Climate Change Plans for Canada: a Full Cost-Benefit Framework for Evaluating Options at the Provincial Level

by

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Abstract

This paper examines the provincial economic impacts from implementing the Kyoto Protocol in Canada under two policy options currently being considered by the federal government: the Broad-as-Practical and Reference-Package options. Using information from federal documents and academic literature, we find that the federal forecasts of undiscounted GDP losses to provincial economies represent misleading indicators of true economic impacts. We suggest that a more accurate provincial impact analysis of GHG policy options would be based on a net present value framework that incorporates discounted costs and ancillary benefits over the time-frame of the program. Once these elements are accounted for, we find that most provinces would benefit under both policy options, and would prefer the Reference-Package. Specifically, the Reference-Package option reduces provincial burdens of achieving Canada's Kyoto commitment, and may do so at virtually no net efficiency cost relative to the Broad-as-Practical option. These findings emphasize the importance of incorporating both market and non-market values into the policy-making arena.

Introduction

With its ratification of the Kyoto protocol in 2002, Canada has indicated its commitment to reducing greenhouse gas (GHG) emissions to 6% below 1990 levels by the first commitment period of 2008-2012 (Government of Canada 2003).[1] The Protocol encourages Canada to use a wide array of market and non-market instruments to meet their target. Provincial governments have been asked to work with the federal government to implement this Protocol. To encourage participation amongst the provinces, the federal government has made a commitment that no region should bear an unusually high share of economic costs (CICS 1997).

In April 2002, the federal government released its white paper entitled: *A Discussion Paper on Canada's Contribution to Addressing Climate Change* (Government of Canada 2002b). In this white paper, the government states that the most efficient policy option to achieving its Kyoto commitment, namely the Broad-as-Practical policy option, would yield disproportionate burdens of economic costs to the energy-producing provinces, and in particular Alberta. Soon after the release of the report, the Alberta government undertook strong opposition to the federal government's commitment to Kyoto.

Consequently, as Alberta's opposition to Kyoto intensified, the federal government began developing alternative policy options in attempts to provide more regional equity. In November 2002, the federal government issued its most recent Kyoto policy paper entitled: *A Climate Change Plan for Canada* (Government of Canada 2002a). In this climate change plan paper, the federal government unveiled its Reference-Package policy option, under which it claims that a reasonably equal sharing of economic costs across provinces is achieved. The results from this recent federal policy paper reveals that provincial equity would be improved upon at significantly

[1] The federal government intends on committing to the Kyoto target even if the Protocol does not become internationally binding (Martin 2003).

higher overall economic costs for most regions. Thus, an efficiency vs. equity trade-off seems to have emerged.

Our paper describes the above federal government policy options, and discusses the economic implications of each at the provincial level. We find that, contrary to the recent federal forecasts, most provinces would benefit from either policy option and would gain most under the Reference-Package option. Moreover, the Reference-Package option may prove to be comparable to the most efficient solution for Canada as a whole. The reason why our conclusions differ from federal accounts is due to the different methodologies employed in assessing economic impacts. While the federal government has used undiscounted changes in provincial GDP as their measure of economic impacts, we use a full net present value framework. We contend that this latter framework is a more appropriate method for assessing the true economic impacts from GHG policy options as it falls more closely in line with economic theory.

In the following section, we review the federal government's business-as-usual (BAU) GHG emission projections by province, and discuss Canada's commitment to achieving its national Kyoto target. In the third section, we detail the two main policy options as presented by the federal government – the Broad-as-Practical and Reference-Package options. In section four, we compare these policy options as they pertain to provincial economic impacts. 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.[2] The projections are based on provincial-level analysis, and then rolled-up to produce an aggregate trend. Figure 1 portrays long-term emissions growth projections on a provincial basis, within the context of the BAU 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. First, in 1990-2000, GHG emissions growth was greater than the national average in Saskatchewan, Alberta and British Columbia. These increases were associated with the resource boom in the West and, in the case of British Columbia, population increases. Second, in 2000-2010, growth in emissions is projected to be somewhat 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 (Government of Canada, 2001).

The most recent federal projections for provincial BAU GHG emissions in 2010 are 14 million tons (Mt) in Newfoundland, 2 Mt in PEI, 21 Mt in Nova Scotia, 23 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. Rolled-up, this produces approximately 809 Mt of GHG emissions in Canada (Analysis and Modeling Group 2002; National Climate Change Process 2002). Overall, a 'gap' of 238 Mt. (or

[2] 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 (of which CO_2 figures predominantly). Lastly, results are shared with stakeholders and revised if comments are found logical and consistent (Government of Canada, 2001).

[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.

a 29% difference) exists between the BAU GHG projections and Canada's commitment under the Kyoto Protocol.[4] Figure 2 presents the BAU scenario along with the required emission reductions to meet the Kyoto Protocol.

The Climate Change Policy Context

The federal government has developed a number of policy options directed toward achieving their Kyoto commitment.[5] The Broad-as-Practical and Reference-Package options, often referred to in government documents as the least cost and most preferred, respectively, are compared in Table 1 and are described in detail below.

Within the Broad-as-Practical option, a diverse set of policies and instruments would be used to achieve the desired 240 Mt GHG emission reductions (Government of Canada 2002b). Specifically, the following instruments (and associated emission reductions) would be employed: (i) Action Plan 2000 and Budget 2001 (50 Mt); (iii) existing sinks (24 Mt); (iii) a domestic emissions trading (DET) permit system with domestic reductions (16 Mt) and international permit purchasing (128 Mt); and additional targeted measures (22 Mt). Additionally, in order to manage risk, the government considers purchasing 0-30 Mt of international emissions permits under this policy option.

The DET system in the Broad-as-Practical option 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 through the

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

personal income tax system (50 percent federal and 50 percent provincial).[6] The allocation and re-distribution of permit revenues in this way is thought to be the most economically efficient 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 (Government of Canada 2002b).

The Reference-Package option also contains a number of policy instruments to achieve GHG emission reductions (Government of Canada 2002a). However, this option is expected to achieve only 180 Mt emission reductions from the BAU projection. The remaining 60 Mt gap would be left to voluntary initiatives, government investments, and other such measures.[7] The particular instruments promoted to achieve the 180 Mt reduction include: (i) the previously announced Action Plan 2000, the 2001 Budget, and existing carbon sinks (80 Mt); (ii) a domestic emissions trading (DET) system for the large industrial emitters (55 Mt); (iii) other targeted measures (27 Mt); (iv) future carbon sinks (20-28 Mt); and (v) international emission permit purchases (10 Mt minimum).

Within the DET system of the Reference-Package option, permits are allocated freely to a small group of industrial sectors (representing about 40 percent of total emissions) in a way that reflects emission intensity, capacity to reduce emissions, and forecast BAU output (Government

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

[7] 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 ton per year by 2008-2012" (Government of Canada 2002a).

of Canada 2002a).[8] More specifically, the government would allocate to each included, or 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 2002). 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 from which limited reduction options exist (AMG 2002).

Economic Impact Analysis of GHG Policy Options

Federal Government Forecasts of Provincial GDP Costs and GHG Reductions

The federal government has published its 2012 and 2010 forecasts of provincial GDP under the Broad-as-Practical and Reference-Package options, respectively, at a likely $10 CO_2 emission permit price.[9] Table 2 shows the comparison of the provincial burdens of economic cost for the Broad-as-Practical and Reference-Package options, relative to the BAU scenario.[10] Note that the federal government uses reductions in real GDP, for the 2010/2012 year only, as their

[8] In particular, all the emissions from mining, iron and steel, pulp and paper, smelting, refining, industrial minerals, oil refining, pipelines, fossil-fuel electricity generation, and approximately 70 percent of oil producers and 50 of natural gas producers are included.

[9] It is not clear why the government chose to change the date of analysis from 2012 to 2010 when analyzing these two scenarios.

[10] Under the Reference-Package option, the government specifies a government-finance scenario whereby federal Kyoto initiatives are financed out of forgone future budget surpluses, and a tax-financed scenario whereby such spending comes from increased taxes. We present here only the former scenario since, as the government stresses, the government-finance scenario yields lower economic costs, because of the negative impacts from higher tax rates, and is therefore the more likely scenario.

measure of economic cost. Reduced GDP, expressed in percentage point change form, represents the reduction in GDP from the BAU scenario.

As can be seen from Table 2, the burden of GDP costs tend to be more evenly shared across provinces under the Reference-Package option relative to the Broad-as-Practical option. Specifically, while Alberta is the relative loser under the Broad-as-Practical option, almost all provinces share in the losses under Reference Package option. This move toward provincial equity, however, entails a significant efficiency cost. Specifically, moving from Broad-as-Practical to the Reference-Package options entails a significant increase in GDP costs at the national level, as GDP falls from +0.4 percent in the former case to -0.4 percent in the latter case. Associated with this is the finding that all provinces (with the exception of Alberta) would favour the former option over the latter on grounds of 2010/2012 GDP impacts.

The estimated changes in GHG emissions that result from each option are revealed in Table 3. Here, we incorporate an allocation for provincial carbon 'sinks' (where forests and agricultural lands sequester carbon and thereby offset GHG emissions). These allocations, which have not yet been determined by the federal government, are computed as follows. From the Government of Canada (2002a) and other unpublished documents, we established that national "forestry sink" and 'agricultural sink' allowances were projected at 20 and 14.1 Mt, respectively, over the 1990-2020 period. We used the total inventoried forest area (productive and unproductive), and agricultural land to allocate the associated forestry and agricultural sinks across provinces. This data, in thousands of square kilometres, was made available from Stats Can (2000). The resulting sink allocations were then added to the provincial non-sink reductions to arrive at the total provincial reductions as they appear in Table 3.

The reductions in provincial GHG emissions shown in Figure 3 are smaller under the Broad-as-Practical option when compared to the Reference-Package option. This is due to the relatively large use of international emissions permits by industrial emitters in the former option. Specifically, under this option, industry would opt to purchase a large number of international permits because it is cheaper than finding the required emissions reductions in the domestic market. Thus, although the former option is thought to be more efficient, it may lead to less pollution reductions at home, and thereby produce fewer ancillary benefits (as discussed in more detail later).

Comparing Tables 2 and 3, it is observed that some provinces experience large GHG emission reductions at relatively high GDP costs, whereas other provinces achieve equal reductions at relatively low costs. Additionally, as we move from the Broad-as-Practical to the Reference-Package option, most provinces experience larger GHG emission reductions at higher costs. These observations emphasize the important role that international permits play in the outcomes, and the complexities involved in assessing trade-offs amongst economic efficiency, regional equity, and pollution reduction components.

All together, the above analysis might lead one to conclude that most provinces would not support the Reference-Package option as it results in higher GDP costs and marginal reductions in provincial equity considerations. However, we argue below that GDP costs are not the only factors that should be considered when evaluating the economic impacts of Kyoto policy options. Indeed, there are many other costs and benefits that need to be considered before we can reach any conclusions.

Net Present Value Analysis of Provincial Economic Impacts:

According to economic theory, the most appropriate economic impact assessment of a regulatory policy is through a full net present value framework (see for instance Field and Olewiler 2002). Such analysis allows for a complete understanding of the full implications of a policy, taking account of the time value of money in all future market and non-market costs and benefits. With regard to costs in the current context, an unpublished government document, produced by Kanudia and Loulou (2002), uses the MARKAL model to calculate present value (PV) industrial output, investment, fuel, permit, and total cost estimates over the 2000-20 period.[11] The discount rate employed for these calculations is unknown, however, it is standard practice to assume 10% (see Field and Olewiler 2002).

Kanudia and Loulou (2002) show that industrial output costs from the PV perspective are highly unequal across provinces under the Broad-as-Practical option. Such costs range from a high of approximately +$5 billion in Alberta and Ontario to a low of -$0.3 billion in New Brunswick and Newfoundland. Such an inequality is also realized for permit costs (where a high of +$3 billion in Alberta and a low of –$0.07 billion in Manitoba is realized), investment costs (where a high of +$0.4 billion New Brunswick and a low of over -$4 billion in Quebec is realized), and fuel costs (where a high of +$0.7 billion in Alberta and a low of over -$9 billion in Ontario is realized).

Moving from the Broad-as-Practical option to the Reference-Package option, Kanudia and Loulou (2002) show that industrial output cost variation between provinces is reduced. The high

[11] The Analysis and Modelling Group (AMG) 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 models, as described in AMG (2002), share many similarities. However, the MARKAL model has a more detailed depiction of energy technologies and cost minimization strategies. In particular the MARKAL 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: (i) all agents have perfect-information over the model horizon of 40 years; (ii) each agent adopts the long-term view to optimize its financial cost; (iii) all agents use the same discount rate; and (iv) electricity is priced using marginal costs in a competitive environment.

industrial output costs borne by Alberta in the former option, for instance, are significantly reduced in the Reference-Package option to +$1.7 billion. Additionally, other regions such as Quebec, Ontario, and a number of Atlantic Provinces have negative industrial output costs. 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 +$3.5 billion moving from the former to the latter option.

There are also significant cost variation reductions for investment and fuel costs moving from the Broad-as-Practical to the Reference-Package option. However, within this context, Kanudia and Loulou (2002) reveal that there is a dramatic investment switch from benefits to costs for many regions. This factor plays a role in affecting the changes in total costs moving from the former to the latter option.

The total PV cost estimates produced by Kanudia and Loulou (2002) for both policy options are summarized in Table 4. Here it is evident that the Broad-as-Practical option results in a large variation in provincial PV economic costs. Under this option, Alberta and British Columbia experience relatively high total costs, at +$6.8 and +$1.7 billion, respectively. Quebec and Ontario, on the other hand, experience negative PV total costs, at -$2.9 and -$5.5 billion, respectively. Other provincial impacts range between these two extremes.

When moving from the Reference-Package to the Broad-as-Practical option, total PV costs tend to be reduced for provinces bearing large burdens under the former option. Specifically, under this option Alberta and British Columbia experience total PV costs of +$5.3 and +$0.9 billion, respectively. Other provinces, including Quebec, Manitoba, and most of Atlantic Canada, experience increased negative PV costs. While others yet experience decreased negative total PV costs. Overall, the Reference-Package option seems to go some way in reducing the Kyoto burden, relative to the Business-as-Usual option, and would be favored by most provinces under the PV cost criteria. Additionally, this option has the added attraction of increasing negative PV costs (benefits) for Canada as a whole.

The total PV cost results discussed above, however, still point to serious regional inequity, much more than the federal government has indicated through their percentage change analysis of GDP. As such, it is expected that provinces such as Alberta will continue to claim that the Reference-Package option is unfair, as some provinces will still experience greater economic burdens (in terms of total PV costs) than others.

Turning now to the benefits-side of the GHG policy issue, recent academic and government literature have reported a number of ancillary benefits that may result from reducing CO_2 emissions under GHG policies (OECD 2002, AMG 2000). These include benefits under the categories of health benefits, ecological pressure reductions, economic benefits, and social benefits. These benefits are detailed in Table 5.

A number of case studies have been conducted that measure the extent of the ancillary benefits described in Table 5 for particular regions under consideration. Most analyses of these benefits indicate that health effects account for 70% to 90% of the total value of ancillary benefits (Aunan et al. 2000). Table 6 summarizes the current academic literature dealing with ancillary benefits.

The ancillary benefits emerging from the studies summarized in Table 6 range from $20 to over $300 ($1996 US) per ton of CO_2 emissions reduced, depending on a number of assumptions over: (i) the type of GHG policy considered (taxes, permits, etc); (ii) the region under consideration; (iii) the economic, environmental, and health-effect modeling; and (iii) the valuation techniques used. Studies that focus on health effects alone tend to produce ancillary benefits estimates in the \$20-\$70 range, while those that focus on a wider array of benefits tend to produce estimates in the \$125 to \$300 range.

In our analysis, we are concerned with a wide array of benefits, and therefore consider conducting our analysis using benefit estimates in the range of \$125 to \$300 per ton CO_2 emissions reduced. This range is consistent with the AMG's (2000) preliminary pollutant-specific analysis. For completeness, and due to the fact that there has been no primary research conducted on ancillary benefits in Canada under the most recent policy options, we present our benefits estimates based on both a low ancillary benefits estimate of \$125, and a high ancillary benefits estimate of \$300. Each of these estimates is applied to the forecasted provincial emissions under the Broad-as-Practical and Reference-Package options, revealed in Table 3.

When computing our benefit estimates, we assume that all ancillary benefits under the Broad-as-Practical option occur in year 2012, and under the Reference-Package option occur in year 2010 (for reasons mentioned previously in Table 3). We then discount these benefits accordingly using a 10% discount rate (see Field and Olewiler 2002 for a discussion of discount rate choices). We also assume that GHG emissions remain at the respective 2010 or 2012 level throughout the 2010/12 to 2020 period.[12] The above assumptions will undervalue the true economic benefits since GHG emission reductions will be distributed throughout the 2000 to 2010/12 period. However, without further information about this inter-temporal distribution, we choose to compute the most conservative measure. Table 7 provides a summary of provincial PV ancillary benefit estimates from each policy option.

As seen in Table 7, there are significant ancillary benefits from both climate change policy options. The benefits, however, are generally smaller for the Reference-Package option

[12] There are no estimates available for GHG emissions in 2020 under both policy options.

relative to the Broad-as-Practical option as a result of less domestic emission reductions in the latter case.

The NPV estimates of provincial economic impacts from the Broad-as-Practical and Reference-Package options can be computed by subtracting the PV total costs (in Table 4) from PV benefits (in Table 7), as shown in Table 8. Here, it is revealed that, regardless of the option, many provinces experience benefits (positive NPVs) in excess of +$1 billion from the GHG policy. Some regions stand to gain much more than this. For instance, Ontario may benefit in the $6 to $8 billion range, depending on the policy option and respective ancillary benefits. Overall, it is estimated that Canada as a whole could see benefits in the +$4 to +$12 billion range, depending on assumptions over ancillary benefits and policy option followed.

Under the NPV criteria, the Reference-Package option has a number of desirable attributes relative to the Broad-as-Practical option. More specifically, the Reference-Package: (i) leads to a larger net present value for all provinces but Ontario and Saskatchewan; (ii) reduces the burden for provinces in achieving the GHG objective (as emphasized in the $300 ancillary benefits case where Alberta's NPV is reduced to -$1.5 billion); and (iii) results in only marginal efficiency loss for Canada as a whole (as emphasized in the $300 ancillary benefits case).

The results shown in Table 8 provide a very different picture of overall economic impacts from the federal accounts, shown in Table 2. Most obvious is in the 'Reference-Package Preferred?' columns where most provinces have a 'Yes' in Table 8 and a 'No' in Table 2. Additionally, the Reference-Package option in Table 8 indicates that most provinces gain from the policy, whereas the opposite occurs for that in Table 2. These results are largely due to the inclusion of ancillary benefits that occur from the reduction of GHGs in these regions.

Conclusions

Our paper critiques the federal government's economic impact forecasts of implementing its Kyoto commitment under two major policy options: the Broad-as-Practical and Reference-Package options. We report two key conclusions. First, the federal government, in choosing foregone real GDP as a measure of economic costs, understates true economic costs. In particular, the government neglects the time value of money in their analysis and excludes other economic costs such as higher fuel costs, investment costs, and CO_2 emission permits. By incorporating discounting and adding these additional costs to lost industrial output, we find that most provinces would support the Reference-Package as an option that reduces total PV costs relative to the Broad-as-Practical option.

The second conclusion drawn from our analysis is that the federal government ignores significant ancillary benefits that emerge from the Kyoto policy options. We argue that the government should incorporate a full net present value framework into their economic impact analysis where discounted costs and benefits are included. Once this is done, we find that most provinces benefit (or have positive NPVs) under both policy options and prefer the Reference-Package.

The conclusions outlined above must be treated with caution. For instance, some of the federal documents used in this study were obtained through the Access-to-Information Act, and included information 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 was released, the federal government has announced a softening of rules for automobile CO_2 pollution, and is also considering additional federal subsidies to large CO_2

emitters paying more than \$15 a CO_2 emission ton. These major changes to the Kyoto plan must be modelled to quantify changes to economic costs and benefits.

Additionally, there are a number of assumptions that have been made with regard to the computation of costs and benefits. These assumptions, over such issues as the level and timing of ancillary benefits, need to be more fully investigated. Nonetheless, the results of this paper stand that if the federal government were to consider both the full costs and benefits of implementing the Kyoto Protocol in Canada, a better case could be made for implementing their most recent and preferred policy option.

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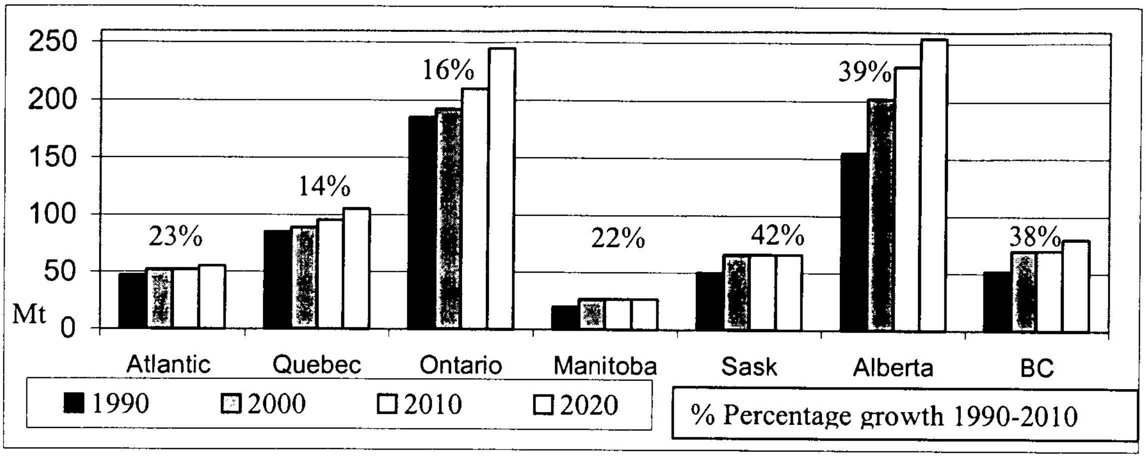
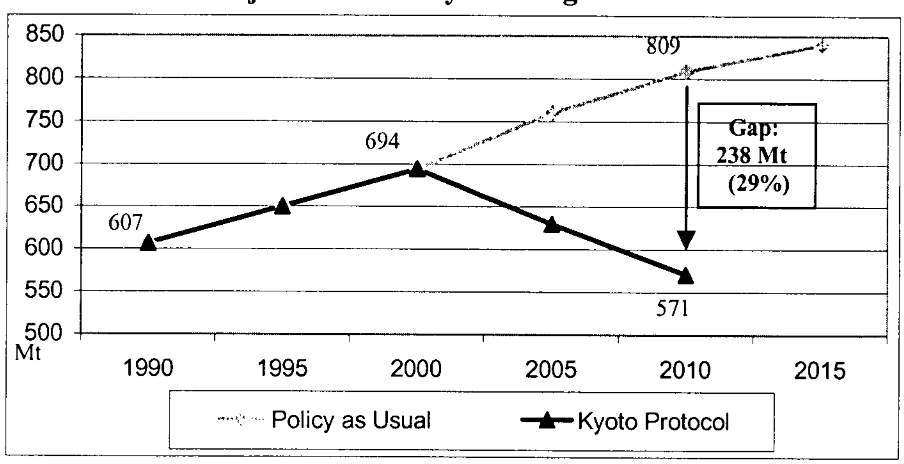
Figure 1: BAU GHG Emission Projections by Region in Canada (1990-2020)



Source: Government of Canada (2001)

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



Source: AMG (2002).

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

Broad-as-Practical Option	Reference-Package Option
• 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.

Table 2: Provincially forecasted changes in real GDP under Broad-as-Practical and Reference-Package options, relative to BAU, at a \$10 CO_2 Emission Permit Price (2010-12 range)[a]

Region	Broad as Practical (% change)	Reference Package (% change)	Reference Package Preferred? (Col. 3 vs. 2)
NFL	+0.1	-0.2	No
PEI	-0.1	-0.4	No
NS	+0.3	-0.3	No
NB	-0.1	-0.2	No
QUE	+0.5	-0.2	No
ONT	+0.6	0.1	No
MAN	+0.3	-0.2	No
SASK	-0.1	-0.4	No
ALB	-0.5	-0.4	Yes
BC	+0.4	-0.5	No
TERR	+0.5	0.0	No
CANADA	+0.4	-0.4	No

[a] The range 2010-12 is specified due to the limited data provided by the Government of Canada (2002a,b). Specifically, the % change in GDP data from the Broad-as-Practical option is provided for the year 2012, while that for the Reference-Package option is provided for the year 2010.

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

Table 3: Provincially forecasted changes in GHG emissions under Broad-as-Practical and Reference-Package options, relative to BAU, at a $10 CO_2 emission permit price (2010-12 range)[a,b]

Region	Broad-as-Practical (Mt change)	Reference-Package (Mt change)
NFL	-2.0	-2.5
PEI	-0.1	-0.3
NS	-1.9	-1.8
NB	-3.7	-2.1
QUE	-13.6	-15.5
ONT	-30.5	-31.2
MAN	-4.2	-7.1
SASK	-6.9	-15.9
ALB	-25.8	-32.5
BC	-11.1	-12.5
TERR	-4.5	-4.5
SUBTOTAL	-104.2	-125.8
INTL. PERMITS		
- Government	---	-47.3
- Industry	-128	---
CANADA	-232.2	-178.2

[a] The range 2010-12 is specified due to the limited data provided by the Government of Canada (2002a,b). Specifically, emission data for the Broad-as-Practical option is provided for the year 2012, while that for the Reference-Package option is provided for the year 2010.
[b] Provincial emission reductions include agricultural and forestry sink allowances.

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

Table 4: Present value (PV) costs under Broad-as-Practical and Reference Package options, relative to BAU, at a $10 CO_2 emission permit price (2000-20)

Region	$10/ton CO_2 Permit Price		
	'Broad-as-Practical' ($M PV)	'Reference-Package' ($M PV)	Reference Package Preferred? (Col. 3 vs. 2)
NFL	-242	-489	Yes
PEI	-43	-66	Yes
NB	-392	-493	Yes
NS	107	-239	Yes
QUE	-2909	-3786	Yes
ONT	-5527	-5183	No
MAN	-724	-1875	Yes
SASK	-678	-112	No
ALB	6793	5287	Yes
BC	1654	893	Yes
TERR	115	-40	Yes
Non-Cov.	773	4191	No
CANADA	-1074	-1911	Yes

Source: Adapted from Kanudia and Loulou (2002).

Table 5: Potential ancillary benefits from GHG mitigation

Category	Ancillary Benefit	Description
Improved Health Benefits	Reduced mortality	Reductions in associated local emissions (i.e. SO_2, NO_2, Lead, and particulate matter) reduce premature death.
	Reduced morbidity	Reductions in associated local emissions reduce chronic illness, lost days of activity, allergies, etc.
Reduced Ecosystem Pressure	Reduced waste residuals	As energy production and intensity of use decreases, less handling and disposing of waste results.
	Reduced physical restructuring	Reduction in GHG emissions reduce climactic instability and reduce management of biological carbon reservoirs.
	Increased harvesting of food sources	Reduction in associated local emissions (i.e. NO_x) reduce chemical loadings to water/soil ecosystems.
	Reduced Material Damages	Reduction in associated local emissions (i.e. SO_2) reduce structural maintenance costs.
Increased Economic Benefits	Increased jobs in some sectors	Changes in fuel uses have potential to increase jobs in the provision of low emissions technologies.
	Technological advances	As new processes and technologies are implemented, it may increase productive efficiency.
	Avoided cost reductions	Cost savings for other objectives (health, ecological, social, etc) may be achieved from GHG policy.
Social Benefits	Increased safety and reduced congestion	As incentives for alternative transportation are introduced in GHG policy, accidents are reduced.
	Increased equity	GHG policy may improve intra and inter-generational equity as polluters pay.

Source: Adapted from OECD (2002)

Table 6: Summary of sector-wide ancillary benefit estimates from GHG reductions

Study	Region	Benefits Measured	Ancillary Benefit $ per ton CO_2 ($1996 US)
Ayres and Walter (1991)	Germany US	Health and visibility effects of all criteria pollutants.	$312 $165
Barker (1993)	UK US Norway	Health, accidents, congestion.	$125-$282 $332 $254-$386
Boyd et al. (1995)	US	Health and visibility effects of all criteria pollutants.	$40
Cifuentes et al. (1999)	Chile	Health and ecological effects of six air pollutants.	$20-$70
Dessus and O'Connor (1999)	Chile	Health and ecological effects of seven air pollutants.	$150-$300
Elkins (1996)	Various	Synthesis of previous studies.	$273
Lutter and Shogren (1999)	US	Integration of models measuring a diverse set of benefits.	$300
Sheraga and Leary (1993)	US	Health effects of six air pollutants.	$33
Viscusi et al. (1994)	US	Health effects of all criteria pollutants.	$88

Table 7: Present value (PV) ancillary benefits estimates under Broad-as-Practical and Reference-Package options, relative to BAU, at a $10 CO_2 emission permit price (2000-20)[a]

Province	Ancillary Benefits at $125 per ton of CO_2 Emissions Reduced		Ancillary Benefits at $300 per ton of CO_2 Emissions Reduced	
	Broad as Practical ($M PV)	Reference Package ($M PV)	Broad as Practical ($M PV)	Reference Package ($M PV)
NFL	96.5	120.7	231.7	289.6
PEI	4.8	14.5	11.6	34.7
NS	91.7	86.9	220.1	208.5
NB	178.6	101.4	428.6	243.2
QUE	656.4	748.1	1575.3	1795.4
ONT	1472.0	1505.8	3532.8	3613.9
MAN	202.7	342.7	486.5	822.4
SASK	333.0	767.4	799.2	1841.7
ALB	1245.2	1568.5	2988.4	3764.5
BC	535.7	603.3	1285.7	1447.9
TERR	217.2	217.2	521.2	521.2
CANADA	5033.8	6076.3	12081.1	14583.0

[a] A 10% discount rate was used in the calculations.

Table 8: Total net present value (NPV) under Broad-as-Practical and Reference-Package options, relative to BAU, at a $10 emission permit price (2000-20)

Province	NPV with Ancillary Benefits at $125 per ton of CO_2 Emissions Reduced			NPV with Ancillary Benefits at $300 per ton of CO_2 Emissions Reduced		
	Broad-as-Practical ($M NPV)	Reference-Package ($M NPV)	Reference Package Preferred?	Broad-as-Practical ($M NPV)	Reference-Package ($M NPV)	Reference-Package Preferred?
NFL	338.5	609.7	Yes	473.7	778.6	Yes
PEI	47.8	80.5	Yes	54.6	100.7	Yes
NS	483.7	579.9	Yes	612.1	701.5	Yes
NB	71.6	340.4	Yes	321.6	482.2	Yes
QUE	3565.4	4534.1	Yes	4484.3	5581.4	Yes
ONT	6999.0	6688.8	No	9059.8	8796.9	No
MAN	926.7	2217.7	Yes	1210.5	2697.4	Yes
SASK	1011.0	879.4	No	1477.2	1953.7	Yes
ALB	-5547.8	-3718.5	Yes	-3804.6	-1522.5	Yes
BC	-1118.3	-289.7	Yes	-368.3	554.9	Yes
TERR	102.2	257.2	Yes	406.2	561.2	Yes
CANADA[a]	5334.8	3796.3	No	12382.1	12303.0	No

[a] Includes non-covered sector costs.