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The Kyoto Protocol:

Canada's Risky Rush to Judgment

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In this issue...

Canada's Prime Minister Jean Chretien has pledged to ask Parliament to ratify the Kyoto Protocol before the end of 2002. However, little is known about how the accord would be implemented or what it would cost. By some estimates, its economic impact would be similar to that of the 1988 Free Trade Agreement between the United States and Canada. As a result, the government's timetable is precipitous, at best; at worst, it could lead to serious economic damage.

The Study in Brief

The Kyoto Protocol mandates a set of country-specific reductions of emissions of "greenhouse" gases that absorb and re-emit infrared radiation. Canada has agreed to a target of six percent below 1990 levels by the end of the decade, which will require about a 30 percent absolute emissions cut. Canadian Prime Minister Jean Chretien recently pledged that his government will ask Parliament to ratify the Kyoto Protocol before the end of the year. In light of the sparse information about how Kyoto will be implemented and how much it will cost, this timetable is, at best, precipitous; at worst, it risks serious economic damage.

The federal government released a Discussion Paper last April outlining four hypothetical options for achieving compliance. We discuss some of the economics behind the estimated policy impacts, and conclude, among other things, that the Discussion Paper does not provide an adequate basis for making an informed decision on Kyoto. Given the scale of the policy commitment and the potentially far-reaching economic effects, without a more thorough understanding of the economic impacts a decision to ratify on the basis of what has been presented thus far would be precipitous.

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The Border Papers

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Canadian Prime Minister Jean Chretien recently pledged that his government will ask Parliament to ratify the Kyoto Protocol before the end of the year. In light of the sparse information about how Kyoto will be implemented and how much it will cost, this timetable is, at best, precipitous; at worst, it risks causing serious economic damage.

This treaty mandates a set of country-specific reductions in emissions of "greenhouse" gases that absorb and re-emit infrared radiation. The rationale for the policy is the belief that increasing concentrations of these gases in the air affects the global climate in ways that may be harmful to humans and the ecosystem.

The Kyoto Accord grew out of studies done by the Intergovernmental Panel on Climate Change (IPCC), which was formed in 1988 to help coordinate research in scientific and socio-economic aspects of climate change. The organization's Second Assessment Report, released in 1996, concluded that climate change had taken place and that at least some of it could be attributed to human activity. As a result, governments around the world, including Canada's, adopted a goal of reducing so-called greenhouse gas emissions. This led to the Kyoto Protocol in 1997. In 2001, the IPCC released its Third Assessment Report (IPCC 2001), restating its conclusion that there was a human influence on climate.

The major gases involved are water vapour, carbon dioxide and methane. The Kyoto Protocol names several other gases as well. For policy purposes, attention is focused on CO_2 (carbon dioxide), because it is emitted in large volumes worldwide. Canada's obligation is to reduce emissions of carbon dioxide six percent below 1990 levels. The target must be attained on average over the period 2008 to 2012.

Prime Minister Chretien has now committed the federal government to ratify the treaty before year's end. This Commentary will outline the reasons why that timetable is an unrealistic and unsound policy.

The government released a Discussion Paper (DP) called "Canada's Contribution to Addressing Climate Change." It outlines four policy packages (called here the Options) that could be used to implement the treaty should it become binding on us.

The three-fold purpose of the DP is to:

- propose four Options for meeting Kyoto obligations
- present economic cost estimates of the Options
- provide a basis for public consultations on whether Canada should ratify Kyoto.

This paper will explain what the four Options are, discuss some of the economics related to estimating policy costs, and evaluate how well the Discussion Paper achieves its goals. Part 1 will provide some information on the Kyoto Protocol.

We would like to thank the many people who took time to discuss the policy analysis and help us obtain the information we needed to write this paper. In particular, Neil McIlveen of NRCan and Carl Sonnen of Informetrica gave us a lot of assistance in tracking down details of the modeling and numerical results. Finn Poschmann, Bill Robson and Jack Mintz of the C.D. Howe Institute provided several rounds of critical feedback as did several anonymous reviewers. Any remaining errors are our responsibility

Box 1: *Glossary of Terms*

Annex B Countries Annex B of The Kyoto Protocol lists the countries which have made commitments to reduce carbon dioxide emissions. This group of nations is made up of high-income Western nations, in addition to several Central European nations.

Cap-and-Trade Permit Program Under a cap-and-trade permit system, the regulatory authority sets a limit (cap) for emissions and allocates or auctions that amount of permits to emitters. In the US, where this has been used most, the rights to emit (allowances) are for the most part allocated (or 'grand-fathered') to firms at no cost. Firms with allowances that exceed their actual emissions can sell the difference. Companies with emissions that exceed their allowance must purchase the difference.

Carbon Sinks Carbon dioxide can be kept out of the atmosphere if the associated carbon can be stored in a forest or in the soil. The Kyoto Protocol permits credit to be gained when nations expand the size of their carbon sinks.

Clean Development Mechanism The Clean Development Mechanism or CDM is one of the Kyoto Flexibility Mechanisms. It allows Annex B nations to fund greenhouse gas abatement projects in developing nations and apply the emissions reductions achieved toward meeting their Kyoto Protocol Target.

CGE Model A Computable General Equilibrium (CGE) model is an economic model of a real world economy. Firms and consumers in such models act to maximize profits or welfare when given knowledge of how the tax and regulatory policies in place work. They are particularly useful for evaluating the impact of policies which are new in form or structure.

Double Dividend An environmental tax is said to generate a double dividend when the revenue from the tax is used to reduce other more distorting levies in such a way as to enable economic activity to expand.

Flexibility Mechanisms The Kyoto Protocol has a number of Flexibility Mechanisms intended to help reduce the cost of compliance. These include the Clean Development Mechanism (CDM) and Joint Implementation (JI) and international permit trading.

'Grand-fathering' Allocating emissions permits (or allowances) to existing polluters, usually based on their past emissions history.

'Hot Air' The Kyoto Protocol specifies Russia's emission target as 100 percent of 1990 emissions. However, since 1990, the Russian economy has almost collapsed. As a result, it is expected that Russia's emissions of GHG's will be significantly below 1990 levels, even if no effort is made to reduce emissions. Hot air is the amount of permits Russia could sell even without engaging in any emissions reduction plan.

Joint Implementation The process whereby an 'investor' Annex B country can fund abatement projects in 'host' Annex B countries and get credit toward the investor country's Kyoto target.

Revenue Recycling If tax revenue from an environmental tax is used to reduce other taxes or reduce the debt, the revenue is said to be 'recycled.'

Social Costs Costs incurred by some agents in the economy as a result of a policy, which do not accrue as revenue to other agents.

Transfers Costs incurred by some agents in the economy as a result of a policy, which accrue as revenue to other agents. For instance, if firms must purchase a tradable emission permit under a pollution control policy, the purchase price is a transfer from one agent to another.

Utility The index of overall economic welfare of a household, taking into account consumption, leisure and other amenities.

Part 2 will examine the economic issues and Part 3 will focus on the Options themselves. Part 4 will comment on the modeling techniques used. Part 5 will discuss the policy implications. From this discussion it will be clear that there is no solid information on the social or economic costs or the environmental benefits, if any, of implementing Kyoto.

Some of the jargon and terminology we use are summarized in Box 1.

We will focus on evaluating the proposals as stated in the federal Discussion Paper. We conclude, among other things, that the Discussion Paper does not provide an adequate basis for making a decision on Kyoto. That is, the analysis to date does not provide sufficient information to understand the economic consequences and risks of accepting the Kyoto target as legally binding. Given the scale of the policy commitment and the potentially far-reaching economic effects, without a more thorough understanding of the economic impact a decision to ratify on the basis of what has been presented thus far would indeed be precipitous.

A key problem is that there is no "cost of Kyoto" estimate. The cost estimates in the DP and in related studies are very sensitive to the specific tools used to achieve compliance. To date, the federal government has not committed itself to any specific policy package, so cost numbers have been hypothetical and based on implementation strategies that Ottawa has not embraced and in some cases has explicitly rejected, as in the case of carbon dioxide taxes. A key message of this study is that seemingly minor changes to the policy regime can add many billions of dollars to the overall implementation costs. As a result, the paper does not produce a general "cost of Kyoto" estimate. Kyoto is a target, not a policy. One can only estimate the costs of specific policy choices that might be made for achieving the Kyoto target.

The four Options presented in the Discussion Paper propose policy tools that have the potential to be very expensive, depending on certain contingencies that have not been fully analyzed.[1] Costs are provided for only two of the four Options, and the results that are available suggest that small changes in the policy mix or the international context can have large impacts on the economy.

Moreover, seemingly minor changs to the policy can add many billions of dollars to overall costs, the mix of policies proposed in the DP are unlikely to be even remotely cost-effective. This means that whatever they achieve can be done at lower economic cost with better-designed instruments.

The motivation for Kyoto is that many credible scientists believe carbon dioxide accumulation in the atmosphere will change the climate in ways harmful to humans on a global scale. The Kyoto options are ultimately intended to address this concern. In its current form Kyoto can slow the process somewhat, but will not stop it. As a result, the potential benefits of Kyoto are, for one, a small delay in future damage and, for another, the creation of institutions that might yield deeper emission cuts in the future. Such benefits are much more difficult to quantify than the costs of the policy, especially on country-specific scales. The question of

1 The contingencies include, for instance, the question of whether an international permits market forms, whether provinces or industry groups agree to costly, but voluntary measures, and so forth. These are discussed below.

whether the estimated benefits (on a global or country scale) exceed the estimated costs is something that the DP does not address. Consequently, we do not comment on this aspect of the policy issue. However it ought to be given proper consideration as part of the process of deciding on ratification.

PART 1: The Kyoto Protocol

The Particular Challenge of Carbon Dioxide

Canada has long experience in air pollution-control policies, however carbon dioxide is in some ways different than smog-related air pollutants. First of all, other than its possible role in changing climate, carbon dioxide is not considered a pollutant and is not part of conventional provincial air quality regulations. Second, most smog-related pollutants can be controlled through 'end-of-pipe' treatment, such as scrubbers on smokestacks, or more efficient burning technology. This is not the case for CO_2.

While improving energy efficiency can reduce CO_2 emissions as well as other air emissions, there is virtually no scope for reducing CO_2 emissions by improving the burning efficiency of the fuels (see, for instance, Jacques 1990). End-of-pipe treatments for CO_2 tend to be expensive because they involve capturing the gas and storing or sequestering it. The main ways of reducing CO_2 emissions involve reducing fuel consumption or switching to fuel types that generate less CO_2 per unit of energy. Of the three main fuels types, coal generates the most carbon dioxide per unit of energy, folwloed by oil and natural gas.

Kyoto: Some Details

Treaty participants are divided into Annex B and non-Annex B countries. The distinction refers to whether the country has accepted an emissions reduction target. Non-Annex B countries, such as India, China and other developing countries, can join and ratify the treaty, though they are not required to cut emissions.

Annex B countries include the industrialized West and some former Soviet Bloc members. The treaty will enter into force if it is ratified by 55 countries, including enough Annex B members to account for 55 percent of the Annex B emissions. As of July 2002, 75 countries had ratified the Protocol, including 23 Annex B members accounting for 36 percent of Annex B emissions. The US accounts for 36.1 percent and the Russian Federation accounts for 17.4 percent of Annex B emissions. Neither of these countries has ratified. The US has indicated that it has no intention of doing so, while Russia is still considering the matter. Australia, which has 2.1 percent of Annex B emissions, has also indicated it will not ratify.

The European Union ratified jointly, as is permitted under Article 4, but member countries must secure internal agreement on the sharing of the emission reduction requirements among themselves. Japan recently voted to ratify the treaty, though the government proposed only voluntary measures and plans to revisit the

issue in several years. Japan's ratification does not seem to involve imminent formal implementation plans.

Canada's Annex B share is only 3.3 percent, so its decision on its own is not particularly influential in the larger context. However, if the Russian Federation ratifies, then Canada, Poland or a combination of smaller countries could push the total emissions share over the 55 percent cut-off.

The US pullout from Kyoto has several contrasting implications. For one thing, if Canada goes ahead with ratification on Mr. Chretien's timetable, there is a risk that Canadian industrial activity, especially energy-intensive activity, will decline as emission-control policies begin to raise operating costs relative to the US. For another, if an international market for emission permits forms - an issue discussed later in this paper - the absence of the US will cause the market price to be lower than would otherwise be the case. Since Canada expects to be a net buyer this would be helpful. Third, if the US economy grows more quickly than it otherwise would because the US is not bound by Kyoto this may translate into greater export sales for Canada.

If Canada goes ahead on Mr. Chretien's timetable Canadian industrial activity will decline.

For the purpose of the DP, emissions are measured in "megatonnes (tonnes are metric tons) carbon dioxide equivalent," or MT. Canada's emissions as of 2010 are projected to be 809 MT, while the Kyoto target is 571 MT. This creates a gap of about 240 MT. The treaty requires compliance, on average, over the period 2008 to 2012 and treaty members must submit evidence of having made "substantial progress" towards meeting their goals by 2005. The treaty does not specify what happens after 2012, though plans are being made for a subsequent treaty that would tighten the targets further. There are no financial penalties for non-attainment of one's target, however a recently proposed rule would require deeper cuts in subsequent periods by parties failing to meet their goals in the current compliance period.

Following the signing of the original treaty, negotiations at Bonn and Marrakech in 2001 authorized the use of "sinks" credits. Under this arrangement, Canada, Japan, Russia and other countries are allowed to claim credits for the fact that forest and plant growth within their boundaries draws CO_2 from the air. In Canada's case the original target was relaxed by 10 percent. That is, the country can claim 24 MT worth of sinks from existing plant and forest growth.

Since then, Canada has also sought 70 MT worth of credits for so-called "clean energy exports." Under this proposal, if another country, for example, the United States, reduces its emissions by switching from coal or oil to natural gas bought from Canada, Ottawa wants to claim the reduction in the other country's emissions for Canada. The accounting rules for Kyoto do not allow states to claim credits for other country's actions unless by prior agreement under the Joint Implementation plan (see the Glossary). Canada's request for these credits has been twice turned down by other parties to Kyoto. At another meeting in the fall Canada will press the matter again. All of these issues, however, are unresolved and few, if any, are likely to be settled by the end of the year, when Mr. Chretien proposes ratification.

The Kyoto Effects

The original form of Kyoto required countries responsible for about half the world's CO_2 emissions to reduce them to just under five percent below 1990 levels. Because of economic growth, by 2010 emissions among participating countries could be about 30 percent above their aggregate target. Consequently the original Kyoto would have led to a nominal target amounting to a 15 percent cut in global emissions as of that date (half of 30 percent).

However, there are leakage effects to consider. Reduction in fossil fuel consumption in Annex B countries would lower the world price of fuels and induce higher consumption in non-Annex B countries. That development, as well as migration of energy-intensive capital, would cause emissions to increase in non-Annex B countries, partly offsetting the original emission reductions. The process is known as the "leakage effect." Global economic simulations have found the leakage rate to be anywhere from below 10 to almost 50 percent (see, for example, Oliviera-Martins et al., 1992, Smith 1994). If the leakage rate is 30 percent, then the emission cuts in Annex B countries will induce emission increases elsewhere that offset 30 percent of the cuts. Under the original terms of Kyoto a 30-percent leakage rate would imply total global emissions would fall by about 11 percent (15 times 70 percent).

The United States' withdrawal from Kyoto means two-thirds of world emissions are not covered by Kyoto.

The US withdrawal from Kyoto reduces the impact of the treaty further, because the United States is responsible for over one-third of Annex B emissions. While the United States proposed some unilateral initiatives, the country's withdrawal means about two-thirds of the world's emissions are not covered by Kyoto. If the remaining participants reduce their emissions by 30 percent, this amounts to a 10 percent cut in global emissions (one-third of 30 percent) as of 2010. But if the leakage rate is 30 percent, global emissions will only be reduced by about seven percent against 2010 levels. Once we add in the credits for sinks given to the remaining participants we get an expected global emissions reduction of about six percent of 2010 emissions.

Kyoto's climate impact was analyzed in a simulation model by Wigley (1998). The original form of the treaty, under the assumption that additional accords are developed subsequently to keep emissions from going back up to business-as-usual levels after 2012, only slowed the accumulation of CO_2 in the atmosphere by a small amount. The concentration of CO_2 reached at 2100 under business-as-usual would be reached about five years later under Kyoto-plus-subsequent treaties. With 60 percent of the original emission reductions undone, this small delay shrinks as well. Consequently Kyoto can, at best, only delay by about a few years whatever would happen as a result of increasing CO_2 in the atmosphere, unless the Protocol's targets are later tightened.

Part 2: Economic Analysis of Pollution Policy

Policy Types

While pollution control policies come in many forms, economists find it useful to distinguish between those that work by putting direct constraints on behaviour,

backed up by regulation, and those that work by creating economic incentives. Regulatory measures, also known as "command-and-control," include such things as emission regulations, requirements to install particular technologies, requirements to limit fuel use or reduce energy intensity. Incentive-based measures include emission taxes and tradable emission permits. Other measures also exist that are not so easily categorized. Subsidies for emission control are like incentive-based measures, whereas subsidies to adopt particular technologies can resemble command-and-control, especially if the subsidy is only partial reimbursement for actions forced by regulation. Advertising, "awareness-raising" and moral suasion are sometimes used in combination with other measures. Their effectiveness is hard to predict or measure.

Microeconomics of Pollution Control

Firms and consumers generate pollution because the emitting activities are valuable in some way. If emissions are constrained by a policy measure, valuable activity is foregone. This is what makes pollution control costly. These costs must be weighed against the benefits of the emission reductions. At a particular target, there will be some amount that a firm constrained by the emissions policy would be willing to pay for the right to increase its emissions by one unit, that is one tonne. This is the *marginal value* of the emissions, or alternatively, the marginal cost of abatement.

Cost-Effectiveness

In the case of carbon dioxide there are millions of activities that generate emissions. Each individual activity will have its own marginal value. It is unreasonable to assume that they are all the same or that they change at the same rate. Indeed we would expect there to be large variations in these values. There is no way to get enough information to compute all these different values; however, the fact that they differ affects the choice of emissions control policy.

If a set of emission control policies is put in place, it allocates emission reduction targets across the various sources in some way. Once people have come into compliance with these rules, it is possible that there will be wide variations in the marginal values of the emitting activities at the constrained levels. For instance, one company might be willing to pay C$500 for the right to emit one more tonne while another would be willing to pay only $50. By implication the second company would be willing to reduce its emissions by one tonne for a payment of approximately $50. If the two companies could bargain directly, the first firm could pay, for example, $100 to the second company to induce it to reduce emissions by one tonne, which would then let the second firm increase its own emissions without adding to the economy-wide emissions total. Each company would be better off under such a trade, but the overall emissions cap is maintained.

A policy that is cost-effective must arrange things so that the marginal value of emissions is equalized across all sources (see, for example, Field and Olewiler 2002). This is known as the "equimarginal criterion." A cost-effective policy must

Table 1: ***Summary of Emission Reductions Assuming $10 Permits***

	Option 1	Option 2	Option 3	Option 4
		Megatonnes		
Command-and-Control				
Action plan 2000	45	45	45	45
Budget 2001	5	5	5	5
New targeted measures (*)	22	104	25	25
Total	72	154	75	75
Sinks				
Previously credited	24	24	24	24
Additional sinks	10	10	10	10
Total	34	34	34	34
Permit Trading				
Pricing-induced reductions (*)	16	0	23	25
Private purchases of international permits	128	0	76	10
Government purchase of international permits	0	62	42	16
Total	144	62	141	51
Adjustments				
New sinks included in items marked (*)	-10	-10	-10	-10
Transport target difference between runs#	-5	-5	-5	-5
Credits for other countries' actions	0	0	0	+70
Offsets	0	0	0	+20
Total	-15	-15	-15	75
Total Reductions	235	235	235	235
Estimated Kyoto Gap	238	238	238	238

Tables 4 and 5 in the DP reported on runs that assumed lower targets for the transport sector than was the case for runs discussed elsewhere in the DP.

satisfy the equimarginal criterion. If it does, then once the policy has taken effect it will not be possible to reallocate emission targets in a way that maintains the same overall environmental effect, while reducing the total abatement costs borne by polluters. If the policy is not cost-effective then there would be some way to reallocate emissions targets that reduces total compliance costs without increasing total emissions. The equimarginal rule thus ensures that society gets the most "bang for the buck" in its pollution policy.

Incentive-based instruments naturally satisfy the equimarginal criterion. Tradable permits, whether auctioned or given away according to some allocation rule, create incentives for firms to look for a mutually beneficial trade such as that described above. Under emission taxes, all emissions sources have an incentive to cut back until the marginal value of emission reductions equals the tax rate. In all these cases the equimarginal criterion is satisfied.

Regulation-based approaches typically cannot satisfy the equimarginal criterion because the regulator does not have information about marginal emission values at

each source. It is possible that by assigning specific targets the regulator forces some companies to levels where marginal emission values are hundreds of dollars higher than they are for other sources. Within the command-and-control structure no information is generated to allow these departures from cost-effectiveness to be corrected.

The federal DP proposes a mix of incentive-based instruments (specifically tradable permits) and command-and-control, called "Targeted Measures." We asked for information about the marginal costs of the many targeted measures being proposed, but this request was turned down on the grounds that the numbers were not solid enough to publish. This illustrates the problem that leads to cost-inefficiency under command-and-control. Targeted Measures are significant elements of each Option (see Table 1). The fact that their marginal costs are too uncertain to publish means that the cost estimates in the DP are likewise very uncertain.

A request for information about costs of proposed measures was turned down on grounds that they are not solid enough to publish.

Transfers versus Social Costs

Some of the policy compliance costs incurred by individuals are actually *transfers*, that is, they are incurred privately by some economic agents, but accrue as revenue to others. Costs incurred by some agents that do not become revenue to others are true *social costs*. A policy that minimizes the social costs must be configured in such a way that the cheapest emission abatement options will be undertaken first, followed by progressively more costly ones. In this sense emission control policies have rising marginal costs.

Understanding the distinction between transfers and social costs is important for several reasons. True, social costs can be quite a bit smaller than transfers, but at the same time they are often hidden and more difficult to quantify. Also, it is sometimes the case that those policies that involve large and visible transfers, emission taxes, for example, generate comparatively small social costs. Conversely, policies where the transfers are hidden, such as command-and-control, often have relatively high social costs attached to them.

The total value of transfers created by a pollution-control policy can be estimated from the product of the emissions target and the marginal value of emissions. If carbon dioxide emissions are constrained to 571 MT and at that level are worth, say, $100 per tonne, the transfers will be about $57 billion dollars annually in Canada. Depending on the design of the policy this amount might be grand-fathered to the emitters themselves or accrue to others, including, possibly, the government.

It is important to recognize that this is *not new money*. The transfers represent the value to existing emitters of the activities currently being taken and are already factored into balance sheets, asset prices, property prices and related areas. For instance, if emissions were curtailed by using a textbook tradable-permits system, the total market value of the permits would be about $57 billion. This new asset class would be comparable to that created by dairy quota or taxi licensing systems.

Transfers of this size are created regardless of whether the policy is incentive-based or relies on command-and-control regulations. This is important to stress. In the case of incentive-based instruments that raise revenue by auctioning permits or

charging emission fees, this pool of money becomes a valuable asset or liability. Both those who end up with a claim to some of the transfers and those with a liability to pay them soon realize this.

In the case of command-and-control measures the same magnitude of transfers are involved, creating winners and losers, but the pool of money does not become visible to the same extent. The transfers happen through changes in consumer prices, real wages and the rates of return to capital in some sectors. These effects are real enough at the macro level, but are easy to overlook when considering the up-front costs of a policy. While the microeconomic effects of the policy are not affected by where the transfers go, the macroeconomic effects are, as will be discussed below.

The social costs of an emissions-control policy can be approximated using the old "Harberger triangle" formula from public economics. If emissions are reduced by 240 MT and go from a marginal value of 0 to $100, the social cost of the policy will be approximately $12 billion annually, assuming the emissions reduction required for Kyoto are done domestically.

International Permits Purchases

If carbon dioxide emission reductions sufficient for Kyoto compliance are done domestically, analysts have generated marginal values in excess of $200 per tonne, but not typically below $30. Consequently, a big question in studying Kyoto is whether Canada could get away without doing much domestic emissions reductions, instead purchasing permits at a low cost on an international market. The four Options in the DP all rely heavily on this assumption, as we will explain below.

If emission permits can be purchased on an international market, the marginal value of emissions would likely fall because the international price would likely be lower than that for just a domestic emissions market. At the same time, however, there would be less abatement at home. Estimates in the DP suggest that if the world price of emission permits were $10 per tonne, between 26 and 34 MT of abatement (including sinks) would occur domestically at this price (see Part 3 below). The rest of the gap would be closed by permits purchases. The Options presented in the DP use combinations of tradable permits with other policies.

Macroeconomic Aspects of CO_2 Emissions Control

The disposition of the large transfers created by domestic emission reduction requirements will have macroeconomic implications. If the transfers are collected by the state, the choice of whether to use the revenue to reduce other tax rates or to reduce the national debt can cause the aggregate effects to vary by amounts measured in percentage points of gross domestic product (McKitrick 1997). Changing the scope of policy coverage by, for instance, exempting a subset of industries based on energy intensity, can double or triple implementation costs (Wigle 2001). If the transfers are collected by the state and used for deficit reduction, measuring the long-term macroeconomic benefits would require use of

a forward-looking "rational expectations" model, something that has not been applied to Kyoto policy simulations in Canada.

With carbon dioxide taxes or auctioned permits, emitters must pay a penalty proportional to their total emissions. This is a source of revenue for the government, though it raises concerns about the private cost of compliance to large emitters. "Cap-and-trade" usually refers to a program in which emitters are granted a fixed amount of tradable credits free, thereby reducing private compliance costs while preserving the incentives to find an equimarginal cost allocation of emissions across all sources. The Options propose different rules for this allocation, in one case (Option 3) based on past emissions and in another (Option 4) based on a formula that takes account of output levels and trends.

If a source's emissions exceed the amount of their permits allocation they are required to purchase additional credits from other sources, but if their emissions are less than their granted credits they can sell the excess. The cap-and-trade program reduces the compliance costs of individual firms, but may lead to higher social costs. Because the system does not raise revenue for the government, it leaves no room for offsetting tax cuts elsewhere.

In the case of policies like command-and-control or cap-and-trade that do not capture the transfers for the government, the tax interaction effects still occur. But the government has no new money with which to reduce factor income taxes and thereby offset the tax interaction costs. So the macroeconomic impact of such policies is worse. This has been borne out in numerous empirical simulations (see, for example, Parry, Williams and Goulder 1999, McKitrick 1997, Bovenberg and Goulder 1996, Beauséjour, Lenjosek and Smart 1992).

PART 3: Description and Analysis of the Kyoto Options

The Four Kyoto Options

While the federal government has studied many implementation scenarios and other technical matters, there has not yet been a commitment to specific emission reduction policies. Hence, the discussion to date has only provided hypothetical parameters for determining the costs to Canada of meeting the Kyoto requirements. Comparing specific costs and benefits will require studying well-defined measures that stakeholders - governments, industry and individual citizens - would be prepared to implement and which would be likely to attain the required emission reduction targets. The Discussion Paper of April 15, 2002, was intended as a step towards laying such a foundation by spelling out four specific options which are potentially detailed enough that economic models can produce meaningful cost estimates and the affected parties can assess their willingness to participate in implementation.

All four policy Options share a number of features. They each presuppose that an emissions gap of about 240 megatonnes carbon equivalent (MT) will need to be met, representing the difference between the Business-as-Usual estimate of 809 MT and the Kyoto target of 571 MT. The gap shrinks based on some assumptions:

- Canada can claim "sinks" credits of 24 MT for biomass growth following concessions won at the Bonn and Marrakech meetings.
- The 2001 federal budget and the "Action Plan 2000" are together assumed to generate 50 MT of emission reductions.

This leaves a gap of 166 MT to be closed through new measures. The way each Option proposes to do this will be described below. The DP claims that Budget 2001 will reduce emissions by 5 MT (p. 15) There is no explanation in the Discussion Paper of how the Budget will actually do this. Some programs are mentioned on page 22, but there is no information about when they will be implemented, how much they will cost or what will each accomplish. As well, two of the mechanisms, Technology Partnerships Canada and the Infrastructure Programs, are not designed as emission-reduction programs.

Action Plan 2000 includes proposals such as a national "refuelling infrastructure for fuel-cell vehicles" (AP2000 p. 5). There are no project-specific emission reduction or cost estimates in Action Plan 2000, instead the introduction asserts without explanation that the package will yield 65 MT of emission reductions. This amount was reduced to 45 MT for the purposes of inclusion in the new Discussion Paper, because 20 MT of AP2000's 65 MT are achieved through purchase of CDM and JI credits, which are already detailed in those options. Achieving these reductions presumes the existence of the domestic emissions trading system.

A minimum of 72 MT of emission cuts through command-and-control measures is required in all simulations. Ideally, none of these programs would conflict with each other and they must all be assumed feasible in the given time frames and, because many rely on subsidies, the public budget is able to expand to accommodate them. Representing all these options in an economic model is challenging. For instance, the increased cost of motor vehicle transport due to road tolls, bio-fuels requirements and traffic speed reduction may affect the affordability of any of the major capital investments, but this is difficult to calculate in an economic model.

The mix of policy instruments is summarized in Table 1. The figures are based on the assumption that the price of emission permits on the international market is $10. If the price is different, that will change the relative cost of domestic and foreign action, which will change the distribution of measures in the Table.

Domestic and international tradable permits are used in some of the Options. Where both instruments are traded, the price must be equal in the two markets so the only distinction between them is whether the sale transfers money domestically or to a foreign seller.

Option 1

This approach involves an auction of emission permits covering about 80 percent of domestic emitters The permits sale is coordinated with an international permits market, which is assumed to be up and running. It results in 16 MT of domestic emission reductions being done and 128 MT of foreign permits being purchased. In

addition to these, 22 MT of emission reductions are brought about through Targeted Measures.

It is noteworthy that only 16 MT of domestic emissions are done in response to a price of $10 per tonne. This suggests that over 90 percent (200/216 MT) of the emission reductions required to close the Kyoto gap, if done domestically, would cost more than $10. Since 72 MT of reductions are forced through on the Action Plan 2000 and Targeted Measures lists, this makes it highly unlikely that the equimarginal criterion is satisfied and that Option 1 is cost-effective.

That said, the reliance in Option 1 on a broadly designed permits trading system make it likely that it is the least costly of the four. Cost estimates are not provided for Options 2 and 4 so we cannot provide a full ranking. But evidence from the reported simulations and consideration of the theory of policy design suggests that Option 1 is the least costly proposal.

Option 2

This approach relies even more heavily on command-and-control measures. There is no domestic emissions trading market; instead 104 MT worth of new Targeted Measures are forced through. The federal government also purchases 62 MT of permits on the international permits market. The DP does not provide cost estimates for this option. However the lack of a permits-trading mechanism will likely make this Option dramatically more costly than Option 1.

Option 3

Compared to Option 1 this approach slightly adjusts the mix of permits trading and command-and-control, and also distributes the permits freely rather than auctioning them. The permits distribution is based on past emissions, as estimated by emission intensity and output levels. Compared to Option 1, the command-and-control measures account for 75 MT rather than 72 and it permits trading accounts for 141 MT rather than 144. Unlike Option 1, only large emitters are involved in the trading system, covering about 40 percent of domestic emission sources. A total of 23 MT worth of emission reductions are undertaken domestically at the $10 price, compared to 16 under Option 1.

Option 4

This approach combines a tradable permits system in which, as with Option 3, only large final emitters are involved, but where the permits are distributed according to estimates about sectoral emission reduction costs, expected future emission growth rates and some "other economic, social and environmental goals" (DP p. 34). Also, Option 4 is implemented assuming that 70 MT worth of "Clean Energy Export" credits are given to Canada.

Option 4 also enables use of "offsets." These are emission reductions undertaken by individuals and companies that are not part of the trading system. The emission reduction is then treated as a credit that can be bought by a company

BOX 2: *Major Command-and-Control Initiatives Implemented Under Options 1, 2 and 3*

- Road tolls on major highways and enforcement of current speed limits (4.1MT)
- Increase ethanol content of gasoline to 50 to 100 percent (1.8 to 6.0 MT)
- Expansion of public transit (3.4 MT)
- Retrofit of 20 percent of the existing housing stock (1.5 MT) and commercial buildings (1.2 MT)
- CO_2 capture and storage in oil and gas sector (2.2 MT)
- Reduce flaring and improve energy efficiency in oil and gas extraction equipment (8.0 MT)
- Increase role of renewable sources in electricity production (13.0 MT)
- "Improved East-West power transmission" (6.0 MT)
- CO_2 capture and storage on coal-fired plants (19.5 MT)
- Invest in energy efficiency and "low-emissions capital stock" for industry (6.0 MT)
- "Incite" the generation of electricity in locations where the waste heat can be captured and utilized (2.0MT)
- Workshops and "awareness initiatives" to promote "best practices" in commercial vehicle use (1.0 MT)
- "Urban Showcase Renewal" program (1.0 MT)

within the trading system, subject to auditing and approval. It is assumed that at a $10 market price, in addition to 25 MT of reductions induced by the permit price an additional 20 MT of emission reductions are implemented by companies wanting to sell offsets. There are no model simulations of this option.

The specific command-and-control measures to be implemented under Options 1 and 3 are listed in Appendix 1. As mentioned above, our requests for cost information on these measures were refused, complicating our task. The reader must therefore assume that these measures can be implemented as early as 2008 and that there will not be significant problems of compliance, affordability or conflict among the measures. These questions are central to whether the Discussion Paper has succeeded in setting out credible estimates of feasible and adequate options for Kyoto compliance. An overall judgment on this point therefore involves a certain amount of guesswork.

The major command-and-control proposals listed in the Discussion Paper Annex are shown in Box 2. They amount to almost 69 MT of new emission reductions. All these options are assumed implemented in Option 2, and many are implemented in Options 1 and 3 (see Appendix 1).

Most of these measures are identical to those already proposed in the Action Plan 2000. Nonetheless, they are presented as new proposals in the Discussion Paper. Since Action Plan 2000 has very few measures that are not repeated in this Discussion Paper it is not possible to rule out overlap, resulting in double counting. Also, the reduction of flaring from oil and gas wells is presented as a new program. Alberta began a flaring reduction initiative in 1998 (Flaring Project

Team 1998) and claims that flaring has been reduced by almost 40 percent below 1996 levels already (Government of Alberta 2002).

The fiscal rule for the two modeled Options is to adjust personal income taxes so as to keep the federal budget unchanged. Under Option 1 the introduction of a permits auction in 2008 raises enough revenue for the government to allow income taxes to be reduced. In other Options income taxes must be increased.

The Discussion Paper is silent on the income tax implications of the Options. Based on information supplied to us, we graphed the projected changes in the effective tax burden, or average income tax rates (see Appendix 2). There is an obvious question of whether future federal and provincial governments will commit to raising income taxes to pay for these policy Options. This is something that ought to be brought out into the public debate more explicitly.

If provinces are not willing to raise their personal income tax rates, it is possible for the federal government to shoulder the whole burden. However, this would amount to a different fiscal rule and, since this would have a substantial impact on the federal budget, it is important to analyze how this contingency would be handled.

The question is: will future governments commit to raising income taxes to pay for implementation.

All options assume the government or the private sector purchases international emission permits, totalling 26 MT (Option 4), 62 MT (Option 2), 118 MT (Option 3) and 128 MT (Option 1). The Kyoto "Flexibility Mechanisms" include a number of avenues for low-cost abatement projects in one country (either Annex B or Non-Annex B) to be financed by an Annex B country in exchange for credits against its Kyoto target. The best known of these are Joint Implementation, the Clean Development Mechanism and International Permit Trading (IPT). In order for these mechanisms to be workable, a number of international legal and enforcement mechanisms must be established and associated institutions created. The likelihood of an international market being created is increased the fewer the number of participants because it is easier to coordinate development of these institutions. It is conceivable, for instance, that a market might initially only involve the developed countries of Western Europe, Canada and Japan. However all these regions expect to be net purchasers, so the market price would have to rise high enough that some of these regions would begin to overshoot their Kyoto commitments and generate excess permits for sale.

If Russia, the Ukraine and other former Soviet countries join, as most recent studies assume, there will potentially be an ample supply of cheap permits. In particular, if Russia joins the treaty and institutional barriers to setting up a trading market can be overcome, having permits available at an initial price of $10 is a reasonable assumption (Löschel and Zhong 2002). This is because the collapse of the Soviet system in the early 1990s in these regions caused carbon dioxide emissions to fall to the point where today they are well below where they were in 1990. On the other hand, if the international price is only about $10, the incentive for Russia to join is thereby diminished, compared to a situation with $50 permits.

Some analysts (for example, Victor 2000) dismiss the idea that an international permits market could form, because institutional barriers are too formidable. Others, including several researchers at Resources for the Future (see, in particular, pages 205-235 of Toman (2001)) are more optimistic. Since all four Options include some purchases of permits, they depend on the existence of at least some of the

Flexibility Mechanisms, which in turn require the existence of these institutional and legal mechanisms.

We see in this a chicken-and-egg problem, since the establishment of the permits market requires the treaty to enter into force, but for that to happen countries must believe it is economically feasible. However, for that to happen, a permits market would have to exist. It is conceivable that Canada might decide to ratify based on the expectation that international trading mechanisms would keep down implementation costs, only to find out later that the trading mechanisms are not feasible or emerge on too limited a basis to supply low-cost credits. This being the case, it is important that analyses be produced exploring not just the contingency of $50 international permits, but also the contingency of no international permits at all. Full information about the functioning of the various Flexibility Mechanisms is likely to follow, rather than precede ratification. These broader analyses would both illuminate whether Canada should ratify the Protocol in the first place and give us some guidance about the conditions under which Canada might later withdraw from the Protocol.

Is There A Cheaper Option?

There actually is a cheaper way of achieving Kyoto's goals.

It is worth pointing out that there is another option besides the ones presented in this Discussion Paper. If the international permits market really becomes operational and practically unlimited numbers of permits are available at $10 per tonne, the federal government could levy a $10 per tonne carbon dioxide tax on all fossil fuels, yielding an expected 30 MT emission reduction, then buy 210 MT of international permits at that price to meet the rest of the Kyoto target. If the CO_2 tax were revenue-neutral and income taxes were reduced by $0.3 billion as an offset, the net economic impact of the tax shift would be very small. The overall cost then would be $2.1 billion annually for the permits, and even taking into account the social costs of the taxes needed to raise this money this would be much cheaper than anything proposed in the DP.

The analysis of the four Options suggests that at $10 per tonne only about 16 to 24 MT of new emission reductions will be cost-effective at home, as well as a small number of sinks projects amounting to approximately 10 MT. It is assumed in the modeling exercise that all the Action Plan 2000 measures are already in place when the pricing system is introduced. This means that about 26 to 34 MT of emission reductions (11 to 14 percent of the Kyoto gap) would be done domestically at a marginal cost of less than $10 per tonne. The fact that all the options (including Option 4) require at least 88 MT of new domestic emission cuts means that the marginal cost of domestic action is likely to be well above $10 and, therefore, the proposals in this Discussion Paper are needlessly expensive. The DP stresses that the distribution of the cost burden is a key consideration, but since federal purchases of international permits can be financed by modifications to the tax system, this concern can in principle be dealt with.

The Status Quo Option

While not stated in the DP, there is of course the option of doing none of the above and deferring action until the costs and benefits are more thoroughly understood. Because of the scale of the potential economic impact of any of the Options proposed this should not be dismissed without due consideration.

Will These Options Meet the Kyoto Targets?

As shown in Table 1 all the options yield estimated reductions that pretty much close the Kyoto gap. The question is whether the strategy in this Discussion Paper is likely to generate the promised domestic emission reductions. We have noted the possible overlap between the Discussion Paper and the Action Plan 2000, as well as with existing initiatives like the Alberta gas flaring reductions. In addition, the time scale is exceedingly tight for ambitious projects such as retrofitting 20 percent of the domestic and commercial building stock, repaving 6,500 kilometres of highways with cement, retraining 250,000 truck drivers, buying 20,000 alternate fuel vehicles for the government and getting a 30 percent market penetration rate for alternate fuel city buses. Even if a decision on ratification were to be made by the end of this year that would only leave seven years to do all these things. Also, the Protocol requires that parties show "demonstrable progress" towards their commitments by 2005 (Article 3.2), further tightening the time frame.

The specific policies in the Discussion Paper presuppose cooperation among industry, the provinces and the federal government. So far, Alberta and, to a lesser degree, Ontario, have been vocal opponents of speedy ratification. Overall, none of the Options will be easy to implement, in the manner described in the Discussion Paper, within the proposed time frame. The key obstacles include:

- coordinating federal and provincial tax increases to pay for the measures.
- implementing the long list of projects and measures in all major sectors of the economy (including homeowners and motorists).
- developing an international permits trading market that will make a lot of emission credits available at a low price.
- developing the public sector infrastructure to audit and verify the emission reduction initiatives.

Before turning to the estimates of the economic impact we discuss the structure of the models used in the DP and some possible implications of the particular choice of modeling strategy.

PART 4: The Economic Modeling

The Cost Estimates

The DP cost estimates were prepared using a macroeconomic model called TIMS and an energy / technology model called Energy 2020. This section briefly describes

how these models work and how they were used to estimate the economic impacts of two of the Options.

Models Used for the Discussion Paper Cost Estimates

Economic models can be divided into those based on assumptions of optimizing behavior and those based on recursive macroeconomic structures. Optimizing models start with the assumption that consumers and producers minimize the cost of achieving their goals, which for consumers means maximizing utility given current income and for companies means maximizing profits. An outcome in which consumers and producers have all implemented privately optimal strategies is called a "general equilibrium." Under these circumstances if an energy-saving technology can yield net private benefits it will be adopted without the need for a regulatory push.

Computable General Equilibrium (CGE) models are based on an examination of the price system and market activity. They do not usually incorporate a specific description of technology types in the energy sector, but instead represent the availability of different types of energy at different hypothetical prices.

The cost estimates in the Discussion Paper are provided by a macroeconomic model known as TIM - The Informetrica Model. This is a recursive forecasting tool that captures aspects of the transition between before- and after-policy states, including unemployment and capital stock reallocation. "Recursive" means that agents are assumed to make decisions based on current and past information, rather than on expectations about the future. TIM resolves the final-demand sector in detail, using multiplier coefficients to translate policy shocks into final macro changes. It uses input-output coefficients to downscale those changes to specific industry outputs and inputs and a sub-model called RIM (the Regional Informetrica Model) to downscale on a provincial grid. Industry output prices are built up using unit cost functions.

Because the social costs of policy changes are transmitted through the price system, policy evaluation is usually done with CGE models rather than - or in addition to - macroeconomic models like TIM. The conventional measure of the social cost of a policy change is called "utility" in economic theory. Utility changes can be evaluated in CGE models, but not in macroeconomic models like TIM. Hence the discussion that follows will look at what can be learned from the macro model approach, but evaluation of the true social costs of the Kyoto options will have to await application of a CGE modeling approach.

TIM was paired with an energy-sector sub-model called Energy2020. This model represents the specific technology types and capital stock vintages in energy-producing and consuming sectors. The effects of the targeted measures and the imposition of domestic tradable permit regimes were computed in the energy sector on the assumption that output in the industry remains constant after the policy takes effect. Economy-wide changes were estimated by transferring data from Energy2020 up to TIM. Because of the structure of the models there are only three linkages between Energy2020, where the policy change is simulated, and TIM, where the economic changes are simulated:

- the capital stock changes in the energy sector
- the cost of buying foreign permits
- the energy savings in the affected industries.

The Informetrica Model then simulated the economic changes for the economy as a whole on this basis.

Potential Shortcomings of the Approach Used

This one-way linkage has two potential shortcomings. First, the models do not impose the assumption of cost-minimizing behaviour in the base case. Second, macroeconomic changes ought to feed back into affected industry sectors, which would in turn change the inputs to TIM, implying an iterative process should be used. Work on model iteration is now underway and the results may give guidance as to the implications of this particular modeling structure.

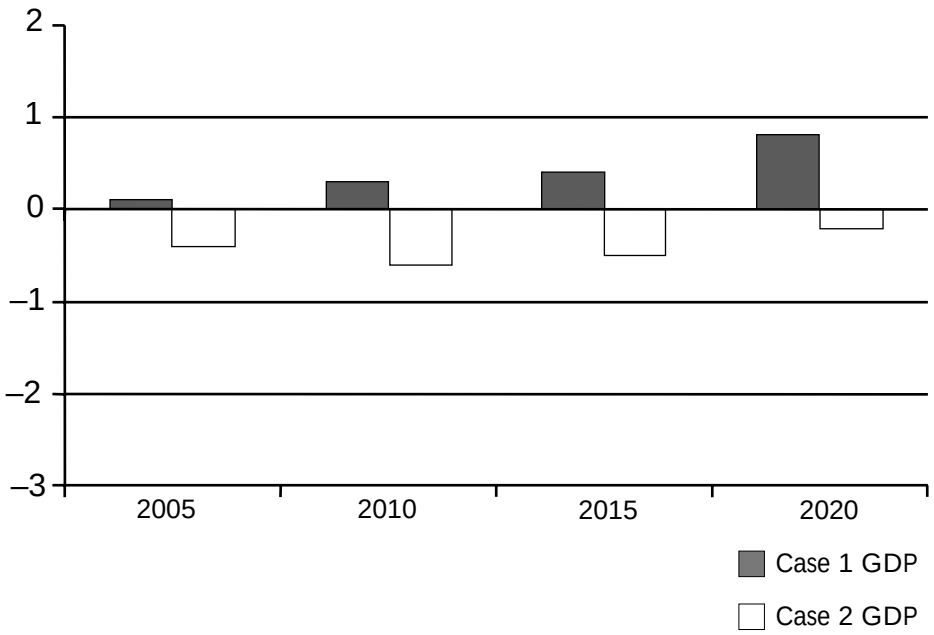
There is a possibility of a "free lunch" in one of the modelling approaches.

The first point illustrates the difference between using a macroeconomic forecasting tool and a CGE model. In a CGE model it is assumed that all agents in the economy are cost-minimizers. Policy shocks can only improve general welfare by reducing distortions in the price system, increasing returns to factors of production and other such efficiency enhancing changes. Of particular note here is the fact that it is not possible to generate an economic benefit by simply requiring a company to change its factor or material inputs so as to reduce energy use. The reason is that if a company could really save money by using some new energy-saving technology, a profit-maximizing organization would have undertaken it already. Companies are assumed to have exhausted all such economically beneficial innovations. Further substitutions between capital and energy are costly to the company.

In the TIM/Energy2020 framework, however, the starting point is not a cost-minimizing equilibrium. Thus it is possible that a regulator could order a firm to adopt some new energy-saving technology that would increase the rate of return to capital in the sector. It is not *necessarily* the case that targeted measures have this effect, but they are not ruled out as they are in CGE analyses. In short there is a possibility of a "free lunch" in the macro-modeling approach because the information transmitted to TIM may include the claim that capital rates of return have risen as a result of complying with the Kyoto plan. On its own this means the modeling framework used for the Discussion Paper may understate some of the economic costs of the Kyoto options.

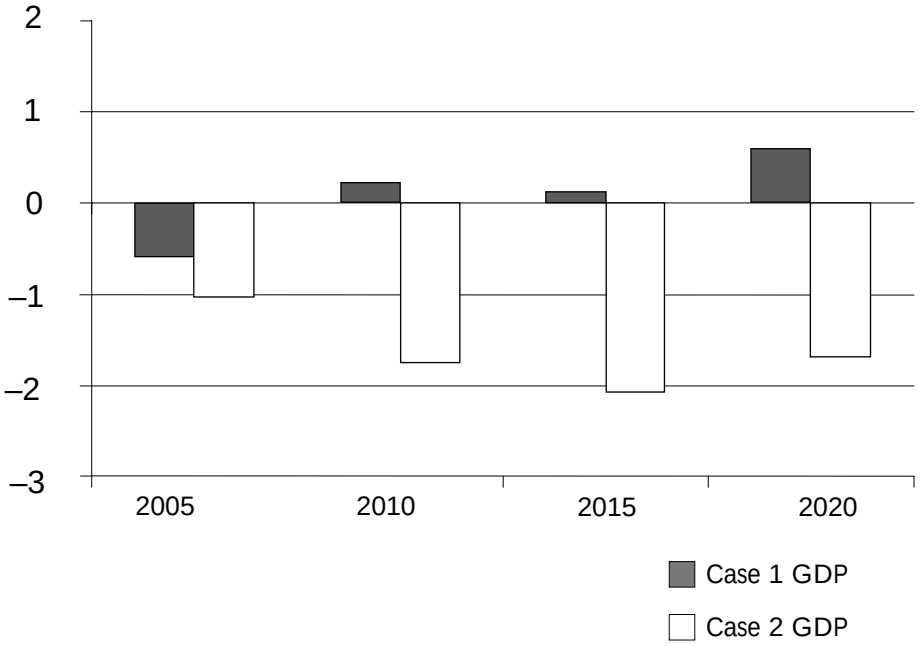
The second point, that macroeconomic changes would cause changes in output and input usage in the energy sector, implies that information should be iterated between TIM and Energy2020. This was not done for the AMG 2000 Report, nor for the recent federal discussion paper estimates. It is not likely that such iteration would produce large changes in the results at the macro-economic scale, but there would probably be some important changes to industry- and province-specific results. The policy changes at the industry level assume that emission reductions cannot occur through output reductions, only through process changes. This structure may, if anything, overstate the costs to industry of the policy changes because it implicitly limits the range of responses that companies will actually have available to them.

Figure 1 - **$10 world:** Changes in Real Gross Domestic Product in percentage change from base case, 2005 to 2020, assuming $10 per tonne international permits. "Case 1" corresponds to Option 1, "Case 2" corresponds to Option 3.



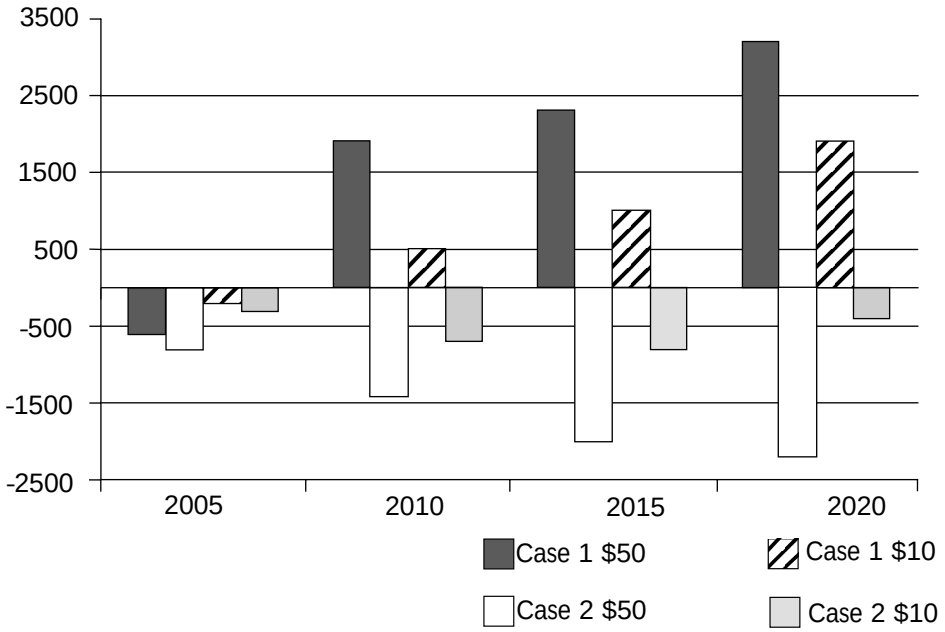
Source: From "The Economic Impacts of Kyoto," background material for Joint Ministers Meeting, May 21, 2002, prepared by the Analysis and Modelling Group.

Figure 2 - **$50 world:** Changes in Real GDP (in percentage change from base case), 2005 to 2020; assuming $50 per tonne international permits. "Case 1" corresponds to Option 1, "Case 2" corresponds to Option 3.



Source: From "The Economic Impacts of Kyoto," background material for Joint Ministers Meeting, May 21, 2002, prepared by the Analysis and Modelling Group.

Figure 3: Changes in Per Capita Real Disposable Income, 2005 to 2020, in dollars. "Case 1" corresponds to Option 1, "Case 2" corresponds to Option 3.



Source: From "The Economic Impacts of Kyoto," background material for Joint Ministers Meeting, May 21, 2002, prepared by the Analysis and Modelling Group.

The Estimated Economic Impacts

The proper measure of the aggregate cost of a policy is not the change in real gross domestic product (GDP) but the change in total potential consumer utility in each period after a policy change has occurred. This is related to, but not necessarily equal to, the change in total potential GDP. One of the main differences arises from the treatment of the labour supply, since changes in utility take account of substitutions in consumption and leisure. The change in utility can also differ from the change in GDP if other aspects of environmental quality, specifically urban air quality, are improved as a result of the policies adopted and this is factored into the utility function.

Not all models can provide estimates of changes in terms of utility changes and, as a result, comparisons rely on GDP changes instead. However, some policy experiments can yield an increase in GDP while reducing aggregate welfare or utility. Therefore it is essential that the policy Options in the Discussion Paper be further studied in a CGE framework in order to assess their welfare implications.

For the purpose of the macro-economic simulations, the DP assumes - $10 and $50 respectively - world prices for permits. If international permits are $10 per tonne the effects on real GDP are as shown in Figure 1. The results for $50 permits are in Figure 2. Figure 3 shows the changes in real per capita income. Some other information is available in a background document from the Analysis and Modeling Group (2002).

These diagrams were taken directly from the Analysis and Modeling Group background briefing slides. The terminology used calls Option 1 "Case 1" and Option 3 "Case 2."

Inferences About Marginal Costs of changing the Policy Mix

There are striking differences between the results for Option 1 (Case 1) and Option 3 (Case 2). In Figures 1 and 2 for instance, notice that as of 2010 the change from Option 1 to Option 3 increases the aggregate cost by one-to-two percent of GDP. Comparing the mix of instruments in the two Options in Table 1, however, they are not all that different. The differences are:

- in Option 3 only about 40 percent of emitters participate in the market
- in Option 3 there is slightly more reliance on targeted measures
- in Option 3 permits are given away rather than auctioned.

It is this last feature that generates the most significant differences between the Options. Giving away permits means the potential transfers accrue to the recipients rather than going to the state, so a fiscal rule cannot be used to offset the social costs of the emission control policy (see Part 1).

Figure 3 shows that free permits distribution rather than auctioning, (with revenue recycling via income tax reductions, costs between $1,100 and $3,000 per capita as of 2010. This shows that small changes in the form of the Kyoto policy can have large effects on the estimated final costs. Along this same theme, the Analysis and Modeling Group (2002) reports that if the revenue from permits sales in Option 1 is applied towards the federal deficit rather than towards cutting income taxes, the GDP gains for $50 permits turn into losses of one-to-two percent of GDP, in the context of a macro model.

How do These Results Compare with Previous Studies?

To re-cap, the overall target is 240 MT, or about 30 percent of base case emissions as of 2010. In both Options 1 and 3 about half the gap is dealt with by purchasing international permits. This leaves a domestic emissions reduction requirement of about 15 percent of the base case and the aggregate costs in terms of GDP as of 2010 are estimated to be 1.6 to -0.2 percent of GDP. The difficulty of comparing earlier results to those of the DP is that other studies generally simulated emission taxes or an equivalent policy, rather than the mixed approach in the Discussion Paper. Also, a variety of models have been used and the results need to be interpreted in the light of the specific assumptions and structures employed.

Some studies that pre-date Kyoto (Beauséjour, Lenjosek and Smart 1992; McKitrick 1996) used static CGE models to examine the costs of a 12.5 percent emissions cut from 2000 levels, which was then called the "Rio target." Beauséjour et al. used a calibrated CGE model and estimated that a package of emission standards on energy intensive industries and a carbon dioxide tax on final demands would cost about 0.8 percent of GDP. This could be reduced by relying just on a carbon dioxide tax for all sources. McKitrick (1997) used an econometrically estimated CGE model and found that for a 12.5 percent domestic emissions cut just using a CO2 tax the costs range from a reduction of 0.9 percent of GDP to an increase of 0.6 depending on the revenue-recycling rule. However aggregate utility was unchanged or fell in all cases.

The Kyoto Protocol is almost comparable in economic impact to the 1988 Canada-US Free Trade Agreement.

Following the signing of the Kyoto Protocol in 1997 a series of studies yielded social cost estimates ranging from 0.2 to 2.2 percent of GDP, depending mainly on whether permits could be traded globally (see Wigle 2001). With global permit trading the costs are usually below one percent of GDP. In 2000 Industry Canada commissioned a study (Wigle 2001) that looked at a range of policy options. This study used the MRT-C model, which is of the CGE variety. A uniform emissions charge to attain the Kyoto target was found to cost between 1.0 and 1.5 percent of GDP if there were no international emissions permit trading. However, if exemptions were given to certain sectors the costs quickly rose. Exempting the non-energy intensive sectors led to economic losses in the range of 1.5-to-2.0 percent, while exempting energy intensive sectors and focusing policy elsewhere might cost up to 7.5 percent of GDP. The costs of such exemptions are reduced markedly however by the availability of international permit trading. In that case, instead of raising the domestic cost of compliance, the exemptions led Canada to buy more permits in the world market and do less abatement at home.

Finance Canada produced a set of CGE simulations using the CasGEM model to consider the mix of industry-specific policies proposed by the Issues Tables. They estimate a 0.9 percent contraction in GDP to achieve the Kyoto target, on the assumption that targeted measures are successfully deployed at relatively small costs.

To get a sense of these numbers, note that one percent of Canada's GDP is about $10 billion. This is an annual cost. These findings taken together imply that the aggregate GDP changes estimated by TIM/Energy2020 are similar to those produced by earlier studies when they modeled programs with zero or very limited targeted measures. However the policy experiments are different and the models are all sensitive to small changes in the policy design. Predictions of the economic impact depend strongly on specific assumptions about the policy design and since none of the earlier studies have simulated the four Options from the DP it is not possible to compare the results directly.

PART 5: Forming a Basis for Making a Policy Decision

What Information is Needed?

The government presented the Discussion Paper as the basis for deciding on a significant policy innovation in Canada. Adopting the Kyoto Protocol will likely affect all regions and all sectors of the economy one way or another. As a policy change it is almost comparable in its total economic impact to that of the 1988 Canada-US Free Trade Agreement. In that case, the independently estimated aggregate welfare effect ranged from a loss of 0.1 percent of GDP (Wigle 1989) to a gain of almost 10 percent (Harris 1986). Also, the FTA had a potential impact, both positive and negative, across the country that needed to be studied to form a basis for making a decision. The federal government produced estimates from both the Department of Finance and the former Economic Council of Canada and those reports contained considerable detail about the analytical methods and the results. Numerous federal departments, including Industry, Energy, Transport, Agriculture and Fisheries, also produced reports for their sectors explaining the specific risks

and changes involved. The exact text of the policy was available and several groups studied the adequacy of labour market adjustment programs.

The amount of information available about the four Options in this Discussion Paper is much more limited. Two specific issues need to be clarified in greater detail:

- the exact design of the policy package
- the distribution of the cost burden across industries and regions

Before there will be an adequate information basis for deciding if Canada should ratify Kyoto it is necessary to cost out all relevant Options, under all reasonable contingencies. So far we have cost estimates for only two of four Options, under optimistic contingencies.

A Wider Range of Methods

The use of a recursive macroeconomic model has advantages in terms of generating information about the adjustment path. It is ironic then that there is no dynamic information given in the Discussion Paper; just a post-implementation snapshot. But the TIM/Energy2020 framework does not capture optimizing behaviour or the transmission of social costs through the price system, so its results depend in key ways on its particular structural assumptions. This is not to say that it should not be used, only that it should not be the sole modeling strategy. It is essential that a wider range of methods be used to look at the general equilibrium consequences of the policy proposals. Implementation in a CGE framework will also allow for a check on whether the structure in the TIM/Energy2020 pair allows for free lunch effects that understate the costs of command-and-control measures.

Conclusions

The federal Discussion Paper is a starting point only for understanding the costs to Canada of achieving compliance with the Kyoto Protocol. The four Options all involve a mix of incentive-based and command-and-control instruments. Our conclusions are as follows.

The costs of compliance depend in a sensitive way on the specific policy design. Small changes in instrument choice can lead to large changes in the aggregate costs and region- or sector-specific effects. This was shown in the comparison of Options 1 and 3, when the switch to giving away permits rather than auctioning them caused the macroeconomic impacts to worsen substantially even though the mix of instruments hardly changed at all. Costs generated under one implementation scenario do not generalize to other implementation scenarios. Hence the "cost of Kyoto" can only be discussed with reference to specific compliance measures.

This being the case it is essential that cost estimates be produced for all Options that the government is actually proposing to implement, under all reasonable contingencies. The list of contingencies that might arise and which would affect the

implementation costs could include a lack of voluntary cooperation from provinces or industries and the failure of international permit trading institutions to emerge.

All four Options include targeted measures that are unlikely to be remotely cost-effective. Under the $10 emission pricing scenario, less than 10 percent of the emission gap is closed by actions taken in response to that price. In other words, very few domestic-emission reductions have marginal costs below $10. The heavy reliance on Targeted Measures means many emission reduction strategies are being forced through that have potentially very high marginal costs. Unfortunately, the DP does not provide useful information to evaluate the extent of this policy design problem.

Because the Options require a lot of domestic emission reductions they are needlessly costly. A pure pricing system, based solely on international permits purchases, would achieve Kyoto compliance at a fairly low cost if the international carbon dioxide price is $10. But little domestic emission reduction would occur in this case, reflecting the fact that there are relatively few low-cost emissions abatement options in Canada compared to other countries.

Only by seeing more details will we be able to determine whether particular Kyoto Options can be implemented at anything like the modest social costs potentially achievable, or whether through excessive reliance on an ill-conceived range of targeted measures the costs will end up being dramatically higher.

As it stands the Discussion Paper does not provide an adequate basis for making a decision on Kyoto. The analysis offered thus far does not provide sufficient information to understand the economic consequences and risks of accepting the Kyoto target as legally binding. Given the macro-economic scale of this policy commitment and the potentially far-reaching economic effects, without a more thorough understanding of the economic impact a decision to ratify on the basis of what has been determined thus far would indeed be precipitous.

Appendix 1: *Specific Targeted Measures included in Options 1 and 3*

Buildings

Option 1	Option 3
National Standards Program Equipment & Appliances Minimum efficiency standards introduced in 2004 for HVAC equipment major appliances; domestic water heaters; lighting; windows and doors etc. *Penetration Rate: 44%*	*Penetration Rate: 100%*
Energy Performance Labelling Program *Penetration Rate: 44%*	*Penetration Rate: 100%*
Public Building Initiative along the lines of Federal Buildings Initiative *Penetration Rate: 34%*	*Penetration Rate:* 100%
Commercial Building Retrofit Program Enhancement and expansion of a private sector building program *Penetration Rate:* 30%	*Penetration Rate:* 100%
Multi-Residential Retrofit Program Enhancement and expansion of a private sector building program *Penetration Rate:* 8%	*Penetration Rate:* 100%
Provinces Adopt a More Stringent Model National Building Code for Houses (MNECH). *Penetration Rate:* 50%	*Penetration Rate:* 50%
Strengthened R2000 Program: more marketing, access to preferred mortgage rates, expanded builder training and certification, etc. *Penetration Rate:* 20%	*Penetration Rate:* 100%
EnerGuide for Houses: households would receive a home energy audit. *Penetration Rate:* 150%	*Penetration Rate:* 200%
Residential Retrofit Guidelines and Installation Standard Adherence would be encouraged or required in these Measures. *Penetration Rate:* 50%	Same level of effort, but combined to the **National Energy Efficient Housing Renovation & Retrofit Program.**
R-2000 for Existing Dwellings Renovation Program: Including demonstration of new design approaches; demonstration of "market-ready" technology. *Penetration Rate:* 25%	Same level of effort
	Increase the provincial minimum energy efficiency regulations for new buildings to 15 % above MNECB. *Penetration Rate:* 100%
	National Energy Efficient Housing Renovation & Retrofit Program Tax breaks such as removal of GST, PST, HST, and/or accelerated depreciation of costs in rental housing; new financing; home energy audits and labelling (EnerGuide for Houses); renovator training/ certification; store sales force training etc. *Penetration Rate:* 100%

Transportation

Option 1	Option 3
Enhancements to the Pedestrian and Bicycle Environment To be implemented by municipal governments: increased spending on sidewalks, signalized intersections, street lighting, bicycle paths, bicycle racks, lockers, connecting transit, winter maintenance, policing. *Penetration Rate:* 33%	Same as in Option 1
Synchronized Traffic Signals a wide range of programs and projects to reduce delays, and manage incidents. *Penetration Rate:* 33%	Same as in Option 1
Telecommuting Aggressive education and outreach program and mandatory telecommuting programs (as appropriate) for offices with more than 50 employees. Implemented by employers and enforced by provincial government, would take until 2005 to be effective in bringing companies on-board. *Penetration Rate:* 17%	Same as in Option 1
Car Sharing Co-operative ownership and sharing of automobiles, implemented by the private sector. *Penetration Rate:* 33%	Same as in Option 1
Transit Service Improvements Expansions and enhancements by municipal and provincial governments. Improvements implemented by 2010: 10 minute reduction in in-vehicle travel times, 10 minute reductions in headways etc. *Penetration Rate:* 20%	*Penetration Rate: 100%*
Short-Term Aviation Measures To be taken by the aviation industry in Canada between 2000 and 2010. Enhanced air traffic management; oceanic reduced vertical and horizontal minima; preferred aircraft trajectories, polar routes; optimization of noise abatement procedures; decreased congestion at airport. *Penetration Rate:* 100%	Same as in Option 1
Rigid Pavements (Cement) Primarily be the responsibility of the provincial highway agencies. A total of 6,500 km of the National Highway system is involved. *Penetration Rate: 61%*	Same as in Option 1
Truck Driver Training Trucking fleets would implement driver training programs addressing fuel efficiency and GHG emission reduction. 250,000 commercial drivers trained on an annual basis, from 2000 till 2020 through a combination of one-on-one and classroom training. *Penetration Rate:* 100%	Same as in Option 1
Advance Vehicle Control System On-board sensing and processing technologies to facilitate collision avoidance. E.g., adaptive cruise control, night vision sensors, heads up displays, and obstacle detection; reducing incident congestion in urban areas. Primarily the responsibility of the private sector automobile industry, funded by private individuals and organizations. *Penetration Rate:* 100%	Same as in Option 1
Truck Central Tire Inflation All trailers and all heavy trucks in year 2000 to be fitted with static central tire inflation system (SCTI). *Penetration Rate:* 33%	Same as in Option 1

Transportation *(cont'd)*

Option 1	Option 3
Trucking Load Matching All van and flatbed trailers operating in Canada on trips over 300 kilometers are assumed to reduce their empty travel by one percent as a result of new Internet-based services. *Penetration Rate:* 100%	Same as in Option 1
Truck Lubricants All trucks shift to synthetic or partially synthetic engine oils starting in the year 2000. *Penetration Rate:* 33%	Same as in Option 1
Marine Code of Practice I and II *Penetration Rate:* 100%	Same as in Option 1
Fleet Average Fuel Consumption Target Harmonized Vehicle manufacturers would reduce the average fuel consumption of the new light-duty vehicle fleet by 25% by 2010 over a baseline of 1998. Consumer education /awareness component is assumed to be included in the policy. *Penetration Rate:* 100%	Same as in Option 1
Alternative Fuel Infrastructure Canadian Government could provide incentives for provinces and / or metropolitan areas to develop alternative fuel infrastructure within their areas. Government will supply enough subsidy to place the fuel option on at least an equivalency with gasoline or diesel; other incentives could be employed to help market penetration *Penetration Rate:* 100%	Same as in Option 1
	Commercial Vehicle Electronic Clearance Electronic clearance at border crossings and inspection stations *Penetration Rate:* 100%
	Enforcement of Current Speed Limits for both auto and truck travel. Existing posted speeds would be observed; there would be no reductions in posted speeds. (reductions in posted speeds are considered as a separate measure). Provincial enforcement agencies would be responsible. *Penetration Rate:* 100%
	Alternate Fuel Vehicle (AFV) Purchase Assume fleet and government purchase commitments of 10,000 AFVs per year, increasing to 20,000 in 2010 and beyond; spread evenly across electric, CNG, LPG, and ethanol vehicles in the near term and will add fuel cell vehicules and cellulosic ethanol as they becomes available after 2005. *Penetration Rate:* 100%
	Heavy Duty Truck Efficiency Improvements Voluntary engine improvements, aerodynamic improvements, and tire rolling resistance improvements. Sierra (study 2) has estimated that a 10% reduction in fuel consumption could be achieved by 2020 using technology improvements that mostly pay for themselves *Penetration Rate:* 100%
	Transit Bus Design and Alt. Fuels Grants or Loans for CNG Transit Buses to achieve a 30% market penetration within 3 years. *Penetration Rate:* 100%

Transportation *(cont'd)*

Option 1	Option 3
	50% Ethanol Mandate the renewable fuel content of gasoline. Provinces would agree to adopt these; commercialization of converting biomass residues such as wood waste and straw into fuel . *Penetration Rate:* 100%
	Biodiesel from Waste Greases, Stressed Canola In partnership with Canadian industry, the provinces and municipalities. Industrial production of 500 million litres per year by 2010 of renewable fuels made from restaurant cooking oils, tallow and waste stream soybeans and canola. *Penetration Rate:* 100%
	Trucking - Driver Idling Training Trucking fleets would reduce the amount of total engine idling time through training. *Penetration Rate:* 100%
	Diesel Incentive for New Vehicles Increase in the gasoline excise tax. Federal negotiation/suasion with light duty vehicle manufacturers to preferentially market diesel engines in Canada. Assumes that 20% of new light duty vehicles will be diesel powered by 2010, and that upstream emissions would be reduced based on NRCan's Genius fuel cycle GHG model. *Penetration Rate:* 100%
	Freight Intermodal System Improvements Fund improved road access to intermodal terminals *Penetration Rate:* 100%

Agriculture

Improved Nutrient Management Provide the appropriate amount and concentration of nitrogen and reducing fall application of N fertilizer *Penetration Rate: 100%*	Same as in Option 1
Increase No-Till Increasing the sequestration of carbon in agricultural soils. *Penetration Rate:* 100%	Same as in Option 1
Decrease Summerfallow *Penetration Rate:* 100%	Same as in Option 1
Increase Permanent Cover Program Converting marginal (economic and /or environmental) land from annual crop production to permanent cover *Penetration Rate: 100%*	Same as in Option 1
Improved Grazing Management increase forage quality, supply and efficiency. Livestock methane emissions are reduced by increasing the nutritional quality of grasses. *Penetration Rate:* 100%	Same as in Option 1
Improved Livestock Feeding Management Raising awareness, establishing reliable database and incentives to bring existing technologies that improve feed utilization. *Penetration Rate:* 100%	Same as in Option 1

Municipalities

Option 1	Option 3
Green Municipal Enabling Fund (GMEF) Five-year, $50-million fund provides grants (up to 50% of eligible costs) to support feasibility studies to increase municipal expertise and knowledge of leading-edge environmental technologies. *Penetration Rate:* 100%	Same as in Option 1
Regulate New/Existing Landfill Sites Require capture and flaring of landfill gas at new and expanded sites with waste capacity greater than 2.5 million tonnes. *Penetration Rate:* 5%	Same as in Option 1
Green Municipal Investment Fund (GMIF) Low cost loans for up to 25% of eligible costs plus grant funding support up to 50% for investment in innovative technologies. *Penetration Rate*: 70%	Same as in Option 1
Market Value for Emission Reduction (PERRL) Subsidies for emission reductions achieved over period 2002-2007, supporting landfill gas capture, flaring and utilization systems (and other areas) *Penetration Rate:* 25%	Same as in Option 1
Landfill Gas Utilization - Government Procurement Low cost loan and grant funding from GMIF supplemented with expanded eligibility for Federal Producer Incentive for renewable electricity. *Penetration Rate:* 100%	Same as in Option 1
Green Fund Incentives for Waste Diversion Expanded low cost loan and grant funding from GMIF in support of municipal government efforts to establish programs for increased diversion of waste from landfill sites *Penetration Rate:* 90%	Same as in Option 1
Establish a Revolving Fund CES Projects Expanded low cost loan and grant funding from GMIF in support of installation of community energy systems. *Penetration Rate:* 75%	Same as in Option 1
Revolving Fund Energy Efficiency Retrofits Municipal Operations Measures – Expanded low cost loan and grant funding from GMIF for wastewater facility retrofits. *Penetration Rate:* 75%	Same as in Option 1
Water Conservation Expanded low cost loan and grant funding from GMIF to assist municipal governments in developing and implementing Water Conservation measures. *Penetration Rate:* 75%	Same as in Option 1

Industry

Option 1	Option 3
Expand **CIPEC** beyond to include all of industry. CIPEC promotes the establishment, implementation, tracking and reporting of energy efficiency improvement targets. Will entail inviting participation from the upstream oil and gas, forestry, construction and electrical generation sectors and broadening the reach of existing task forces (e.g., SMEs).	Same as in Option 1
Tracking Better align existing survey instruments administered by Statistics Canada and by increasing their scope and the timeliness of results.	Same as in Option 1
Awareness New tools will be developed and delivered to employees of industrial companies to increase their awareness about the opportunities to become more energy efficient and to reduce GHG emissions. Include customized workshops, technical support, guidebooks and videos. Companies are expected to introduce more new practices and technologies that lead to reduced energy consumption and GHG emissions.	Same as in Option 1
Benchmarking consultants will work with companies to record data on businesses as a whole, including profitability, investment, financial management, productivity and innovation with special emphasis placed on energy efficiency and GHG performance. Benchmarking reports expected to have ½ the impact of audits due to their non-prescriptive nature, however by targeting substantial members of large industrial energy users the reduction potential increases significantly.	Same as in Option 1
Audits Financial assistance and guidance will be given to companies to have on-site industrial energy/ emissions audits conducted. Engineers will perform audits at 350 to 500 industrial establishments and outline energy saving opportunities and their associated GHG emission reduction potential and costs. Companies will be responsible for at least 50% of the audit cost. The audits represent a new Industrial Energy Innovator service offered by NRCan.	Increased level of effort focused on the small and medium enterprises. Combined to a Facilitation Fund.
Supply Chain To explore and develop the potential for supply chain management to increase awareness of climate change implications and to encourage small and medium firmsto achieve meaningful reductions in GHG emissions.	Same as in Option 1
Industrial Buildings Incentive Program Financial, technical and training assistance to the design of efficient industrial buildings.	Same as in Option 1
REDI for Industry Similar to REDI, but customized for the industrial sector. Designed to stimulate market demand for commercially reliable, cost-effective renewable energy systems for space and water heating and cooling.	Same as in Option 1
CHP Study on barrier and potential	Same as in Option 1
Industry EnerGuide Encourage energy managers, procurement and financial officers, and plant engineers to consider energy efficiency when procuring or specifying energy using equipment. Small percentage increases in efficiency can generate significant savings.	Same as in Option 1
CO_2 Capture applicable to certain source points within the manufacturing, upstream oil and gas and electricity sectors. Will be expanded to incorporate flue gas sources, principally coal-fired electricity generation facilities, and enhanced coal bed methane recovery, depleted oil and gas reservoir storage and saline aquifer storage.	Same as in Option 1

Industry *(cont'd)*

Option 1	Option 3
Concrete Fly Ash Promote the use of concrete in the construction of roads.	Same as in Option 1
Steel and Aluminum Recycling Establish a national recycling council an network, to bring common understanding and national standards for processing and use of recycled materials and the resulting products.	Same as in Option
Electricity Government Procurement Federal government to purchase 450 GWh of non-emitting electricity from new sources products. Provide subsidy to electricity retailers to stimulate production and sale of electricity from emerging renewable sources.	Same as in Option 1
Windpower Government of Canada will subsidize installation of 1000MW of new wind energy capacity in Canada over the next 5 years. Selected wind energy producers will receive a maximum financial incentive of $0.012 for energy kilowatt-hour produced during the first 10 years of activity of their new wind farms.	Same as in Option 1
	Facilitation Fund Increased audit activities for SME (up to price of carbon) and a facilitation fund to offset to incremental capital cost requirements to realize recommended EE activities from the Audit Program.

Appendix 2: *Income Tax Implications of Options 1 and 3*

The income tax system is modeled in the TIM/Energy2020 system using average (rather than marginal) tax rates. So an average tax rate of 15% means fifteen percent of total income is paid as income tax. In the actual tax system the marginal rate would be higher since no tax is paid on the first $7000 (approximately), and the tax rate rises as you move into higher income brackets. A person with a $21,000 annual income who gets an exemption on the first $7,000 only pays tax on the remainder ($14,000). A tax rate of 22.5% applied to the taxable portion would mean $3,150 is paid in income taxes (14,000 times 22.5%). Since 3,150 is 15% of 21,000 we would have an average tax rate of 15% but a marginal tax rate of 22.5%. The rate applied to the next dollar of income is the marginal rather than the average rate.

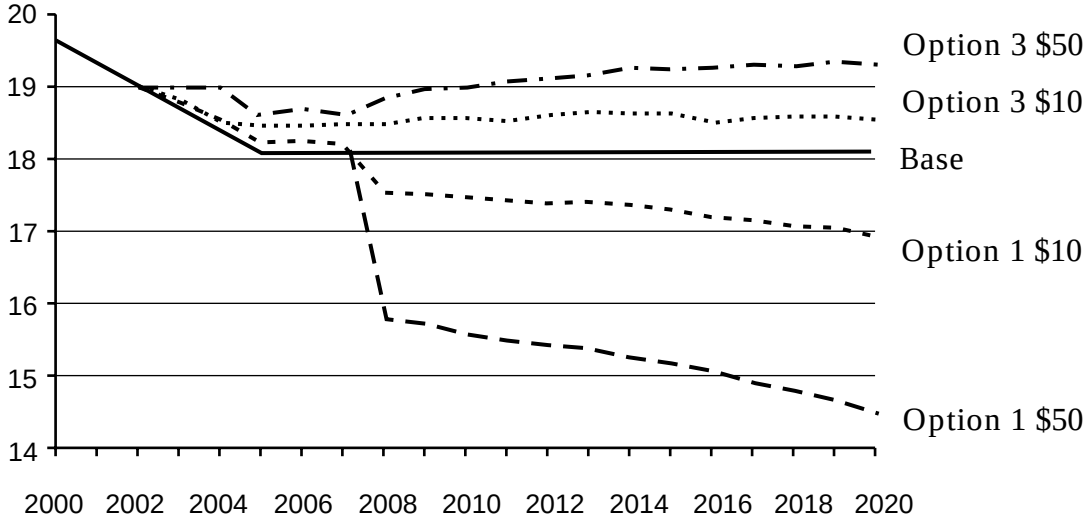
The average tax rate is also referred to as the "effective tax rate" in the TIM framework.

The fiscal rule used for Options 1 and 3 keep the federal budget balanced by raising taxes when needed to cover a net shortfall, or lowering taxes when possible to recycle new revenue. The model assumes that the national effective income tax rate begins at just under 20 percent and declines to just over 18 percent by 2005, remaining constant thereafter.

The first set of graphs compare the effective tax rate under each Option to that under the base case Business-As-Usual Assumption, shown as the heavy black line, from 2000 to 2020. There are four simulations: Options 1 and 3, under the assumption of $10 and $50 international permits.

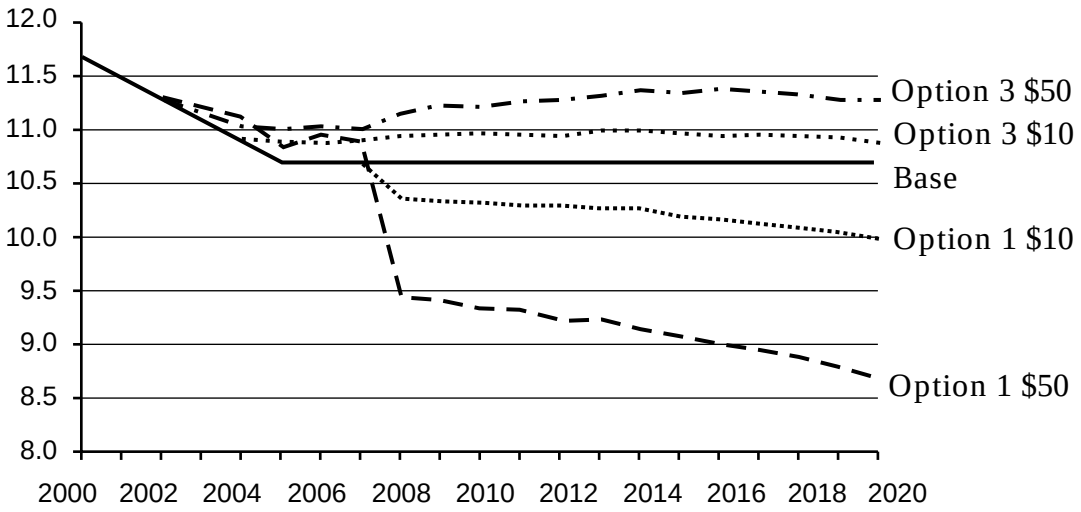
In Option 1, the permits auction begins in 2008, raising enough revenue that income taxes can be reduced. In Option 3 the permits are given away and the policy costs require income taxes to be raised. The change in the average tax rate in 2010 from 18.1 to, say, 19 percent (Option 3, $50 permits) implies a proportionately larger increase in the marginal tax rates. Similarly a reduction in the average tax rate implies a proportionately larger reduction in the marginal tax rate.

Effective Income Tax Rates:
Total, all Jurisdictions



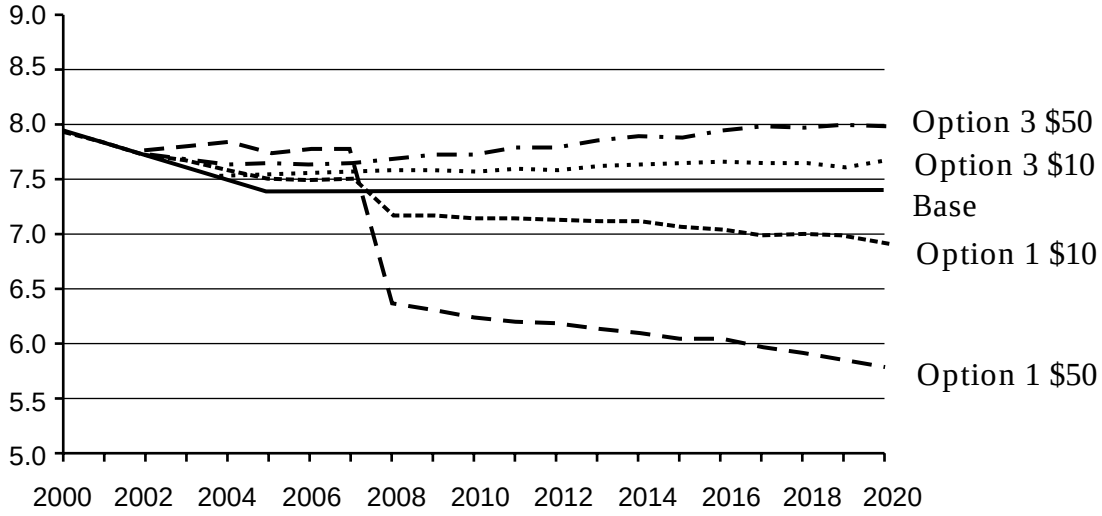
Source: Informetrica Ltd.

Effective Income Tax Rates:
Federal



Source: Informetrica Ltd.

Effective Income Tax Rates:
Provincial



Source: Informetrica Ltd.

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