to reflect the revised forecast for natural gas exports in 2010.

- Cheminfo (Survey of energy experts)[5]. 21 experts were interviewed and 21 different answers obtained.

The average views are that:

Canadian natural gas in the US will be replaced by:

- alternative natural gas supply (i.e., LNG, domestic and imported) 35%
- oil 33%
- coal 9%
- lower demand or non-fossil fuels 23%

Canadian hydro-electricity in the US will be replaced by:

- oil-generated electricity 56%
- coal-generated electricity 41%
- hydro-electricity and other renewables 2%
- nuclear-generated electricity 1%

The estimated net impact on emissions would be 80 Mt in 2010, and the growth in displaced emissions would be 67 Mt.

These average views included two extreme assumptions:

- More than 80% of Canada's cleaner energy will be replaced by conservation and/or renewable non-fossil fuel energy. This very unlikely scenario, which assumes large R&D investments and ignores possibilities of easily substituting natural gas with oil or coal, results in a negative displacement (i.e., lower emissions) of 120 Mt.

- 90% of cleaner energy will be replaced by imported oil and the remainder by domestic natural gas. This scenario would result in at least 170 Mt in displaced global emissions.

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[5] "Adjustments in the U.S. Energy Markets Resulting From Reduced Canadian Exports of Natural Gas and Electricity (A Survey of Energy Experts)", conducted and prepared by Cheminfo Services Inc., February 2002. This study used a telephone survey of 21 Canadian, US and UK energy experts to gather responses related to what they believe would be the market adjustments in US energy flows resulting from the hypothetical elimination of Canadian natural gas and electricity exports. Emissions associated with these responses are estimated by government of Canada.

As noted, there are considerable differences between the assumptions underlying these studies, as summarized in Table 6.

Table 6: Underlying Assumptions of Various Studies

Canada	McCann/Ziff	Cheminfo
Natural gas replaced by higher US natural gas production 26%; more LNG imports 6%; higher consumption of coal 30%; higher consumption of oil 30%; and lower energy consumption (higher energy efficiency) 8%. Electricity displaces high-efficiency coal generation.	All "missing" Canadian cleaner energy will be replaced by 25% domestic (including Alaska) LNG and 75% imported LNG.	Natural gas will be replaced by alternative NG supply (i.e.,LNG, domestic and imported) 35%; oil 33%; coal 9%; lower demand or non-fossil fuels 23%. Hydro-electricity will be replaced by oil-generated electricity 56%; coal-generated electricity 41%; hydro-electricity and other renewables 2%; nuclear-generated electricity 1%.

Table 7 presents the results of the various studies. As may be seen from this table, the results of the studies, even while using different assumptions, were not entirely dissimilar.

Table 7: Results from Different Studies

	Avoided Emissions in 2010	Change between 1990 and 2010
McCann/Ziff	(90 -145 Mt) Average 113	Average 100
Cheminfo (average views)	80	67
Canada	82	69

8. Uncertainty/Conservative Assumptions

8.1 Uncertainty

All estimates are subject to substantial uncertainty regarding :

- the magnitude of projected natural gas and hydro-electricity exports;
- the emissions associated with these exports; and
- US energy market reactions to "missing" Canadian cleaner energy.

These uncertainties, more or less reflected to the same degree, are associated with any plausible scenario and their existence does not reduce the validity of the estimates (at least as compared to other scenarios).

8.2 Conservative Assumptions

In an attempt to assure realism and to minimize uncertainty, we have used the following conservative assumptions in our estimates:

- all electricity produced to replace Canada's "missing" cleaner energy will be generated by high efficiency coal plants (38 to 40% efficiency, as compared to the less than 33% efficiency of existing coal plants);
- emissions associated with production and transportation of additional coal are nil;
- emissions associated with production, transportation and refining of additional (imported) oil are nil;
- emissions associated with LNG production (and/or imports) are the same as natural gas, with no additional emissions associated with its transportation; and
- no additional emissions that could result from required rerouting of US natural gas production or production and transportation of Alaskan natural gas[6].

Notably, Canada's projections of net natural gas and hydro-electricity exports to the United States in 2010 are considerably lower than the US Energy Information Administration's (EIA) projected demand

[6]In order to replace "missing" Canadian natural gas with US natural gas (including Alaskan gas) and imported LNG, some of the US pipeline system may have to be modified. This may result in higher emissions associated with transportation.

for natural gas and hydro-electricity from Canada. Canada has used conservative estimates regarding how much of that demand can be met.

A deviation from these assumptions would result in higher emissions in the United States due to "missing" natural gas and hydro-electricity from Canada and a higher estimate of the global environmental benefit created by Canada's cleaner energy exports.

9. Conclusion

Government of Canada has used conservative and realistic assumptions to produce estimates of the net impact on global GHG emissions if Canadian natural gas and hydro-electricity exports were not available. It is estimated that the global environmental benefit produced from these exports in 2010 is approximately 82 Mt, and that in 1990 it was 13 Mt. The growth in the global environmental benefit between 1990 and 2010 is therefore 69 Mt.

These estimates are well in line with two other estimates undertaken by independent consultants using assumptions very different from each other and from those used by Canada. These three independent studies show that, with any reasonable and defensible assumptions underlying the new market equilibrium in the US, the net impact of Canada's cleaner energy exports on global GHG emissions would be about 80 Mt in 2010, or about 70 Mt more than it was in 1990.

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Annex 1

Detailed calculation of global environmental benefit created by Canada's cleaner energy exports

2010 Emissions in Canada

1. Exports of natural gas	**37 Mt**
2. Exports of hydro-electricity	**0 Mt**
3. Total emissions in Canada associated with production and transportation of cleaner energy (1+2)	**37 Mt**

1990 Emissions in Canada

4. Exports of natural gas	**14 Mt**
5. Exports of hydro-electricity	**0 Mt**
6. Total emissions in Canada associated with production and transportation of cleaner energy (4+5)	**14 Mt**

Growth in Canada's emissions between 1990 and 2010 due to exports of cleaner energy (3-6)	**23 Mt**

2010 Displaced emissions due to Canada's natural gas exports

Without Canada's natural gas exports to the US there would be:

7. More production of US natural gas and/or LNG imports	**12 Mt**
8. More consumption of oil	**105 Mt**
9. More consumption of coal	**139 Mt**
10. Lower energy consumption	**0 Mt**
11. Less consumption of natural gas	**157 Mt**
12. Displaced emissions in the US due to Canada's exports of natural gas (7+8+9+10-11)	**99 Mt**
13 Net displacement (global environmental benefit) in 2010 due to Canada's exports of natural gas (12-1)	**62 Mt**

2010 Displaced emissions due to Canada's hydro-electricity exports

Without Canada's hydro-electricity exports to the US there would be

14.	More coal-based electricity generation	**20 Mt**
15.	But Canada imports coal-based electricity from the US	**1 Mt**
16.	Displaced emissions in the US due to Canada's net exports of electricity (14-15)	**20 Mt** [7]
17.	Net displacement (global environmental benefit) in 2010 due to Canada's net exports of electricity (16-2)	**20 Mt**
18.	**Total net displacement (global environmental benefit) in 2010** due to Canada's net cleaner energy exports (17+13)	**82 Mt**

1990 Displaced emissions due to Canada's natural gas exports

Without Canada's natural gas exports to the US there would be

19.	More production of US natural gas and/or LNG imports	**4 Mt**
20.	More consumption of oil	**35 Mt**
21.	More consumption of coal	**43 Mt**
22.	Lower energy consumption	**0 Mt**
23.	Less consumption of natural gas	**51 Mt**
24.	Displaced emissions in the US due to Canada's natural gas exports (19 +20+21+22-23)	**31 Mt**
25.	Net displacement (global environmental benefit) in 1990 due to Canada's natural gas exports (24-4)	**17 Mt**

1990 Displaced emissions due to Canada's hydro-electricity exports

[7] The figures in lines 14, 15 and 16 were rounded after calculations. In effect, there were several decimals in each figure. The decimals were kept in the calculation, but they were rounded (e.g. 0.6 becomes 1) for simplicity in the presentation. In this case 20.49 (line 14) - 0.6 (line 15) = 19.9 (line 16) became 20 -1 = 20.

Without Canada's hydro-electricity exports to the US there would be

26.	More coal/oil-based electricity generation	**5 Mt**
27.	But Canada imported coal-based electricity from the US	**9 Mt**
28.	Displaced emissions in the US due to Canada's net exports of electricity (27-26)	**4 Mt**
29.	Net displacement (global environmental benefit) in 1990 due to Canada's net exports of electricity (28-5)	**4 Mt**
30.	**Total net displacement (global environmental benefit) in 1990** due to Canada's net cleaner energy exports (25-29)	**13 Mt**

Growth in net displacement (global environmental benefit) between 1990 and 2010 due to Canada's natural gas exports (13-25) **45 Mt**

Growth in net displacement (global environmental benefit) between 1990 and 2010 due to Canada's net electricity exports (17+29) **24 Mt**

Growth in net displacement (global environmental benefit) between 1990 and 2010 due to Canada's net cleaner energy exports (18-30) **69 Mt**