Implementing the Kyoto Protocol in Canada: an Analysis of Provincial Economic Costs

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Paper Presented at the Canadian Economics Association Conference
Carleton University, Ontario
June 1-3, 2003

Abstract

This paper compares federal forecasts of provincial economic costs of implementing the Kyoto Protocol, for two different policy scenarios: the "Broad-as-Practical" option and the "Reference-Package" option. To do this, we use information from the two major public federal discussion papers, and unpublished federal documents.

We first explain Canada's Kyoto targets at the national level, and outline forecasts of greenhouse emissions by province under the "business-as-usual" assumption. We then explain the two policy options in detail and compare the estimated provincial economic costs of the two approaches, looking at investment costs, fuel costs, permit costs and total costs.

This investigation reveals that: (1) forecasted changes to GDP, by province for a single year, represent a misleading indicator of true economic cost; and (2) the variance of economic costs, across provinces, is wider than that suggested by the federal government.

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Introduction

The Kyoto Protocol commits Canada to reduce greenhouse gas (GHG) emissions by 6 percent below 1990 levels by 2010. At the same time, agreements made by the First Ministers meeting in 1997 state that no province or region should bear an "unreasonable cost" of implementing the Accord. To this end, provincial governments across Canada have been asked to work with the federal government to implement the Protocol.

In April 2002, the federal government released its white paper, *A Discussion Paper on Canada's Contribution to Addressing Climate Change* (referred to here as the *Discussion Paper*). In the paper the government states that the most efficient policy option to achieving its Kyoto goals – namely the "Broad as Practical" (Case 1) option – yielded disproportionate burdens of economic costs to the energy-producing provinces, in particular Alberta. Soon after the release of the federal discussion paper and throughout the summer and fall of 2002, the Alberta government undertook strong opposition to the federal government's commitment to Kyoto. The Alberta government in fact announced its own made-in-Alberta Kyoto policy.

Consequently, as Alberta's opposition to Kyoto intensified, the federal government throughout 2002 developed various implementation scenarios. The result has been an efficiency vs. provincial equity tradeoff. The federal government states that a first-best Kyoto solution is not possible, given an unequal distribution of economic costs across provinces.

In November 2002, the federal government issued its main Kyoto policy paper, *A Climate Change Plan for Canada* (Referred to here as the *Climate Change* paper). In this paper the federal government states that, under what it calls its "federal finance" "Reference-Package" option, provincial economic equity, or a reasonably equal sharing of economic costs across provinces, is achieved. The results from this second federal policy paper suggest that provincial equity is achieved, but at a somewhat higher overall economic costs.

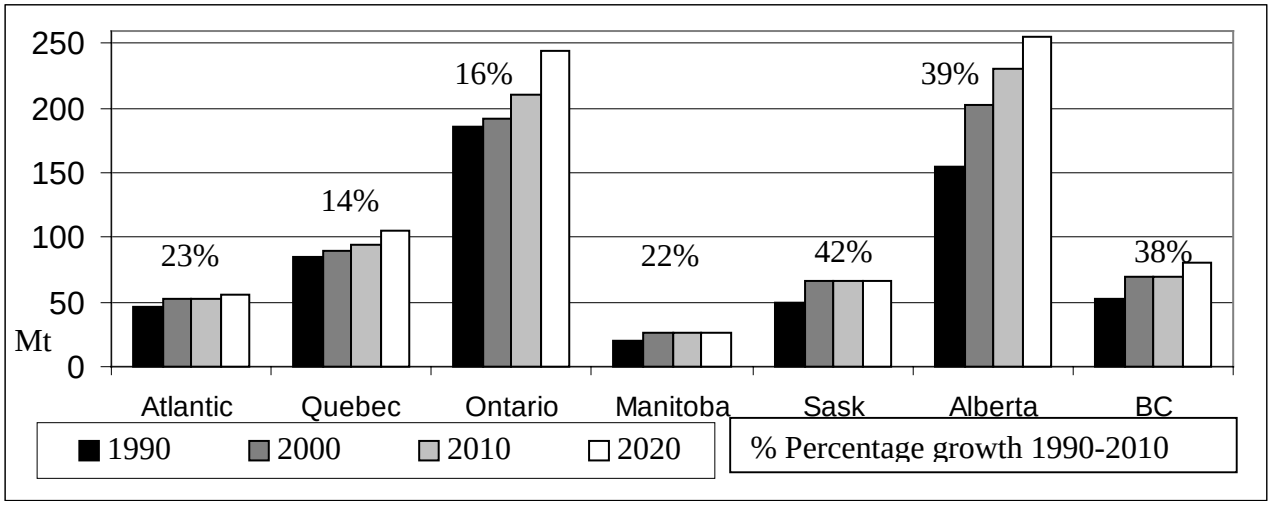
Our paper describes the above federal government policy scenarios, and their implications as to economic costs by province. In the following section, we discuss Canada's commitment to achieving a national Kyoto target, and show the "business as usual" GHG -emission projections by province. In the third section of the paper, we discuss the various policy proposals suggested by the federal government, moving from the first April 2002 *Discussion Paper* to the November *Climate Change Paper*. In section four, we compare the two main policy proposals – the "Broad-as-Practical" and "Reference-Package" options as they pertain to provincial economic costs. We do this in two ways, by comparing total economic costs from unpublished federal documents, and by comparing changes to provincial GDP from the two policy papers. Section five concludes.

Projections, Gaps, and Targets

The federal government has released a number of updated GHG emission projections over the past few years, reflecting in part the changing economic climate that Canada is expected to face in the near future.[1] The projections are based on provincial-level analysis (the aggregate trend is composed of a provincial 'roll-up').[2] Figure 1 portrays long-term emissions growth projections on a provincial basis (within the context of the 'Policy as Usual' scenario).[3] The information is organized to indicate, for each region, the expected percentage growth in GHG emissions in 2000, 2010, and 2020, relative to the 1990 level.

Several points are worth noting in Figure 1 (Government of Canada, 2001): (i) In 1990-2000, GHG emissions growth was greater than the national average in Saskatchewan, Alberta and British Columbia. These increases are associated with the resource boom in the West and, in the case of British Columbia, population increases; and (ii) In 2000-2010, growth in emissions is projected to be more evenly distributed across provinces, with Ontario and British Columbia recording above average increases. For Ontario, the major reasons for the increases are the greater use of natural gas and coal for electricity generation. Also in this period, Alberta and Saskatchewan's emissions growth are expected to slow largely as a result of the increasing effectiveness of the oil and gas industry initiatives to constrain emissions.

Figure 1: 'Policy-as-Usual' GHG Emission Projections by Region in Canada (1990-2020)



Source: Government of Canada (2001).

As revealed in Figure 1, the most recent provincial business-as-usual (BAU) GHG emission projections for 2010 are 14 Mt in Newfoundland, 2 Mt in PEI, 21 Mt in Nova Scotia, 23

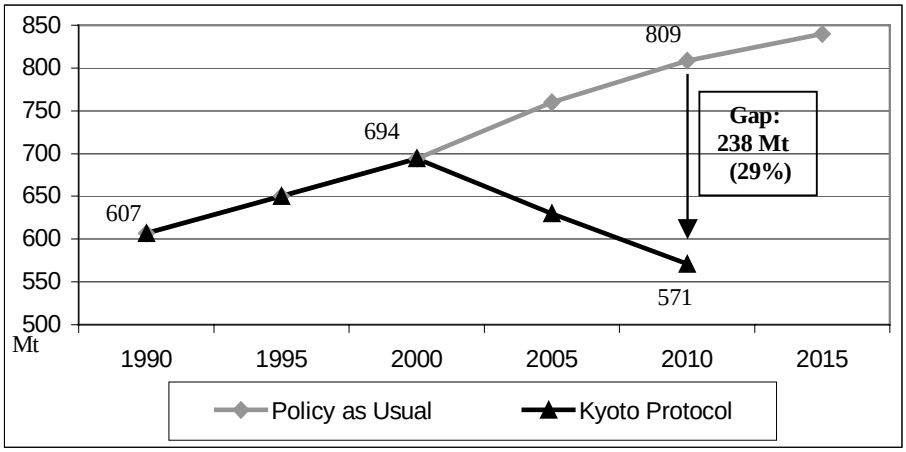
[1] Projections are based on a three-step procedure. First, the major framework procedures are defined (including assumptions about energy prices, the US economy and energy market, Canadian macroeconomic performance and demographics, and current policies). Second, a modeling structure that combines econometric, end-use, and process techniques is then used to project energy demand, supply and associated emissions. Lastly, results were shared with stakeholder and were revised if comments were found logical and consistent (Government of Canada, 2001).

[2] To date, there have not been any provincial or regional targets set to achieve the Kyoto Protocol.

[3] These regional projections, provided by Government of Canada (2001), have changed slightly since this province-level report. However, more recent data was not available to the public at the time of writing this paper.

Mt in New Brunswick, 99 Mt in Quebec, 215 Mt in Ontario, 26 Mt in Manitoba, 69 Mt in Saskatchewan, 260 Mt in Alberta, 74 Mt in British Columbia, and 3 Mt in the NWT/Yukon, and Nunavut region. All added up, this works out to approximately 809 Mt of GHG emissions in Canada (Analysis and Modeling Group 2002; National Climate Change Process 2002). This represents a 238 Mt. 'Gap' (or 29 percent difference) between the GHG projections and Canada's commitment under the Kyoto Protocol.[4] Figure 2 presents the BAU scenario (hereto referred to as 'Policy as Usual') along with the required emission reductions to meet the Kyoto Protocol.

Figure 2: Canada's GHG Projections and Kyoto Target:



Source: AMG (2002a).

The Policy Implementation Context

The federal government has developed many implementation scenarios. The least cost scenario, known as 'Broad-as-Practical', and the most likely scenario, known as the 'Reference-Package', are introduced below.

In the 'Broad-as-Practical' scenario, a diverse set of policies and instruments would be used to achieve the desired 240 Mt GHG emission reductions. Specifically, the following instruments (and associated emission reduction contributions) would be employed: (i) previous actions and credits (74 Mt); (ii) Action Plan 2000 and Budget 2001 (50 Mt); (iii) existing sinks (24 Mt); (iii) a domestic emissions trading (DET) permit system (144 Mt); (iv) new reductions (16 Mt); private sector purchases of international permits (128 Mt); targeted measures (22 Mt); and incremental government purchases of international purchases (0-30 Mt).

The DET system in the 'Broad-as-Practical' scenario is applied to most fossil fuel producers and process emissions (covering about 80 percent of total GHG emissions). Here, a given number of GHG permits (equaling 94 percent of 1990 emissions plus a portion of the forest sink in 2010, 2015, and 2020) are auctioned and permit revenues are redistributed to consumers

[4] The GHG emission 'Gap' accounts for the 1995 National Action Program On Climate Change (NAPCC) plan. This initiative includes various government-level 'leading-by-example' policies and a private sector component called the Voluntary Challenge and Registry Inc. (VRC) program.

through personal income tax system (50 percent federal and 50 percent provincial).[5] The allocation and re-distribution of permit revenues in this way is thought to be the most desirable since: (i) this follows the polluter-pays philosophy and does not provide excess profits to fossil fuel suppliers as might occur if permits were distributed freely; and (ii) energy prices are expected to be driven upward causing undue hardships on consumers who need to be compensated; and most importantly, (iii) the double-dividend hypothesis of environmental taxation (and associated reduction in income taxes) will stimulate the economy.

In their Discussion Paper document, the federal government stresses that the "Broad-as-Practical" (Option 1) approach is hypothetical (p. 22), for a number of reasons. First, the paper stresses inequity results across provinces. Given an Option 1 policy, the paper forecasts that several provinces – New Brunswick, Prince Edward Island, and Saskatchewan – would witness slight real GDP declines , and Alberta would see a large .5 percent real GDP fall. Second, consumer energy prices – electricity, natural gas, gasoline – are predicted to jump sharply – and while it is true that consumers would be compensated through income tax reductions, it may be the case that very poor consumers (who pay no income tax) would lose out. Third, a predicted heavy use of international CO2 trading permits would imply a large capital outflow ($1.28 billion), capital though perhaps could be better used to finance in-Canada investment and new technology (p. 26).

Since the release of the federal Discussion Paper in April 2002, the Government of Alberta has formally opposed the federal government initiative. In September 2002, the provincial government announced spending of $1 ½ million on a publicity campaign to outline its its case. In October 2002, the provincial government announced its own made-in-Alberta plan, entitled Albertans and Climate Change: Taking Action. Their plan centres on achieving a 22 percent reduction in CO2 emissions (20 Mt) by 2010 – using energy conservation and targeted CO2 reductions though industry agreements.

In November 2002, the federal government released its *Climate Change* paper, that promoted what the federal government termed its Reference Policy Package. This policy option is a slight variant of "Option 4" in the previous *Discussion Paper*. At the time of the earlier paper's release, economic simulations of Option 4 were not finalized, or at least had not been released in that earlier paper (see Government of Canada, 2002b, p. 61).

The 'Reference-Package' scenario also contains a diverse set of policy instruments to achieve GHG emission reductions. This scenario is expected to directly achieve 170-180 Mt emission reductions from the BAU projection. The remaining 60-70 Mt Kyoto Protocol gap would be left to voluntary or other such measures.[6] The particular instruments promoted in this scenario include: (i) the previously announced Action Plan 2000 and the 2001 Budget (25 Mt); (ii) a domestic emissions trading (DET) system for the large industrial emitters (55 Mt); (iii)

[5] Uncovered sectors (covering 22 percent of total GHG emissions) are directly allocated 94 percent of their 1990 emissions plus a portion of forest sink in 2010, 2015, and 2020. These sectors cannot (and will not need to) sell permits. Instead, the government must purchase international permits if needed.

[6] In the Climate Change Plan for Canada, it is not clear where the additional 60-70 Mt of emission reductions comes from. It seems as though these reductions may rely heavily on the federal government's challenge to individual Canadians to voluntarily reduce GHG emissions "by an average of one tonne per year by 2008-2012" (Government of Canada 2002a).

targeted measures (60-70 Mt); (iv) agricultural and forest sinks from current practices (30 Mt); and (v) a system of offsets emanating from future agricultural, forestry, and landfill gas sectors (0-20 Mt) (Government of Canada 2002a).

Within the DET system of the 'Reference-Package', permits are allocated freely to the covered industrial sectors[7] (representing about 40 percent of total emissions) in a way that reflects emissions intensity, capacity to reduce emissions, and forecast BAU output (Government of Canada 2002a). More specifically, the government is considering allocating to each covered sector: (i) a permit-per-output that is a fixed (province-specific) fraction of its 1990 emission-per-output, and (ii) an additional number of permits in the sector as a whole as determined by a 'tripych formula' (AMG 2002b). The triptych formula is based on a set of equations reflecting various socio-economic factors in each jurisdiction. These parameters include economic growth, fuel types, and desired emission performance. Equations are applied to three sectoral categories including energy-intensive industries (where growth requirements are accounted for), electricity generation (where a given rate of emission reductions is assumed), and the domestic sector (where a given rate of convergence of emissions per capita is assumed). Separate equations are used for non-CO_2 gases from controllable process emissions, high emission growth sources, and emission fro which limited reduction options exist (AMG 2002c). Appendix 1 provides the resulting allocation of emission targets by province and sectoral category. Table 1 summarizes the major differences between the 'Broad-as-Practical' and 'Reference-Package' scenarios.

Table 1: Major Differences Between the 'Broad-as-Practical' and 'Reference-Package' Scenarios

'Broad-as-Practical'	'Reference-Package'
• Permits auctioned and revenues re-distributed to consumers through income-tax reductions	• Permits allocated freely to polluters.
• Permit system covers approximately 80% of emissions from a wide range of industrial sectors.	• Permit system covers about 40% of emissions from large final emitters.
• Permit System expected to deliver a significant reduction in Canadian emissions.	• Permit system expected to deliver a modest reduction in Canadian emissions.
• Permit system provides as much emission reductions as other instruments such as subsidies and voluntary actions.	• Permit system plays a much smaller role than other instruments in contributing to emission reductions.
• Thought to be the low cost scenario in aggregate, but leads to greater inequity between jurisdictions.	• Thought to be the high cost scenario in aggregate, but leads to more equity between jurisdictions.

Implementation Scenario Comparisons

Federal Government Forecasts of GDP Costs by Province in 2010:

In this section, we compare the federal government's forecasts of 2010 provincial GDP output, given the two policy options discussed in this paper: the "Broad-as-Practical" option

[7] In particular, all the emissions from mining, iron and steel, pulp and paper, smelting, refining, industrial minerals, oil refining, pipelines, and fossil-fuel electricity generation are covered. Additionally, about 70 percent of oil production and 50 of natural gas production are covered.

(Option 1) from the May 2002 *Discussion Paper*, and the "Reference-Package" option from the November 2002 *Climate Change* paper. The "Reference-Package" option is discussed in two ways: (i) a "government finance" option whereby increased federal Kyoto measures are financed out of forgone future budget surpluses; and (ii) the "tax finance" option, whereby increase federal spending comes from increase taxes. As the *Climate Change* paper stresses (p. 60), the "government-finance" option yields lower economic costs, because of the negative impacts from higher tax rates. The Climate change policy paper states that the "government-finance" option is the more likely scenario (p. 62).

Table 2 shows the comparison of the provincial burdens of economic cost, for the "Broad-as-Practical" option and the "Reference-Package" option (under "government-finance" and "tax-finance" options). Note that the federal government uses reduced GDP, for the target year 2010 only, as their measure of economic cost. "Reduced GDP", expressed in percentage point change form, represents the reduction in GDP from the "Policy-as-Usual" case, whereby the federal government did nothing to affect business as usual. We will extend the GDP analysis by reporting actual changes in GDP (a measure of economic costs) further below.

As can be seen from Table 2, moving from "Broad-as-Practical" to the "Reference-Package" options does entail increase economic costs at the national level, since GDP falls from +0.4 percent in the former case to -0.4 percent in the latter case, for a \$10 CO_2 emission price.[1]

As the *Climate Change* paper states (pp. 66-67), under both the "government financing" and "tax financing" options, the economic costs are shared roughly equally across provinces, for the likely \$10 emission price. Specifically, Alberta and Saskatchewan were relative losers under "Broad-as-Practical", but under "government financing" their -0.4 percent real GDP losses are at the Canada-wide mark. This is a change towards provincial equity, from that of "Broad-as-Practical", but the change entails an efficiency cost. If the federal model calculations are accurate (and we do not at all question the integrity of the actual model calculations), the results from the *Climate Change* paper might be seen as going a long way to answering Alberta's objections.

The manner in which Alberta and Saskatchewan gain in relative terms moving from "Broad-as-Practical" to "Reference-Package" options deserves further attention. From the expected changes in CO_2 reductions (see Table 3) below, it at first glance appears that Saskatchewan and Alberta suffer from increased CO_2 reductions, at a rate higher than that for central or Atlantic Canada. But the "sinks" allocation line for the "Reference-Package" ("tax finance" option), does not include agricultural sinks, and one this non-inclusion is factored in the percentage increase for the two prairie provinces would decline appreciably.

[1] In this paper, we will discuss only the \$10 emission price for brevity's sake. Note that economic costs are higher for the \$50 CO_2 price, since such a price curbs use of emission permits, and induces further conservation measures by non-permit agents.

Table 2: Percentage Changes in Real GDP under the Federal Governments' "Option 1", "Government Finance", and "Tax Financed" Scenarios (relative to "Business-as-Usual")

	$10 CO2 Emission Permit Price			$50 CO2 Emission Permit Price		
Province	**Option 1: Disc.Pap.**	**"gov fin": Clim.Chg**	**"tax fin" Clim.Chg.**	**Option 1: Disc.Pap.**	**"gov fin": Clim.Chg**	**"tax fin" Chim.Chg**
NFL	0.1	- 0.2	- 0.7	-1.0	- 0.1	- 0.1
PEI	- 0.1	- 0.4	- 0.2	0.4	- 0.5	-1.1
NS	0.3	- 0.3	-1.0	0.6	- 0.4	-1.3
NB	- 0.1	- 0.2	- 0.9	0.1	- 0.3	-1.2
QUE	0.5	- 0.2	-1.1	0.7	- 0.4	-1.3
ONT	0.6	0.2	- 0.8	0.9	0.1	-1.0
MAN	0.3	- 0.2	- 0.9	0.4	- 0.4	-1.2
SASK	- 0.1	- 0.4	-1.0	- 0.7	- 0.4	-1.1
ALB	- 0.5	- 0.4	- 0.9	-3.7	- 1.5	-2.2
BC	0.4	- 0.5	- 1.3	0.7	- 0.8	-1.7
TERR	0.5	0.0	- 0.6	0.5	- 0.4	- 0.8
CAN	0.4	- .4	-1.2	0.1	- 1.2	- 1.6

Sources: Government of Canada (2002b); Government of Canada (2002a).

Table 3: Changes to Forecast Provincial Emission Reductions of CO2 (Mt), Comparing "Case 1" in Discussion Paper with 'Reference-Package' option: "tax-financed" – for 2010

	$10 CO2 Emission Permit Price			$50 CO2 Emission Permit Price		
Province	**Option 1: Disc.Pap.**	**"tax.fin." Clim.Chg**	**% point change**	**Option 1: Disc.Pap.**	**"tax.fin": Clim.Chg**	**% point change**
NFL	0.8	1.4	0.6	1.1	1.6	0.5
PEI	0.1	0.4	0.3	0.2	0.4	0.2
NS	1.3	1.7	0.4	1.6	1.9	0.3
NB	2.9	2.4	- 0.5	2.8	2.6	- 0.2
QUE	7.6	13.0	5.4	10.1	14.5	4.9
ONT	25.8	31.4	5.8	29.4	39.1	9.7
MAN	1.7	6.0	4.3	2.2	6.3	4.1
SASK	2.8	13.3	10.5	3.6	15.1	11.5
ALB	20.8	30.0	9.2	21.9	47.6	25.7
BC	6.1	10.9	4.8	7.7	13.8	6.1
TERR	0.3	0.4	0.1	0.5	0.4	- 0.1
Sinks*	34.1	20.0*	-14.1	34.1	20.0*	- 14.1
Sub-Total	104.2	130.9	26.1	115.2	163.6	48.4
Permit Purchases		47.3		18.6		
Total		178.2		181.9		

Sources: Government of Canada (2002b); Government of Canada (2002a).

* carbon sink allowances exclude agricultural sinks, which are included with provinces.

Differences in Total Costs by Province in 2010

We stress here that, in its *Climate Change* paper, the federal government reports only "losses in GDP" as provincial economic costs. But in one unpublished document (Kanudia and Loulou 2002), the MARKAL model was used to calculate other economic costs, by province and by industry, given various policy and CO_2 emission price scenarios.[8] In Figure 3, we report the cost estimates produced from the Kanudia and Loulou document for the 2010 year (which include investment, fuel, and permit costs), and graft onto their results economic costs in lost GDP to obtain a total 2010 provincial economic cost.[9]

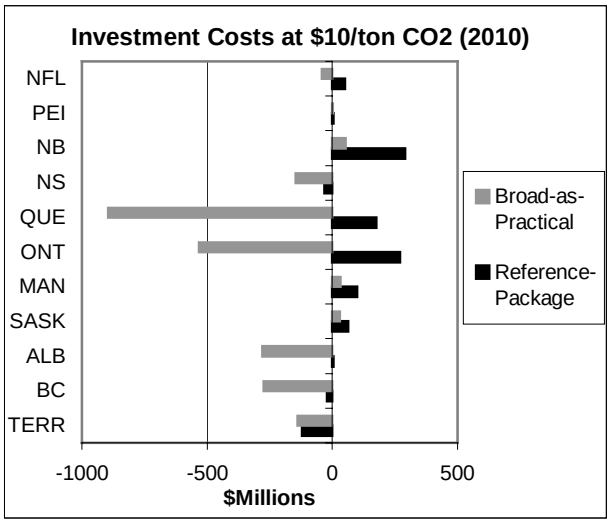
At the Canada-wide level, under Broad-as-Practical, there are efficiency gains (negative losses) for investment costs, fuel costs, and GDP. Moving from a "Broad-as-Practical" scenario to the "Reference-Package" increases total 2010 costs, from $-7.2 billion to $1.6 billion (not shown in Figure 33, but see Table A2.5 in Appendix 2). Under the Reference Package scenario, there is a positive $780 million in investment costs and positive foregone GDP. Note that a total $1.6 billion cost of Kyoto, while less efficient than the efficiency gains under "Broad-as-Practical", is not a large cost when measured against total GDP. Nearly all of this increased cost is borne by central Canada (Ontario and Quebec), with Alberta seeing a modest increase in total economic costs. But for Alberta, the $1.2 billion in total economic costs is not large when measured against its 2010 GDP.

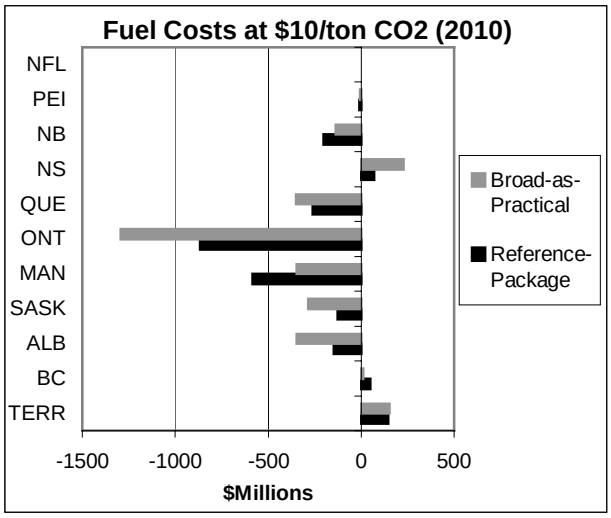
Under the "Reference-Package", Ontario still registers a net total economic benefit (negative cost) of $1.7 billion. Note further that Canada's West (Alberta, Saskatchewan, and British Columbia) bear a total economic cost that is greater than Canada as a whole. While this is also true looking only at foregone GDP, the economic costs borne by Canada West is slightly higher looking at total economic costs. The reason for this is from a decline in benefits accruing to the West, from lower gains from investment and fuel prices. As such, we conclude under the 2010 perspective that the use of total economic costs accords a modest move towards provincial economic inequality against Alberta (and Saskatchewan and British Columbia), but the move is only modest.

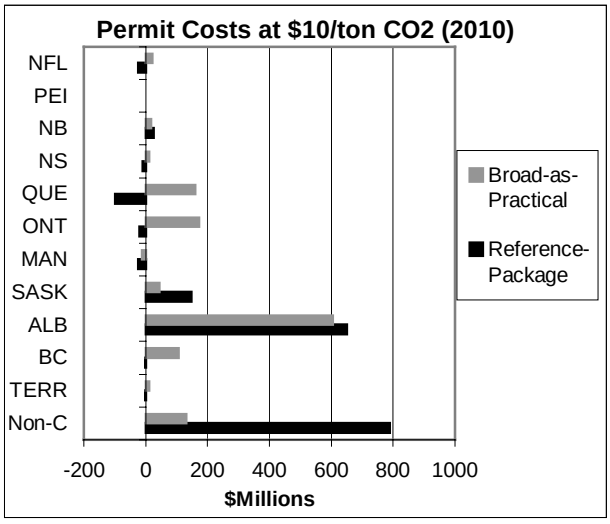
[8] The Energy Modelling Group (EMG) of the Climate Change Secretariat has been using two different economic models to analyze various energy market scenarios by industry sector and by province: the Energy 2020 model and the MARKAL model. The Energy 2020 model is described in the Climate Change paper [Government of Canada (2002a, p. 60)]. The MARKAL model is described in AMG (2002b). The MARKAL model is seen to very similar to the ENERGY 2020 paper, but the former has a more detailed depiction of energy technologies and cost minimization strategies. In particular the model computes a regional equilibrium based on the long-run, least total costs for the entire system. It assumes that the markets are fully competitive. It also assumes that all agents (producers and consumers) minimize their own long-run costs under the following conditions: (1) each agent has perfect-information on all agents over the model horizon of 40 years, (2) each agent adopts the long-term view to optimize its financial cost, (3) all agents use the same discount rate, and (4) electricity is prices using marginal costs, reflecting a fully competitive market [AMG (2002b, 16)].

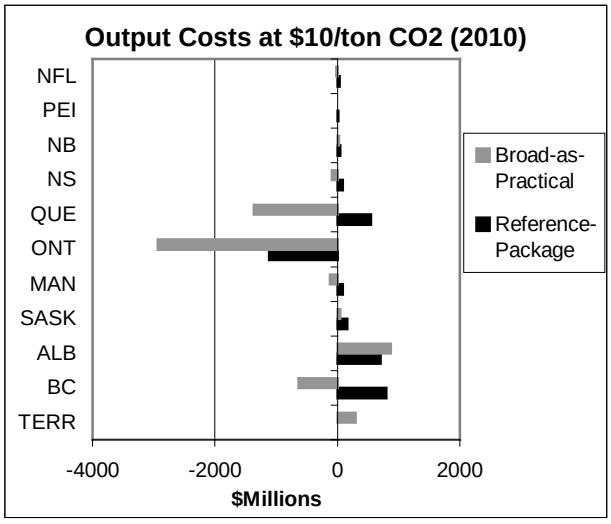
[9] Appendix 2 provides the information for the $10/ton and $50/ton in tabular form.

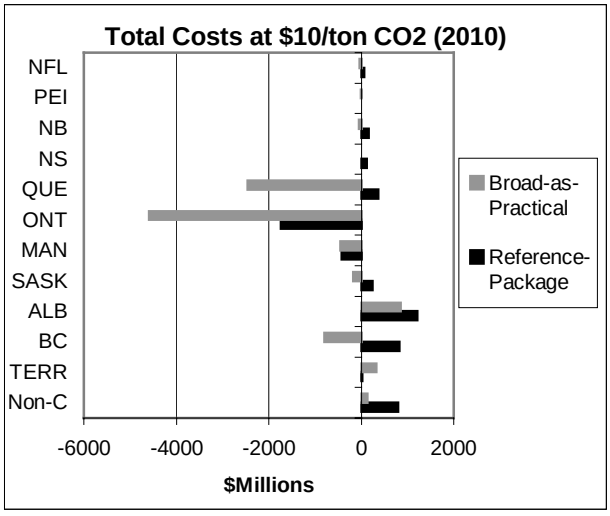
Figure 3: Costs of 'Broad-as-Practical' vs. 'Reference Package' Scenarios with Permits Valued at $10/ton CO_2 Equivalent (2010)[*]











[*] The 'Reference-Package' scenario results are based on the 'government-financing' option.

Source: Adapted from Kanudia and Loulou (2002).

Differences in Net Present Value (NPV) Costs by Province (2000-2020):

According to economic theory, the most appropriate cost-effectiveness analysis of any regulatory policy is in terms of NPV. Such analysis allows for a complete understanding of the financial implications of a policy, taking account of the time value of money. With regard to the current context, Kanudia and Loulou (2002) have developed unpublished NPV investment, fuel, permit, GDP, and total cost estimates over the 2000-2020 period. Results of this investigation (for the \$10/ton CO_2 case) are revealed in Figure 4 and summarized in this section.[10]

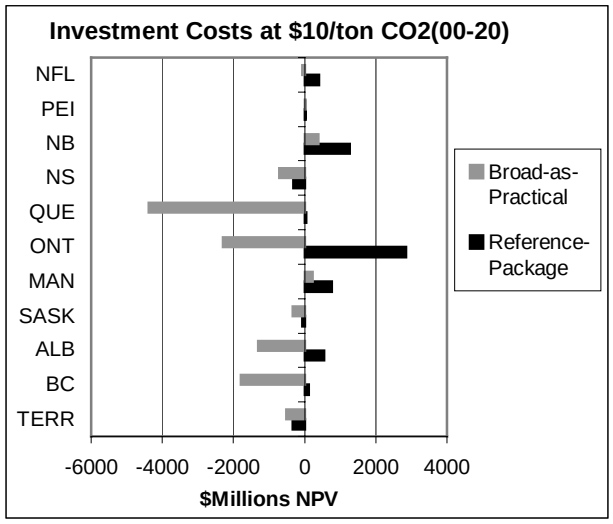
Similarly to the case of the 2010 perspective outlined above, GDP costs from the NPV perspective are highly unequal across provinces under the 'Broad-as-Practical' scenario, with Quebec, Ontario, Alberta, and BC individually taking on costs in the range of \$2-\$6 billion and other provinces experiencing much smaller impacts. This is true of other costs such as permit costs (where Alberta receives the highest cost at approximately \$3 billion, Ontario, Quebec, and BC receive costs of under \$1 billion each, and other provinces experience much smaller costs), investment costs (where Quebec receives the largest benefit at over \$4 billion and other receive at most ½ this value), fuel costs (where Ontario receives the largest benefit at over \$10 billion and other receive at most ¼ this value). Netting out all the costs (and benefits) borne by each province, it is evident that the total costs of the 'Broad-as Practical' scenario results in a large variation in provincial impacts. Here, Alberta and BC are the only provinces that experience positive total costs, at about \$6.7 billion and \$1.6 billion, respectively. All other provinces experience total benefits ranging from \$5.9 billion in Ontario and \$2.5 billion in Quebec to close to zero in most of the remaining provinces.

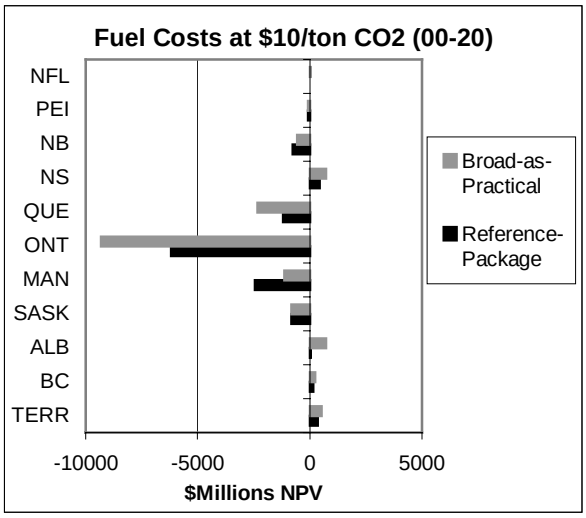
Moving from the 'Broad-as-Practical' scenario to the 'Reference-Package', it becomes evident that GDP cost variation is reduced (similarly to the 2010 perspective outlined above). The high GDP costs borne by Alberta and British Columbia in the first scenario, for instance, are significantly reduced in the 'Reference-Package' scenario to under \$2 billion and \$1 billion, respectively. Additionally, other regions such as Quebec and Ontario experience a reversal of GDP costs to GDP gains. Atlantic provinces such as Newfoundland and New Brunswick also see their GDP gains increase. These results largely emanate from the federal government taking on more of the costs through the purchase of permits in the non-covered sectors. Specifically, non-covered sector permit costs (taken on by government purchases) increase over \$3 billion moving from the 'Broad-as-Practical' to the 'Reference-Package' scenario.

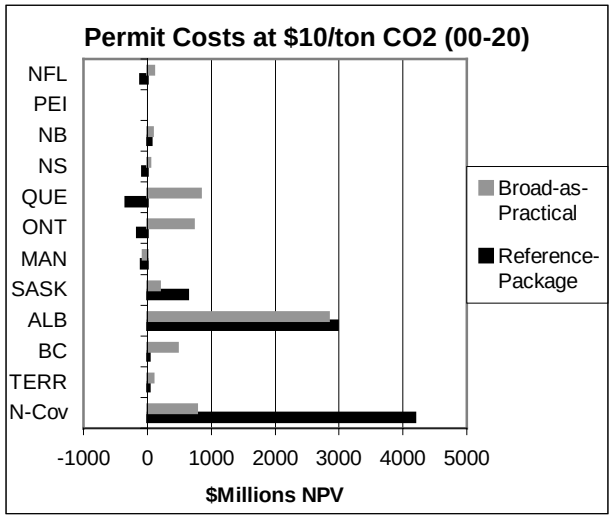
There are also significant cost variation reductions for investment and fuel costs moving from the 'Broad-as-Practical' to the 'Reference-Package' scenario. However, within this context it is important to note that there is a significant provincial investment switch from investment benefits to investment costs. This factor plays a role in affecting the changes in total costs moving from the 'Broad-as-Practical' to the 'Reference-Package' scenarios. Here, although total costs are reduced for Alberta and BC, negative costs (or benefits) are increased in provinces such as Quebec and Manitoba.

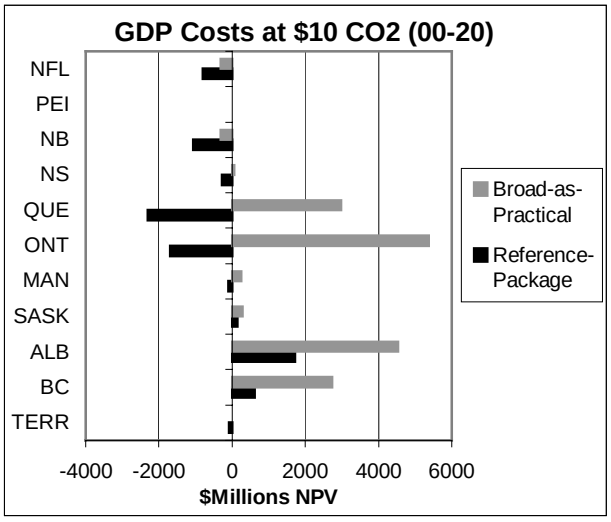
[10] Appendix 3 provides the information for the \$10/ton and \$50/ton in tabular form.

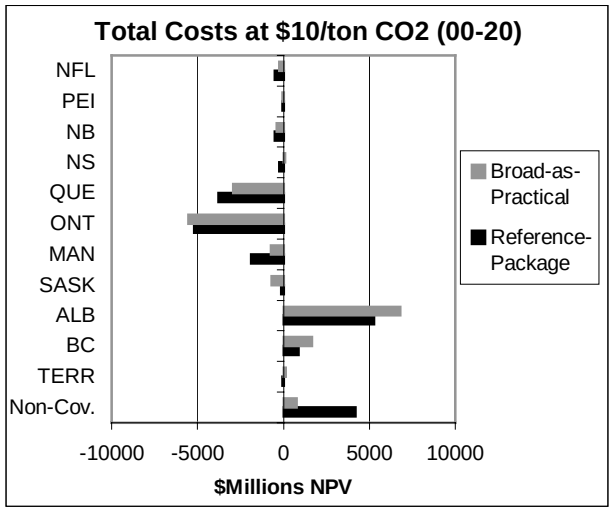
Figure 4: Costs of 'Broad-as-Practical' vs. 'Reference Package' Scenarios with Permits Valued at $10/ton CO_2 Equivalent (2000-2020 $NPV)*











*The 'Reference-Package' scenario results are based on the 'government-financing' option.

Source: Adapted from Kanudia and Loulou (2002).

When comparing the above NPV analysis with the 2010 analysis discussed in the preceding section, some conflicting results emerge. First, in the NPV analysis, Alberta and BC's total costs are reduced under the 'Reference-Package' (relative to the 'Broad-as-Practical') whereas they were increased in the 2010 analysis. And second, in the NPV analysis, Quebec and Ontario's total benefits are increased and reduced, respectively under the 'Reference-Package' (relative to the 'Broad-as-Practical') whereas they switched from a benefit to a cost in Quebec and were reduced significantly in Ontario in the 2010 analysis. Given these conflicting results, along with the fact that NPV is the more appropriate measure, it would seem as though the federal government could provide a more compelling argument of regional equity using the NPV analysis. Not withstanding this finding, the NPV results discussed above still point to serious regional inequity; much more than the federal government has indicated (they have not provided information on total costs). As such, it is expected that provinces such as Alberta will continue to claim that the climate change plan for Canada is unfair as some provinces will gain at the expense of others.

Conclusions

Our paper traces the evolution in federal government economic cost projections of implementing the Kyoto Protocol – by province, by policy option, and by CO_2 emission permit price – from the *Discussion Paper* to the *Climate Change Plan* white paper. We report several key findings:

(1) From the *Discussion Paper* to the *Climate Change Plan* paper, the federal government defines "economic costs" to the provinces as foregone GDP for the 2010 year only. The government defines economic costs in such a manner, to follow an economic trade-off path of bearing higher national economic costs to attain what it sees as provincial equity. In particular, the government is willing to sacrifice some gross domestic product to move projected output declines, particularly for Alberta and Saskatchewan, to approximating that of the central Canadian provinces. To attain a "sharing of Kyoto costs across provinces", the government has shifted its favoured policy option from "Broad as Practical" to a "Reference Package" (Government Financed) option. The latter option entails lower energy prices for the consumer, more federal incentives spending, and the use of international CO_2 emission permits;

(2) The federal government, in choosing foregone GDP as a measure of economic costs, understates true economic costs. In particular, the government neglects other economic costs such as higher fuel costs, investment costs, and CO2 emission permits. If we add these costs to foregone GDP, we show that for the 2010 year that total economic costs are borne less evenly across provinces. In particular the three westernmost provinces bear all of the increased national costs. We concede, however, that the total forecast national cost ($1.65 billion) is not large as a percentage of total national output;

(3) The federal government, in choosing 2010 as a benchmark year, is selecting an arbitrary year as a snapshot look at economic costs. In cost-benefit analysis, and cost-effectiveness analysis, the proper time frame is the discounted time path from when a given project or program is undertaken to some specified end year. For the bulk of federal economic studies,

2010 has been chosen as the end date. So economic costing should be a time period akin to the 2000-2010 period used by the federal study cited in our paper. But using the 2000-2010 period, we show that, first, national economic costs rise moderately. But more importantly, discounted economic costs rise sharply for Alberta, whereas Ontario and Quebec enjoy modest benefits.

The results shown in our paper – results that we feel depict economic costs in a more complete manner than that shown in the two federal policy papers – show a stark inequity in the sharing of provincial economic costs. This inequity contravenes the commitment made at the 1997 First Ministers meeting that no province or region should bear an unusually high share of Kyoto economic costs. Either the federal government must undertake a new Kyoto plan to achieve provincial equity, or it ought to dispense with the provincial equity criterion altogether. We speculate that any redesign of the Reference Package might weaken Canada's Kyoto targets still further.

Our conclusions must be treated with caution. For one thing, we obtained, through the Access-to-Information Act, federal documents only to the beginning of October 1, 2002. Other unpublished federal documents may exist which contradict the results shown in this paper. In particular, since the *Climate Change* paper, the federal government has announced a softening of rules for automobile CO_2 pollution, and additional federal subsidies to large CO_2 emitters paying more than $15 a CO2 emission ton. These major changes to the Kyoto plan must be modelled to quantify changes to economic costs. One can speculate, however, that both measures would have little effect on our last finding, that Alberta pays a large, disproportionate burden of total, discounted future economic costs.

With this being said, we still hold to our position that Alberta will pay a disproportionate burden of the costs of Kyoto. In a way, the results of our paper square with common sense. To achieve real Kyoto targets, it is the heavy CO_2 emitting industries – coal, petroleum extraction, and petroleum products – which must be cut back. Yet Alberta is by far the most important producer of these products. Whatever the final federal policy package adopted, it is Alberta which will witness a disproportionate share of CO_2-emitting cutbacks. Albertans and the Alberta government instinctively understand this common sense, and this forms the basis for their opposition to Kyoto. In the same way, our results show that Ontario and Quebec benefit from Kyoto, and suggest why these provinces favour the Protocol.

We stress that we take no position on Kyoto. We look at costs only, and omit any analysis of positive environmental benefits from Kyoto. Our results suggest that, at the very least, more debate is needed as to economic costs. Certainly the federal government needs to provide further documentation underpinning the *Climate Change Plan for Canada*.

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Appendix 1:

Table A1.1 provides the 'Reference-Package' scenario allocation of emission targets by province and sectoral category. Here, Ontario, Saskatchewan and Alberta receive the largest decreases in permit allocations (relative to 1990 emissions levels).

Table A1.1: 'Reference-Package' Permit Allocation by Jurisdiction Using Triptych Formula

Province (Sectoral Category)	1990 Emissions Mt	LFE[a] Electricity Permits	LFE Industry Permits	Non-LFE Permits	Total Permits	Permit Allocation Relative to 1990 Emissions (as a %)
NFL	10	4.2	2.3	11.7	18.2	+82%
PEI	2	0.1	0.1	-0.4	-0.2	-100.1%
NS	19	5.9	5.7	6.0	17.6	-7.3%
NB	16	3.4	5.9	4.1	13.5	-15.6%
QUE	86	13.5	29.2	47.9	90.6	+5.4%
ONT	182	20.7	56.7	81.5	158.9	-12.7%
MAN	22	3.5	5.4	13.6	22.5	+2.3%
SASK	48	5.4	2.0	27.8	35.1	-26.9%
NWT	1.5	0.3	0.3	0.9	1.6	+6.7%
NUN	0.5	0.7	0.1	0.2	0.7	+40.1%
ALB	168	28.5	53.6	74.5	156.6	-6.8%
BC	51	7.9	13.7	31.2	53.1	+4.1%
YUK	0.6	0.3	0.3	0.5	1.0	+66.7%
CAN	607	94.4	175.3	299.4	571.7	-5.8%

[a]LFE = large final emitters.

Source: Kanudia and Loulou (2002) and AGM (2002c).

Appendix 2:

GHG emission reduction costs from the 'Broad-as-Practical' and 'Reference-Package' scenarios in 2010 (relative to the 'Policy-as-Usual' scenario) are given in Tables A2.1 to A2.5. Total costs are composed of: (i) changes in investment; (ii) fuel costs; (iii) permit costs; and (iv) output losses.

Table A2.1: Investment Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2010).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$)	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$)**	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 6 vs. 5)***
NFL	-42	51	No	-229	132	No
PEI	2	3	No	7	10	No
NB	53	290	**No**	-208	124	**No**
NS	-146	-31	No	-422	43	No
QUE	-896	176	**No**	-2263	707	**No**
ONT	-533	269	**No**	-1402	405	**No**
MAN	33	100	**No**	-14	207	**No**
SASK	31	64	No	-226	-48	No
ALB	-280	4	**No**	-4807	-58	No
BC	-274	-22	No	-1073	-289	No
TERR	-139	-121	No	-188	57	No
Canada	-2191	783	**No**	-10825	1290	**No**

Source: Kanudia and Loulou (2002).

Table A2.2: Fuel Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2010).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$)	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$)**	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 6 vs. 5)***
NFL	0	0	No	-1	0	No
PEI	-7	-10	Yes	-3	-21	Yes
NB	-137	-202	Yes	30	11	Yes
NS	229	69	**Yes**	675	152	**Yes**
QUE	-351	-260	No	-1059	-409	**No**
ONT	-1292	-866	No	-800	-417	No
MAN	-348	-584	Yes	-82	-371	**Yes**
SASK	-286	-128	No	191	312	**No**
ALB	-348	-146	No	5477	290	**Yes**
BC	10	49	No	-142	-119	No
TERR	154	147	Yes	176	-75	**Yes**
Canada	-2376	-1931	No	4462	-647	**Yes**

Source: Kanudia and Loulou (2002).

Table A2.3: Permit Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2010).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$)	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$)**	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 6 vs. 5)***
NFL	21.6	-25	Yes	7.6	-171	**Yes**
PEI	0.6	-0.1	Yes	-4.8	-0.8	No
NB	18.1	25	No	-188.1	-109.6	No
NS	10.3	-10.5	Yes	-168.9	-141.2	No
QUE	159.6	-99.2	**Yes**	203.6	-632.1	**Yes**
ONT	172.7	-19.8	**Yes**	-189.4	-598.4	**Yes**
MAN	-12	-24.1	Yes	-89	-161.5	Yes
SASK	44.4	147.4	**No**	-316.9	238.7	**No**
ALB	605.7	651	No	5.2	1008.9	**No**
BC	106.5	-0.7	**Yes**	211.7	-138.2	**Yes**
TERR	12	-0.5	Yes	39.2	0.7	Yes
Non-C	130.6	789.6	**No**	307	2960.3	**No**
Canada	1270.1	1433.1	No	-182.8	2255.8	**No**

Source: Kanudia and Loulou (2002).

Table A2.4: Industrial Output Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2010).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$)	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$)**	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 6 vs. 5)***
NFL	-18	37	No	-183	18	No
PEI	4	16	No	-16	20	No
NB	24	47	No	-23	70	No
NS	-88	88	No	-176	117	No
QUE	-1367	547	**No**	-1915	1098	**No**
ONT	-2938	-1116	No	-5022	-558	No
MAN	-127	84	No	-169	169	No
SASK	41	164	**No**	287	164	Yes
ALB	875	700	**Yes**	6478	2626	**Yes**
BC	-637	796	**No**	-1115	1274	**No**
TERR	294	0	Yes	-23	18	No
Canada	-3937	1363	**No**	-1511	5016	**No**

Table A2.5: Total Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2010).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$)	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$)**	**'Reference-Package' (M$)**	***RP Preferred over BAP? (Col. 6 vs. 5)***
NFL	-38.4	63	No	-405.4	-21	**No**
PEI	-0.4	8.9	**No**	-16.8	8.2	**No**
NB	-41.9	160	No	-389.1	95.4	No
NS	5.3	115.5	No	-91.9	170.8	No
QUE	-2454.4	363.8	**No**	-5033.4	763.9	**No**
ONT	-4590.3	-1732.8	**No**	-7413.4	-1168.4	No
MAN	-454	-424.1	No	-354	-156.5	Yes
SASK	-169.6	247.4	No	-64.9	666.7	**No**
ALB	852.7	1209	No	7153.2	3866.9	**Yes**
BC	-794.5	822.3	No	-2118.3	727.8	**No**
TERR	321	25.5	Yes	4.2	0.7	**Yes**
Non-C	130.6	789.6	**No**	307	2960.3	**No**
Canada	-7233.9	1648.1	**No**	-8056.8	7914.8	**No**

Appendix 3:

GHG emission reduction costs from the 'Broad-as-Practical' and 'Reference-Package' scenarios in NPV terms (relative to the 'Policy-as-Usual' scenario) are given in Tables A3.1 to A3.5. Total costs are composed of: (i) changes in investment; (ii) fuel costs; (iii) permit costs; and (iv) output losses.

Table A3.1: Investment Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2005-2020).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$ NPV)	**'Reference-Package' (M$ NPV)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$ NPV)**	**'Reference-Package' (M$ NPV)**	***RP Preferred over BAP? (Col. 6 vs. 5)***
NFL	-64	394	No	-1552	269	**No**
PEI	22	27	No	30	45	No
NB	387	1262	**No**	-1705	715	**No**
NS	-717	-311	No	-2016	-154	**No**
QUE	-4378	35	**No**	-13974	-69	**No**
ONT	-2301	2847	**No**	-9397	2478	**No**
MAN	222	769	No	-36	1853	**No**
SASK	-327	-72	No	-1884	-148	No
ALB	-1304	542	**No**	-27114	-3213	**No**
BC	-1791	108	**No**	-6963	-1704	**No**
TERR	-508	-340	No	-3613	-2033	No
Canada	-10759	5261	**No**	-68224	-1961	**No**

Source: Kanudia and Loulou (2002).

Table A3.2: Fuel Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2005-2020).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$ NPV)	**'Reference-Package' (M$ NPV)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$ NPV)**	**'Reference-Package' (M$ NPV)**	***RP Preferred over BAP? (Col. 6 vs. 5)***
NFL	38	23	Yes	-16	-46	Yes
PEI	-67	-87	Yes	-41	-96	No
NB	-558	-750	Yes	-111	62	No
NS	722	428	**Yes**	2484	551	**Yes**
QUE	-2336	-1186	No	-6184	-1588	**No**
ONT	-9327	-6175	**No**	-9144	-7146	**No**
MAN	-1126	-2447	Yes	-879	-1596	Yes
SASK	-827	-812	No	2563	250	Yes
ALB	725	46	**Yes**	32309	4874	No
BC	246	145	Yes	-1035	-815	No
TERR	533	346	Yes	3683	2243	Yes
Canada	-11977	-10469	**No**	23629	-3307	**Yes**

Source: Kanudia and Loulou (2002).

Table A3.3: Permit Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2005-2020).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$ NPV)	**'Reference-Package' (M$ NPV)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$ NPV)**	**'Reference-Package' (M$ NPV)**	***RP Preferred over BAP? (Col. 6 vs. 5)***
NFL	102	-111	**Yes**	24	-867	**Yes**
PEI	3	-2	Yes	-19	-16	No
NB	82	63	Yes	-1107	-932	No
NS	43	-76	Yes	-1095	-1163	Yes
QUE	830	-335	**Yes**	575	-3315	**Yes**
ONT	725	-159	**Yes**	-1730	-3472	**Yes**
MAN	-65	-103	Yes	-680	-907	Yes
SASK	189	632	**No**	-2234	776	**No**
ALB	2834	2981	No	-1703	5966	**No**
BC	475	28	Yes	1194	-675	**Yes**
TERR	94	30	Yes	273	41	Yes
N-Cov	773	4191	**No**	2079	15196	**No**
Canada	6084	7140	**No**	-4422	10654	**No**

Source: Kanudia and Loulou (2002).

Table A3.4: Industrial Output Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2005-2020).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$ NPV)	**'Reference-Package' (M$ NPV)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$ NPV)**	**'Reference-Package' (M$ NPV)**	***Cost Change (Col. 6-5)***
NFL	-318	-795	**Yes**	1390	-434	**Yes**
PEI	-1	-4	Yes	14	1	Yes
NB	-303	-1068	**Yes**	2377	-556	**Yes**
NS	59	-280	**Yes**	870	110	**Yes**
QUE	2975	-2300	**Yes**	17258	737	**Yes**
ONT	5376	-1696	**Yes**	15687	263	**Yes**
MAN	245	-94	**Yes**	894	340	**Yes**
SASK	287	140	Yes	1315	924	Yes
ALB	4538	1718	**Yes**	9448	6812	**Yes**
BC	2724	612	**Yes**	10570	4313	**Yes**
TERR	-4	-76	Yes	309	-4	Yes
Canada	15578	-3843	**Yes**	60132	12506	**Yes**

Source: Kanudia and Loulou (2002).

Table A3.5: Total Costs (relative to Policy-as-Usual) by Province under different Permit Price and Policy Scenarios (2005-2020).

Region	$10/ton CO_2 Permit Price			$50/ton CO_2 Permit Price		
	'Broad-as-Practical' (M$ NPV)	**'Reference-Package' (M$ NPV)**	***RP Preferred over BAP? (Col. 3 vs. 2)***	**'Broad-as-Practical' (M$ NPV)**	**'Reference-Package' (M$ NPV)**	***Cost Change (Col. 6-5)***
NFL	-242	-489	Yes	-154	-1078	**Yes**
PEI	-43	-66	Yes	-16	-66	Yes
NB	-392	-493	Yes	-546	-711	Yes
NS	107	-239	**Yes**	243	-656	**Yes**
QUE	-2909	-3786	**Yes**	-2325	-4235	**Yes**
ONT	-5527	-5183	No	-4584	-7877	Yes
MAN	-724	-1875	**Yes**	-701	-310	No
SASK	-678	-112	No	-240	1802	No
ALB	6793	5287	**Yes**	12940	14459	**No**
BC	1654	893	Yes	3766	1119	**Yes**
TERR	115	-40	Yes	652	247	Yes
Non-Cov.	773	4191	**No**	2079	15203	**No**
Canada	-1074	-1911	**Yes**	11115	17897	**No**

Source: Kanudia and Loulou (2002).