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Communiqué

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Policy on climate change should aim to reduce risks, avoid unnecessary costs, says C.D. Howe Institute

In devising ways to reduce emissions of greenhouse gases (GHGs), Canada's policy toward climate change should neither cause unnecessary declines in Canadians' standard of living nor put Canada at an unfair disadvantage relative to other countries, says a *C.D. Howe Institute Commentary* released today. The study also urges that any climate-change policy be subject to broad public discussion to avoid any perception of a "democracy deficit" on this issue.

The study, *Confronting the Greenhouse Challenge: Matching Protection with Risk*, was written by Daniel Schwanen, a Senior Policy Analyst at the Institute. Schwanen argues that, at the December climate-change meeting in Kyoto, the international community should agree on a policy framework for eventually stabilizing global GHG emissions at an acceptable level — including a timeline for introducing mandatory measures — rather than focus on arbitrary and often unrealistic targets for emissions reduction on a country-by-country basis.

Schwanen points out that there is as yet no scientific consensus on just how serious a problem heat-trapping GHGs caused by human activity might be and that predictions of climatic models are constantly being revised. Nevertheless, he argues, countries are right to contemplate preventive action because firm evidence of the extent of the problem may arrive only after irreversible change has occurred. But, he says, since the costs of both action and inaction are so uncertain, discussing the amount by which emissions should be reduced is not as fruitful as agreeing on what specific reduction measures should be implemented and when, leaving the exact amount of the reduction to be determined later.

Accordingly, Schwanen recommends that, along with continuing and expanding voluntary efforts to reduce GHG emissions, countries meeting in Kyoto should agree on exactly when, and how, they will begin to implement mandatory measures if there is no progress in reducing emissions and if scientific observation confirms that there is a problem. Schwanen argues that an economically efficient and equitable way to reduce emissions would be for all countries, some time after 2015, to begin to impose a common fee for emission permits, which would apply initially only to permits for GHG emissions over and above the level they reached in the year 2000. The fee would be reviewed periodically with the help of scientific evidence on the extent of the problem.

Schwanen notes that autos, industry, commercial transportation services, home and commercial heating and lighting, and agricultural operations are major sources of human-caused GHG emissions. Therefore any attempt to reduce such emissions quickly would impose severe economic costs lasting for many years. Climate-change models show that, in fact, GHG emissions need not be reduced immediately but could be allowed to increase for another 20 years or so, Schwanen says, so long as they were then reduced with certainty and so long as no more emissions were allowed to accumulate than if the reductions had begun immediately but more gradually. This would give the economy time to adjust, to let new capital stock, technological improvements, and even new fuels come on stream.

Schwanen argues that the economic costs of a GHG-abatement strategy could also be lowered by ensuring that emission reductions capture sources (such as the developing countries) that use carbon fuels relatively less effectively than countries such as Canada. Furthermore, since the effect of emissions is mostly global, rather than confined to a particular country or region, less efficient users of carbon-based fuels should not be permitted to increase their emissions of GHGs to the point where such growth cancels out the benefits that other countries may have created by curbing theirs.

Schwanen also argues, however, that individual, corporate, and public sector emitters must understand that they will face mandatory GHG-reduction measures at the end of the 20-year period, if science indicates by then that the "decarbonization" of energy sources that has historically accompanied technological improvements and rising standards of living has failed to reduce the risk, and what those measures would be.

Schwanen observes that the impacts to Canadians of some of the plans being forwarded by some other nations and non-governmental organizations could cumulatively be greater than those of the Free Trade Agreement, which was the focus issue of a national election. But unlike in the case of the FTA where impacts were largely positive, these may be largely negative and they have been little debated and understood. Schwanen therefore recommends that anything agreed upon by the government should be subjected to an open and deliberative Parliamentary scrutiny and that ratification in Canada take full account of the U.S. process.

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For further information, contact: Daniel Schwanen;
Susan Knapp (media relations), C.D. Howe Institute
phone: (416) 865-1904; fax: (416) 865-1866
e-mail: cdhowe@cdhowe.org
The full-text is posted on Internet: http://www.cdhowe.org/eng/pr/new.html

Confronting the Greenhouse Challenge: Matching Protection with Risk, C.D. Howe Institute Commentary 99, by Daniel Schwanen (C.D. Howe Institute, Toronto, October 1997). 36 pp.; $6.00 (prepaid, plus postage & handling and GST — please contact the Institute for details). ISBN 0-88806-419-5.

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Communiqué

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L'objectif de la politique canadienne sur l'effet de serre devrait être d'en réduire les risques, et d'éviter les coûts inutiles, soutient l'Institut C.D. Howe

En instituant une politique visant a réduire les émissions de gaz a effet de serre (GES), le Canada devrait éviter de causer une diminution inutile du niveau de vie des Canadiens, et devrait également éviter que le Canada soit placé dans une position désavantageuse par rapport aux autres pays. C'est ce que dit un *Commentaire* de l'Institut C.D. Howe publié aujourd'hui. L'étude insiste également pour que toute politique sur le changement climatique soit soumise à une discussion publique élargie, afin d'éviter la perception d'un "déficit de la démocratie" sur cette question.

L'auteur de l'étude, intitulée *Confronting the Greenhouse Challenge: Matching Protection with Risk* (Faire face au défi de l'effet de serre: ajuster la protection au risque), est Daniel Schwanen, analyste de politique principal à l'Institut. Il soutient qu'à la réunion qui se tiendra à Kyoto en décembre pour discuter de cette question, la communauté internationale devrait s'entendre sur un cadre de politiques permettant à la longue une stabilisation des GES à un niveau acceptable - incluant un échéancier pour l'introduction de mesures obligatoires - plutôt que de fixer des objectifs arbitraires et non réalistes de réduction de ces émissions pour chaque pays.

M. Schwanen fait remarquer qu'il n'existe pas de consensus de l'opinion scientifique sur la sévérité du problème causé par les GES enserrant la chaleur et qui proviennent des activités humaines, et que les prévisions des modèles climatiques sont constamment révisées. Ceci dit, il estime que les divers pays ont raison d'entreprendre une action préventive, car la preuve qu'il y a vraiment un problème ne pourrait bien survenir que lorsque des changements irréversibles se seraient déjà produits. Cependant, dit-il, puisque les coûts à la fois de l'inactivité et ceux de prendre quelque action sont incertains, débattre des quantités de réduction des émissions de GES ne serait pas aussi fructueux que de s'entendre sur la façon dont ces émissions devraient être réduites, et quand cela devrait commencer, laissant à plus tard la question de la quantité exacte des réductions.

En conséquence, M. Schwanen propose qu'en plus d'élargir le cadre des efforts volontaires existants de réduction des émissions de GES, les pays se réunissant à Kyoto devraient s'entendre sur quand et comment ils introduiront des mesures obligatoires, si un progrès

insuffisant est enregistré d'ici là dans la réduction des émissions, et si le problème qu'elles pourraient causer est confirmé par l'observation scientifique. Il soutient qu'un moyen efficace sur le plan économique ainsi qu'équitable de réduire les émissions serait pour tous les pays d'introduire, après l'an 2015, un frais commun s'appliquant aux émissions de GES dépassant le niveau qu'elles auraient atteint en l'an 2000. Le montant de ce droit serait revu régulièrement à la lumière des observations scientifiques accumulées sur l'effet de serre.

M. Schwanen note que les automobiles, l'industrie, les services de transport, le chauffage des résidences et des commerces, ainsi que les activités agricoles, sont toutes des sources importantes de GES causés par l'activité humaine. Par conséquent, toute tentative de réduire rapidement ces émissions imposerait des coûts importants à l'économie sur une période de plusieurs années. Les modèles de changement climatiques montrent par ailleurs que les émissions de GES ne doivent pas nécessairement être réduites immédiatement, mais pourraient plutôt continuer d'augmenter pendant 20 ans ou plus, pourvu que l'on sache avec certitude qu'elles seraient réduites par la suite et que le total des émissions accumulées sur une longue période ne soit pas plus élevé que si les réductions avaient commencé plus tôt. Ceci permettrait à l'économie de procéder à des ajustements par l'installation d'un stock de capital fixe plus moderne, l'innovation technologique, et même l'introduction de nouveaux combustibles.

M. Schwanen explique que les coûts économiques d'une stratégie de contrôle des GES seraient également réduits si les réductions s'appliquaient aussi aux sources (tels les pays en voie de développement) qui utilisent les combustibles à base de carbone moins efficacement que le Canada. De plus, puisque l'effet de ces émissions se fait sentir globalement, et donc qu'il n'est pas restreint à un pays ou région en particulier, on ne devrait pas permettre aux émetteurs de GES parmi les moins efficaces économiquement parlant de continuer à augmenter leurs émissions à un point tel que les effets bénéfiques des réductions faites par d'autres pays en seraient éliminés.

M. Schwanen explique cependant que les personnes, entreprises et agents du secteur public qui contribuent aux émissions de GES doivent comprendre qu'ils feront face à des mesures obligatoires de réduction à la fin de cette période de 20 ans, si les observations scientifiques montrent que la "décarbonisation" des sources d'énergie, qui par le passé a accompagné le progrès technologique et la hausse du niveau de vie, n'a pas été suffisante pour réduire les risques d'effet de serre, et doivent savoir quelles seront ces mesures,

M. Schwanen fait observer que l'impact cumulatif sur les Canadiens des propositions faites par certains pays et organisations pour réduire les émissions de GES pourrait être plus importants que celui du traité de libre-échange avec les États-Unis, qui lui a fait l'objet d'une élection nationale. Contrairement aux effets largement positifs du libre-échange, ceux-ci pourraient être largement négatifs, mais cependant ils ont été peu débattus et compris. M. Schwanen recommande donc que toute entente signée par le gouvernement sur cette question soit soumise à un processus d'examen parlementaire délibératif et ouvert, et que sa ratification par le Canada tienne également compte du processus américain sur cette question.

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Renseignements : Daniel Schwanen
Susan Knapp (relations avec les médias)
Institut C.D. Howe
téléphone : 416 865-1904
télécopieur : 416 865-1866
courrier électronique : cdhowe@cdhowe.org
Internet : www.cdhowe.org/fr/pr/new.html

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Confronting the Greenhouse Challenge:

Matching Protection with Risk

by

Daniel Schwanen

Many scientists believe an increased concentration of heat-trapping greenhouse gases (GHGs) in the atmosphere caused by human activity could cause severe and irreversible climatic changes. Rich countries have been moving toward instituting legal curbs on GHG emissions, which they will discuss at Kyoto in December 1997.

To make major changes to the GHG intensity of the economy without significant losses in output and incomes would require time to install new capital stock, to switch toward less carbon-intensive fuels, and even to develop new fuels. Because it is GHG concentrations in the atmosphere, not particular annual emission levels, that would cause warming, it should be possible to give economies time to adjust before significant reductions in GHG emissions occur without risking a rise in GHG concentrations to dangerous levels, as long as reductions can actually be made later on.

All proposals for reducing emissions should be judged by their effectiveness, efficiency, equity, and feasibility. Using these standards, countries should agree on a single emissions permit fee, collected domestically, which should begin to apply to emitters some time after 2015 for their emissions over and above the level reached in 2000. The fee would initially be small, and could be periodically adjusted up or down as progress in reducing emissions and scientific evidence warrant.

No matter what approach is eventually adopted, Canada should not ratify any treaty unless it appears that other large current emitters, such as the United States, or future large emitters, such as many developing countries, will do the same since this situation would not only exacerbate the economic sacrifices Canada would make, but it would also have done little to reduce significantly the threat of warming — and may have made it worse. Furthermore, no undertaking should be ratified before a full and open debate has taken place in Parliament, in order to avoid the perception of a “democracy deficit” on this issue.

Main Findings of the Commentary

- Heat-trapping greenhouse gases (GHGs) have a long shelf life in the atmosphere, and it is feared that maintaining human-induced emissions of these gases, notably carbon dioxide (CO_2), even at current levels would increase their concentration in the atmosphere to the point where irreversible damaging changes to the earth's temperature would occur.
- How much of any increase in temperature is due to these GHG emissions, what changes would occur as a result of any particular GHG concentration in the atmosphere, and even whether there is evidence of actual temperature changes remain a matter for debate.
- Policies corresponding to various paths of annual GHG emissions can have broadly similar environmental results if they lead to similar concentration levels over time. In this light, allowing emissions to rise over the next 15 to 20 years would not be incompatible with maintaining reasonably low GHG concentrations in the atmosphere thereafter, provided we can be sure that eventual declines in annual emissions will compensate for the initial rise.
- Much economic activity is currently linked to carbon fuels, the main source of human-made CO_2 emissions. Although certain measures can increase the economy's fuel efficiency in the short run, large changes in carbon intensity can occur only over time as an economy's fixed capital stock — such as industry and the urban infrastructure — gets replaced and as new technologies and even lifestyles emerge. Such turnover normally occurs over a period of 20 years or more.
- Thus, a GHG-abatement strategy calling for reductions in GHG emissions to begin in 20 years or so would be far less costly than one calling for reductions to begin immediately, and need not result in higher GHG concentrations in the long term. In contrast, some of the short-term reduction scenarios being discussed would result in a loss of incomes relative to potential in Canada and most of the world that would be the equivalent of a severe recession and would last for years.
- Any successful Canadian GHG-abatement strategy must take the United States into account. The high substitutability of production facilities between Canada and the United States means that "carbon leakage" — the moving of carbon-intensive economic activities to the United States — would likely occur if Canada's GHG-reduction policies were significantly more stringent than those of the United States. The price might be worth paying if Canada's or the world's environment was improved as a result, but this would not be the case here since the source of emissions would simply have moved.
- Any successful global GHG-abatement policy must involve developing countries to a much greater degree than they have been until now. Within 20 years, developing countries will account for most human-made emissions of GHGs, and although vertical equity considerations may call for a relatively greater effort on the part of rich countries, exempting developing countries from any mandatory measures would be both environmentally and economically counterproductive.
- Voluntary efforts to reduce GHG emissions should be continued and, indeed, expanded to various sectors and countries. At the same time, Canada should focus on promoting a framework agreement among countries to eventually impose an emissions permit fee on major sources of GHG emissions above those of a certain base line at a certain date in the future, if the level of emissions and scientific evidence at that time warrant action. The fee would come into play some time after 2015, albeit for emissions exceeding the level of the year 2000 and, while common to all countries, it would be separately administered by each.
- Canada should not join a multilateral agreement calling for a national and international economic effort to reduce GHG emissions significantly without extensive public and parliamentary debate on the issue.

As every reader of headlines knows, Canadian policymakers must soon make a decision about the country's commitment to reducing the emissions of heat-trapping greenhouse gases (GHGs) in the earth's atmosphere — a decision that must be taken in the face of incomplete knowledge about the potential environmental and economic consequences of any action or, indeed, of inaction.

Even the dimensions of the potential problem are unclear. But many scientific experts, such as those convened by the United Nations under the umbrella of the Intergovernmental Panel on Climate Change (IPCC), have concluded that a sharp (and undisputed) increase in anthropogenic (human-made) GHG emissions over the past 200 years or so is having a discernible and, if continued, potentially dangerous impact on the earth's climate system (see Box 1).

In response to fears of profound environmental change, Canada and 168 other countries signed the Framework Convention on Climate Change (FCCC) adopted in Rio de Janeiro in 1992. This nonbinding document called on the industrial countries ("Annex I Parties," including most states of the former Soviet Union) to reduce emissions of GHGs to 1990 levels by 2000 and subsequently to stabilize them at a level judged to cause no dangerous interference with to the climate system. Other signatories ("non–Annex I Parties," mostly developing countries) were enjoined only to implement a number of possible measures to mitigate and facilitate adaptation to climate change, without any target or deadline.

As is well known, however, emissions have continued to grow globally — and specifically in most Annex I countries (except former communist countries). In Canada, as in many other countries, they now exceed the target level by up to 11 percent in spite of considerable progress in energy efficiency by the manufacturing and mining sectors.[1] The United Kingdom and Germany are the only ones among these countries currently recording emissions of carbon dioxide (CO_2), the most abundant of the anthropogenic GHGs, below their 1990 levels.

This general inability to meet the Rio goals has been evident for some time, evoking reactions from environmentalists and policymakers. In spring 1995, at the first meeting of the Conference of the Parties (COP) to the Framework Convention on Climate Change, held in Berlin, the parties agreed to begin a process that would aim to "elaborate policies and measures" as well as to "set quantified limitation and reduction objectives within specified time frames, such as 2005, 2010, and 2020," for greenhouse gas emissions by sources and removal by sinks for the Annex I nations (the so-called Berlin Mandate).[2] Canada's current stance on the climate change issue is consistent with these undertakings, and other governments, including that of the United States, have developed positions within the same framework, for legally binding, medium-term commitments (that is, emissions targets for 2010 to 2020) from all Annex I countries.

Box 1: *Greenhouse Gases*

Greenhouse gases (GHGs) are gases in the atmosphere that trap solar energy radiated back upward from the earth. Most occur naturally — indeed, the largest concentration results from water vapor — and without their presence in the atmosphere, the planet's temperature would be as much as 30⊃C lower than it is, and life as we know it would be impossible.

The concern about GHGs is that human activity is adding to them, increasing their concentration in the atmosphere. The principal anthropogenic greenhouse gas is carbon dioxide (CO_2), which arises mainly from extracting and using fossil fuels, such as coal, oil, and natural gas, and from felling trees (which are a natural carbon sink in that they absorb and store CO_2). Other anthropogenic GHGs include methane, which escapes during the extraction and transportation of coal and natural gas and from waste dumps and agricultural activity; chlorofluorocarbons (CFCs), whose use is being phased out in industrialized countries because of their impact on the earth's ozone layer; and nitrous oxide.

Negotiations between FCCC signatories on implementing the Berlin Mandate will culminate this December in Kyoto at another COP, where nations anticipate signing a binding agreement on reducing GHG emissions.

Thus, barely five years after the signing of the FCCC, the world's response to the fact that the Rio objectives have not been met has not been to give the so-far largely voluntary approach a longer time frame within which to operate or to attempt an entirely fresh approach to the issue. Instead, governments of Annex I countries have generally responded by expressing willingness to commit themselves to more stringent, "legally binding" reduction targets, albeit under a somewhat extended timetable.

All told, these are objectives that may or may not be more realistic than those set at Rio. Yet Canada seems prepared to accept their sweeping and binding nature in a process that would affect the lives of most Canadians. This constitutes a huge step for the country without the debates and scrutiny that such decisions normally entail in a democracy.

What should Canada do now? In this Commentary, I argue that, although it appears ready to sign binding commitments at Kyoto, any such commitments and the country's general policy toward controlling GHG emissions should be transparently geared toward matching protective measures with the likelihood and extent of possible damage from these emissions. This can be done by grounding the policy in the four criteria of environmental effectiveness, economic efficiency, equity, and feasibility, and in six principles that I have derived from them:

- first, the more immediate the implementation of any measure, the more flexible it should be;
- second, the standard to aim for should be reduced levels of GHG emissions relative to economic activity and population growth, not simply fewer emissions;
- third, Canada's participation should be conditional on the measures and timetables implemented by its major competitors;
- fourth, Canada must ensure that non–Annex I countries participate in any mandatory GHG-reduction process;
- fifth, Canada's participation must be conditional on addressing subsidies to fossil fuels; and
- sixth, Canada should not implement reductions without substantial public input and without appreciating the consequences of a failure by the US Senate to ratify any agreement undertaken by the U.S. Administration.

In the choice of specific policy instruments, I argue that Canada should continue to vigorously promote, nationally and internationally, a voluntary approach toward reaching any agreed targets because it is simply too soon to call the current voluntary efforts insufficient. Given that the Canadian energy-intensive industries recently surveyed in a case study of capital stock turnover typically report using equipment that has a lifespan of 20 to 40 years,[3] most of the effects of voluntary efforts following Rio may not, in fact, be visible before the mid-2010s.

Nevertheless, continued reliance on the voluntary approach until then should be supplemented by the development of a framework for a mandatory approach to GHG-emissions reduction, a strategy countries should agree to implement some time after 2015 (with the exact year being advanced or delayed depending on the progress accomplished by other means and advances in scientific knowledge up to that point). Here, the best option among those proposed in the literature is that of setting, through international negotiations, a single GHG fee, applicable to permits for emissions exceeding those of a given base year and separately administered in all countries. This scheme, essentially as proposed in a recently published paper,[4] would have the advantage of locking in slower emissions growth than is currently occurring, while being flexible enough to provide time for industries and

consumers to adjust and permitting quick revision upward or downward in light of progress in reducing emissions and further advances in knowledge about climate change. It would also ensure that emissions are reduced at the least possible cost in terms of output, incomes, and employment, and its international uniformity would prevent industries moving from one country to take advantage of lenient policies in another. This fee would be horizontally equitable, in that all emitters beyond a threshold level would be made to pay, and it could easily be made vertically equitable — for example, if some of the revenues raised in Annex I countries were then put to work in the developing countries participating in the scheme. This last aspect of the scheme plus the prospect for non–Annex I countries of raising revenues through the fee would provide an incentive for these countries to adopt it.

To conclude this introduction, I emphasize the need for more public information and discussion. A treaty binding Canada to reduce its GHG emissions could (depending on its terms) produce effects that are even more pervasive than those of the Canada-US Free Trade Agreement. Yet, unlike the latter issue, which was central to the 1988 election debate, Canada's policy on GHG-emissions reduction is low on the public's agenda. Further, the legitimacy and effectiveness of any government initiative that is potentially so far-reaching is directly related to public education and support. When the stakes are so high, Canadians, as citizens of a representative democracy, must be afforded an opportunity to comprehend the reasoning underpinning the commitments to which their elected (and unelected) representatives may bind them.

Key Facts, Uncertainties, and Risks

Beyond the definitions and issues sketched out in the introduction and the accompanying box, it is useful to remind ourselves of some key facts and uncertainties relevant to understanding how policies to reduce emissions of CO_2 and other greenhouse gases may help us avert the threat of global warming. Only with such knowledge can we gauge the risks involved.

Key Facts

Four scientific and technical facts are both uncontroversial and important to understanding the possibility of global warming.

Fact 1: Concentration Matters

In considering the possibility of global warming, the concentration of greenhouse gases in the atmosphere is what counts. Most anthropogenic greenhouse gases have a long shelf life in the atmosphere: 15 years for methane, which accounts for only about 10 percent of total emissions; 50 to 200 years for CO_2; even longer for other gases. Thus, even holding the rate of emissions of GHGs at current levels will mean a continued increase in their atmospheric concentration over the next several decades. (In fact, according to the IPCC, it would take at least a 50 percent decline in emissions of CO_2 to immediately stabilize greenhouse gas concentrations in the atmosphere at present levels.[5])

This feature calls for taking seriously, as a matter of intergenerational prudence, environmental models that suggest that increased emissions will have a strong negative impact over time, even if we do not feel this impact currently and even if we cannot know whether these models are correct in their predictions.

A second important implication is that annual emissions do not matter so much as the total accumulation of GHGs over time, so different annual emissions paths could allow us eventually to stabilize concentrations in the atmosphere. To the extent that different policies with different costs are associated with different emissions paths that lead to the same environmental result, the choice of the proper, less costly policy becomes particularly relevant.

To see the point more clearly, consider that in 1800 the concentration of CO_2 in the atmos-

phere was an estimated 280 parts per million per volume (ppmv), and that this number is closer to 360 ppmv today. Under the IPCC's main "business as usual" projection, the level shortly after 2060 will be 560 ppmv — a doubling of CO_2 concentrations since pre-industrial times. This could lead to an increase in the mean global temperature of about 2°C (although this impact is not certain, and estimates of it are being regularly revised).[6]

These projections are, however, pessimistic about both technological change and the availability of fossil fuels other than coal (that is, oil and natural gas, which are less emissions intensive). Under scenarios incorporating more optimistic assumptions on these counts, a concentration of 560 ppmv would occur toward 2100.

The key, however, is that even scenarios that exhibit emissions increases as large as the IPCC's "business as usual" projections over the next 20 years or more can result in the same atmospheric concentration of CO_2 over the long term (2150 and beyond) as the IPCC scenario that incorporates the impact of immediate stabilization measures, provided that faster emissions increases earlier are compensated with sharper declines beginning before 2050.[7]

Fact 2: Origin Does Not Count

The impact of greenhouse gases does not depend on where they originate. Their effects on global warming are essentially the same irrespective of their source. If one country or region reduces its emissions, but an offsetting increase occurs elsewhere, environmental concerns are not alleviated.

To an economist, this means that an acceptably low level of GHG concentration in the atmosphere should be treated as a public good. Individuals, communities, or countries that do not contribute to its upkeep cannot be stopped from enjoying it. On the other hand, one country's contribution to the good does not make much difference in the overall amount available. Hence, no country has much reason to contribute to the provision of the good unless it can be sure that a significant mass of others also provide it.

The corollary is that a local effort — or even an effort by a large group of countries — toward GHG reduction risks being largely ineffective unless it is supported in some ways by most other countries. It also risks receiving little long-term political support because those shouldering the burden of the effort will not see any result from it.

Fact 3: GHG Emissions Are Increasing

Without changes, anthropogenic emissions of GHGs will continue to increase rapidly. The unquestioned evidence is that the concentration of GHGs in the earth's atmosphere has risen since pre-industrial times — by about 30 percent for CO_2 and by more than 100 percent for methane — and that this increase is mostly human induced, being related to population and output growth. (Emissions of CO_2 have increased twentyfold over the same period.)

In the absence of abatement policies or technological changes, economic and population growth inevitably will result in a continuation of this trend. Credible projections show annual CO_2 emissions increasing from 22 billion tonnes in 1990 to about 41 billion tonnes in 2020, an increase of 85 percent. Over that period (some say by the end of the twenty-first century), the share of emissions accounted for by developing countries — the non–Annex I countries — is expected to rise from just under 40 percent of the world total today to more than 60 percent.[8]

Fact 4: The Means of Reduction Are Limited

CO_2 emissions can be reduced in only a few ways. First, the carbon-fuel efficiency of the existing capital stock can be enhanced through, for example, improving production and transportation processes. In the medium term, technological changes can improve the chances of finding more fuel-efficient technologies and products. Technology-based

models show that the adoption of advanced technologies can, in theory, significantly reduce carbon emissions per unit of output or income.[9]

Second, industry and individuals can switch to power sources that are less carbon intensive, notably nuclear energy and hydroelectricity. Although production of these alternatives has also raised safety and environmental concerns, we should also keep in mind that all fossil fuels do not emit the same amount of GHGs per given amount of energy. Thus, fuel switching, especially from coal to natural gas, offers some possibilities for reducing overall emissions. Globally, however, coal will continue to represent a vital source of energy, one that is particularly important for countries with fast-growing energy demands, such as China (which sits on a third of the world's known coal reserves) and India, given that oil and gas may become much more expensive or even run out over the very long run.[10] Here again, however, technological changes may reduce the cost of alternatives — such as solar energy — that are currently uneconomical to operate or even result in a new alternative fuel, perhaps one that is hydrogen based.

All of these possibilities could be achieved, given the appropriate economic incentives, without reducing economic activity. Indeed, some of them could well prove to be what are called no regrets policies — measures that both increase the standard of living and have a beneficial effect on the environment.

All of the above solutions, however, imply using less CO_2-emitting fuels for a given amount of physical output or services. Once they have been exhausted, the only alternative is to implement policies that reduce global economic activity, at least relative to projected trends. The reason is that carbon- based fuels are a vital input into everything the world's economies produce and consume, from necessities such as food and shelter to the two areas of fastest absolute growth in energy use, the generation of electricity needed to power industrial motors, offices, shops, and household equipment and the fuel needed for transportation.[11]

Thus, although a long-lived downward trend in the energy intensity of economic activity has meant that the growth in global energy requirements has generally been less than that of economic output and although the growth in demand for carbon-based fuels has thus been historically less than that of energy as a whole ("decarbonization" of the energy system), it is important to note that this decoupling of economic efficiency, energy intensity, and emissions intensity has always needed time to occur (see Box 2).

In the short run, the emissions intensity of economic activity is highly correlated with energy intensity, which is, in turn, highly correlated with the efficiency with which the current capital stock is used and hence, with employment and incomes. This is particularly true of key aspects of the urban infrastructure, such as density of housing, location of houses near work, and roads or transit systems, which all significantly affect the carbon intensity of the economy, have an even longer turnover period than the capital stock in industry, and are driven as much by individual lifestyle choices as by economic conditions.

Major Uncertainties

Science and technology have given us the facts just listed. But it has been unable to resolve certain major uncertainties that are of key significance to the elaboration of a policy on global warming.

Uncertainty 1: How Fast?

We are not sure of the rate at which global warming is occurring or even if it is occurring at all. This question seems to be the least ambiguous of all — one whose answer is a simple matter of measurement — yet the evidence is inconclusive. True, worldwide surface air temperatures of the past 50 years have averaged higher than those of the previous 50 years by about half a degree Celsius. But the earth's temperature naturally exhibits vari-

ability, so conclusions as to whether a warming or even cooling trend is occurring may differ according to whether one is looking at a fairly short historical period (such as the industrial era, which does provide some evidence of warming) or at a much longer time frame (for example, glacial periods — we may be heading back into one).

Furthermore, the conclusion seems to depend on what instruments are used to measure temperature. Satellite records of radiations emitted by oxygen molecules show a cooling trend since measurements began in 1979; earth-based instruments, which measure surface temperatures proper, show warming over the long period they have been operating.[12]

What do these findings mean for our planet? No one knows for sure, despite many attempts to model the climatic future. As one recent discussion paper backed by prominent Canadian organizations and individuals puts it, "Any significant changes to the composition or concentration of the atmosphere or its constituent gases could render significant changes to our climatic system."[13]

This statement is true but vague. The continuation of current trends for GHG emissions "could" mean a change of as little as 1°C on average over the next century or as much as 3.5°C depending on the model and assumptions used — or no change for the sizable minority who are still not predicting any warming at all. Thus,

> Research and debate does...continue in the area of forecasting future rates of climate change and the exact timing and regional consequences of increasing the concentration of gases which trap long-wave radiation within the atmosphere. This task becomes more complex as variables such as: emission rates, the ocean's ability to absorb carbon dioxide, cloud coverage and the atmospheric lifespan of greenhouse gases are introduced into the projection.[14]

The range of estimates and the sensitivity of the result to the assumptions used are truly perplexing, considering that the effects on our environment and economy would vary considerably with an average of even half a degree's difference over a long period and especially with how fast the change was occurring. (If a given change occurs slowly enough, nature has more time to adapt through, for example, migration of plants and animals, and the costs are therefore mitigated, but if changes occur suddenly, entire species, forests, and agricultural areas may be wiped out.)

Uncertainty 2: Are Anthropogenic CO_2 Emissions Causal?

We are not sure that anthropogenic CO_2 emissions cause global warming. Although the term "climate change" may refer to "all forms of change, natural or otherwise, manifested in the atmospheric and climatological system," it has come to mean specifically

> the impact that society's atmospheric emissions will have on the earth's climate over time. Since climate change can result from both natural and anthropogenic forces, an important part of the science of climate change is separating the two.[15]

Yet such separation — which is required in order to conclude that there is a causal relationship between human-caused GHG emissions and any warming trend — remains very difficult to make. This difficulty is reflected in the cautious language that even those urging immediate action on reducing CO_2 emissions use when describing the trends they perceive as alarming. Thus, IPCC scientists agree only that the influence of anthropogenic gases on the earth's temperature is "discernible," and that the record shows that the warming of the past half- century is "unlikely to be entirely natural in origin."[16]

Part of the difficulty is again that of establishing whether we are facing a "trend" that will lead us outside the normal range of temperature changes, a situation we have not reached yet. Moreover, even if the fact of warming were certain, doubts about causation mean uncertainty about whether we should concentrate on facilitating adaptation to climate change, or on specific policies to control CO_2 and other

Box 2: ***Economic Efficiency, Energy Intensity, and Carbon Intensity***

Economic efficiency requires that an activity use no more resources than it is worth. Because energy is so important in the economy — it is a significant intermediary input to production, as well as a good consumed directly by final users — energy efficiency contributes importantly to economic welfare.

In the short run, when the total amount and proportion of various sources of energy are more or less fixed, economizing on energy implies reducing both the energy intensity and the carbon-fuel intensity of production. As a corollary, reductions in carbon intensity beyond what an economical use of energy would dictate negatively affect economic activity.

In the long run, however, overall energy intensity of output has declined less rapidly than carbon intensity. It is even possible for energy-intensive forms of production and consumption *both* to be efficient economically and to contribute to GHG-emissions reduction. This can happen under any of three conditions:

- New fuels are developed that are both economical to produce and less carbon intensive than those already in use.
- Users switch from carbon fuels to existing noncarbon fuels.
- Users of carbon fuels switch from those that give out high emissions per energy they are producing, such as coal, and those that are less emissions intensive, such as natural gas (see the figure on the last page).

Each of these conditions has been at work historically at one time or another, leading to the decarbonization of energy sources over time accompanying an increase in economic activity.

The indications that this trend will continue include the rapidly declining costs of wind turbines; advances in the economic development of hydrogen-based fuels; anti-smog and other pollution standards that are not directed at climate change but encourage the spread of less carbon-intensive fuels; and opportunities to switch to less emissions-intensive carbon fuels as part of the overall mix of energy in use.

The implication is that the only predictive models of the future path of GHG emissions that do not exaggerate the policy-induced abatement necessary to stabilize CO_2 emissions are those that take this decarbon- ization trend into account. Others must be considered as suspect.

GHG emissions. Also, human activities can have contradictory effects on the earth's environment; some activities, such as the release of aerosols, may increase the greenhouse effect but have a cooling effect through other means.[17]

The Risks of Underreacting

Given these uncertainties, a reasonable question to ask is whether we should refrain from reacting to the alarm until clearer evidence emerges. The answer depends on an assessment of the risks we face if we decide not to address GHG emissions right away.

In climatology as in other fields, uncertainty does not prevent the emergence of scientific opinions informed by theoretical and empirical work. In this case, the facts are that anthropogenic greenhouse gases can cause global warming, and the obviously informed view of the 300 or so scientists comprising the IPCC (although there are many dissenting voices) is that they are doing just that. To what degree (literally) remains a matter of conjecture.

Many politicians and members of the public are also acknowledging that some action is required, either because they believe in the existence of a problem or because they perceive enormous risks inherent in not reacting to the possibility of a problem.

If the worst predictions are realized, the situation would not be easily amenable to quick countermeasures. The fact that concentration, rather than annual emissions, matters for global warming suggests that, even if emissions were to be reduced drastically after a problem emerged, any damage done could not be reversed quickly. Models also suggest scenarios in which "positive feedbacks" (self-reinforcing phenomena) would begin to occur if

temperatures reached a certain level. For example, faster evaporation from the oceans or thawing of the permafrost, both of which could result from significantly higher temperatures, would themselves accelerate the pace of global warming by increasing the concentration of, respectively, water vapor and methane in the atmosphere.

Should temperatures rise significantly and quickly enough, the potential effects are certainly frightening, encompassing, for example, the disappearance of many coastal lands and islands under rising water levels, sharply diminished biodiversity, reduced arable areas in some regions, and increased incidence of tropical diseases. On this score, some economists have tried to put a figure on the costs of serious climate change. Estimates vary from 1 to 4 percent of global income over the next century (dependent, of course, on the extent and pace of the rise in temperature and on assumptions regarding many unquantified or intangible factors, such as value for lost species).[18] These numbers are net estimates for world gross domestic product (GDP); the changes at specific regional or sectoral levels could be far greater.

Thus, although we do not know and cannot know exactly what the effects would be, we can reasonably use as a working assumption that they are something we would like to avoid if we can and if the cost of doing so seems bearable compared with the alternative.

That last point is crucial because the economic costs of some measures proposed to reduce emissions would be as severe and occur in the nearer future than those that might result from global warming. Given the still uncertain and distant nature of the costs of climate change, it is important to mitigate the immediate economic costs of countermeasures to the extent we can without compromising our ability to cover ourselves against the risk posed by GHG emissions. (This tradeoff is addressed in more detail below.)

All told, it is one thing to say that pervasive uncertainties and large variances in the estimates of the risk surround the issue of increasing GHG concentrations in the atmosphere. It is quite another to say that no serious risk exists. Therefore, preventive action may be a prudent policy, depending on what action is taken. This position is endorsed by a number of industry leaders, some of whom represent industries in which GHG emissions originate. For example, John Browne, chairman of British Petroleum, recently declared that the time to contemplate action on the climate change issue "is not when the link between greenhouse gases and climate change is conclusively proven, but when the possibility cannot be discounted and is taken seriously."[19] And in 1995, the president and chief executive officer of DuPont Canada said,

> [T]here is still some uncertainty about the relationship between man-made emissions and the environment, although I accept that some precautionary measures should be taken.[20]

The Economics of Controlling GHG Emissions

The upshot of the previous section is that Canada should take precautionary actions that match the likelihood and extent of possible damage from global warming. What is needed is a policy approach that will unambiguously reduce the risk we may be incurring but that could be quickly modified if further evidence or research shows that the threat is more or less extensive than consensus scientific opinion currently suggests. Like all good precautionary policy, it should not reduce the risk to the point of undermining the health of the (perhaps imaginary) patient.

Economics and Environmental Policy

Good economic management and good environmental management are not in fundamental opposition. In fact, one implies the other, as they both aim at the best possible use of resources and sustainable increases in standards of living.[18] Economists have long recognized that if the activities of an economic

agent, such as a producer, impose costs on third parties for which it does not have to compensate them, then these activities will entail what are called negative externalities; the lack of need to pay all the costs of the activity ensures more of it will take place than is socially desirable. In such cases, forms of public intervention can improve welfare by ensuring that all economic agents take account the costs of their actions in making their production, consumption, and savings decisions. The implication is that there is nothing wrong in principle in imposing an economic cost, such as a tax, on certain activities that markets may price imperfectly (or in providing a subsidy, in the case of activities with "positive" externalities) in order to achieve an allocation of resources that produces a better standard of living.

Yet any public measure, even the most worthwhile, has a cost; someone always pays through taxes or compliance with regulations, reducing disposable income or employment somewhere. So economists' professional concern about the waste of resources leads them to weigh the costs of particular policies against their probable benefits. Such a cost-benefit standard helps to direct public intervention where it is most likely to be socially beneficial.

It also helps to protect against the inevitable claims of self-interested parties that the fulfillment of their own agenda entails a public good and ought to receive public support. Specific cost-benefit calculations themselves can be open to criticism of the pricing of variables such as risk, time, tax compliance, and so on. But the principle of weighing benefits against costs certainly requires that it is wrong (socially wasteful) to impose an economic burden on any activity in the name of ensuring the existence of a public good if the intervention is not likely to produce that public good. Another corollary is that, given the choice of two approaches yielding the same public benefit, the less costly one ought to be selected.

Thus, a major concern of Canada's environmental policy, as part of the broader public policy framework, ought to be finding ways to secure the necessary protection against environmental damage that also minimize the damage in terms of other public objectives — notably, those regarding the amount and distribution of incomes and employment. In this light, I next review the key economic considerations that both experience and the results of economic simulations tell us must come into play in assessing strategies and instruments to control GHG emissions.

The Costs of Controlling GHG Emissions

Although proper management of economic and social resources means that costs not be incurred with little corresponding public benefit or reduction in risk to the public, this could easily happen in the case of policies aimed at controlling emissions of CO_2 and other GHGs. The reasons are twofold.

First, as we have seen, the problem may have been overstated. If so, costs would be incurred out of proportion to any benefit that would flow from reducing GHG emissions. Historically, cataclysmic forecasts about the environment or resource shortages have been disproved; the examples run from the predictions of Malthus, who said in the eighteenth century that population growth would always press on available food supplies and make the alleviation of poverty impossible, to the Club of Rome's limits-to-growth discourse of the 1970s, to Canada's disastrous energy policy of the late 1970s and early 1980s, which was implemented on the heels of presumed shortages of crude petroleum but which actually encouraged its overconsumption in Canada.

In general, such overreaction occurs because forecasters or policymakers do not put enough stock in the feedbacks that economic signals will generate without intervention from the state. Overconsumption of a good relative to its availability tends to increase its price to such an extent that consumers lessen their use of it, enterprises turn over time to technologies that are less intensive in that particu-

lar good, and there is an incentive to use or develop substitutes.

Market feedbacks do not always work, however, especially in the case of public goods, for which feedbacks on their cost do not fully reach individual businesses and consumers. We have already accepted the premises that fast-rising GHG emissions may put an important public good at some (hard to quantify) risk, and that this requires some concerted intervention (because the risk may not be properly priced due to the public good aspect). The historical lesson here is that one effective way of influencing the course of events is to properly signal households and corporate decisionmakers to incorporate this risk in their consumption and investment priorities.[21]

The second reason for incurring unnecessary costs is a decision to tackle a problem in ways more wasteful than necessary. Just as there is no economic model that can predict with great surety the economic costs of serious climate change, so there is no model that can give us definitive answers about the costs of a given policy to control GHG emissions. (One source of uncertainty is that each model emphasizes different linkages within the global economy.)

Looking at a number of models does, however, give a rough idea of the cost of relatively quick stabilization (over a period of ten to twenty years) and reductions (over a period of twenty years or so) in CO_2 emissions for industrial countries compared with a base level (usually 1990). Simply stabilizing emissions within that period of time could cause continuing annual losses relative to a "business as usual" scenario, reaching at their peak between 0.5 percent and 2 percent of GDP. This would mean a yearly shortfall in incomes of up to US$240 billion for the entire Organisation for Economic Co-operation and Development (OECD) during a period of several decades — although some models predict that eventually growth will begin exceeding a "business as usual" scenario.[22] Models that examine actual reductions from the base level predict larger losses to industrial countries' output — of between 1 and 4 percent of GDP annually, also over a period of decades.[23] Most of these scenarios show more severe losses for Canada than for many other countries, at least initially, meaning that, even under mild stabilization scenarios, Canada could experience a loss equivalent to more than 20 percent of one year's annual income (some $160 billion), spread out over ten to fifteen years (again, some models suggest that Canada will begin experiencing faster growth rates in the outer years, while others predict the losses will be much worse).

Such numbers, by themselves, cannot tell us whether the cost incurred would be worth it, however. To do so, they would have to be compared with the cost of doing nothing, which, as we have seen, remains a matter of conjecture. Thus, as useful as it is to keep these ranges in mind as benchmarks, it is probably more important, for choosing a least-cost policy for Canada to control GHG emissions, to study what qualitative links these models uncover between attempts to control GHG reduction and global economic activity and what they can tell us about the relative impacts of such policies on different world regions, individual countries, or industries.

Thus, I now examine which variables the existing research models tell us are most important in these two respects.

Technology and Backstop Fuels

The economy's technological parameters loom large in the calculation of impacts from GHG-abatement policies. One of the key determinants of the effects on economic output is the possible rate of substitution between energy (whose carbon content, as we have seen, can be considered fixed in a static sense, although it has been coming down over time) and other production inputs. This rate describes the combinations of input among which firms choose the most profitable, given the set of prices they are facing. Normally, the easier the substitutability between sources of energy and other inputs, the smaller the reduction in

output incurred by the economy (and the smaller the energy price increase) for a given reduction in GHG emissions. Likewise, the more producers can substitute among the various carbon-based fuels in response to different relative pricing scenarios, the lower the estimated cost of a given reduction in GHG emissions.

Dealing with the emergence of technologies for using inputs in a new or cheaper way poses an inherent difficulty. Even economic models that aspire to make predictions for the long term (or the indefinite future) must incorporate the possibility of technological change essentially as an assumption, albeit one informed by past rates of innovation. Naturally, given the importance of technology for estimating the cost of abatement policies, different assumptions about the rate of future technological change make a large difference in the results. For example, assuming that technical progress will occur faster for nonenergy than for energy inputs tends to increase estimates of the future cost of curbing GHG emissions.

On the other hand, assuming that either regulation or market forces will induce technical progress in the use of energy inputs reduces the estimated long-run economic costs of a particular emissions objective. A number of models implicitly incorporate this last possibility by assuming the existence of a "backstop" (non-carbon-based) fuel, available at some point in the future in infinite quantities but at a price that is a multiple of that of current carbon-based alternatives. (Such pricing makes sense because such a technology is either not available currently and hence would require significant investments to develop, or is available but now costs more than carbon-based alternatives — otherwise, it would currently be in use).

In brief, the numerical differences in the modeling parameters naturally yield quite different cost estimates, yet by assumption are not quickly amenable to policy changes. Clearly, one of the outcomes of the modeling exercise is that an economic and social environment conducive to investments in technologies that would enhance energy efficiency, which past experience suggests can emerge in response to the proper incentives, is a key factor in reducing the long-term cost of a given GHG-abatement target.

Time and Capital Stock Turnover

Time is a defining element of dynamic economic models. It allows accounting for the effects of the accumulation of savings and of fixed capital, which, in turn, yield increases in the economy's productive capacity. This is particularly important in the context of estimating the costs of reducing GHG emissions because successful abatement policy would require, on a global scale, significant investments in equipment and technologies that emit smaller quantities of GHGs per output produced.

The optimal path of fixed capital investments in the economy (the one that yields the highest economywide incomes for a given project) does not depend simply on the anticipated private and social benefits, such as net operating profits or a cleaner environment, that the investment will yield once it is installed. If it did, investments would occur instantaneously, and the corporate and public sectors would constantly operate at their desired level of capital stock.

Instead, for any firm and for the economy as a whole, the desired investments usually occur over time because the cost of new capital stock often increases sharply with the pace at which it is installed. The cost of proceeding is influenced by such variables as

- the rate at which the existing capital stock becomes obsolete (which can be related to the pace of the innovation process itself, as when the prospective investor has a good reason to believe that today's state-of-the-art equipment will soon be supplanted by something much better);
- the cost of financial capital (a key influence on whether the long-term reward of the investment is worth the short-term expenditure);

- the prices of capital goods and of construction services; and
- whether the organization has the management and training capabilities to oversee the changes and adjust to a different working environment.

To attempt to install fixed capital at a faster pace than indicated by these factors quickly increases the private and social costs of the investment to the point of negating what would otherwise be its benefits.[24]

Thus, for the economy as a whole, if a large number of organizations wish to add to or modify their stock of fixed capital simultaneously and before the useful life of the existing capital stock is substantially expired, output from current capital stock will be reduced, while interest rates and the prices of capital goods and of construction services will tend to rise above normal, due to the increased demand for funds and for investment goods and services. Relative to a business-as-usual scenario, the economy will then experience an immediate reduction in current incomes and will also forgo for a time installing new capacity in sectors where it would generate future incomes on an ongoing basis.

Such would be the effect of a requirement to greatly reduce all GHG emissions immediately. Moreover, because investments in research and the funds required to install new equipment depend on the availability of savings, which, in turn, depends on incomes, a too-quick reduction in GHG emissions would probably also reduce the research and development (R&D) and investment capabilities to invest in technologies and equipment less intensive in their use of carbon and other greenhouse gases.

Of course, these effects would have to be weighed against the environmental consequences of making most of the GHG-emissions abatement occur toward the end of a medium-term period of, say, 20 to 50 years, rather than at the beginning. But, as we have seen, the key to reducing the risk of global warming is to stabilize the concentration of GHGs in the atmosphere at a level considered unthreatening over the long term. The specific path of annual emissions leading to a given concentration makes no difference from an environmental standpoint, but economic simulations find that the speed at which emissions reductions occur greatly affects their economic costs. Scenarios with sufficient lead time for installing new equipment and technology tend to show the least economic costs for a given abatement scenario.[25] What seems indicated is an abatement policy that puts most of the onus of reductions in the later years of a fairly long period.

This consideration of the ideal time path does bring up the problem of whether a long-term strategy can be seen as credible. It is one thing to say that the benefits of a particular emissions-control policy can be obtained for less economic cost if it relies more on reducing emissions in the outer years of a plan, and another to expect that this path will be followed as a matter of course. For the policy to be credible, signals and incentives to adopt more efficient technologies and processes must be in place to influence investment decisions so that reductions will, in fact, occur over time.

Sources of the Emissions Reductions

It stands to reason that the least-cost reductions, in terms of total output and incomes, would be obtained from first reducing emissions from the source that produces the least value added (or GDP) in terms of goods or services per unit of GHG emitted and then moving on to the next higher one if further cuts in emissions are required. Thus, in order to ensure the least cost for a given reduction, any abatement policy should first affect activities with low abatement costs (low value of output for a given amount of GHG emissions), and continue up the ladder until the cost of any further reduction in emissions, in terms of economic output and incomes forgone, is equalized across industries or activities (that is, to a point at which it does not matter, in

terms of lost value of output, where the next reduction in emissions comes from).

This economic result has an important implication for policy. It suggests that, in the absence of detailed knowledge about which industries are the least productive at the margin for the amount of GHG emissions they produce, the implementation of an abatement policy should rely on a mechanism that automatically weighs most heavily on the least efficient emitters. In general, analysts prefer a mechanism that would result in a single price for emissions. They see it as a necessary condition for achieving the desired result because it would ensure that the least efficient producers — these who could not then afford to sustain their GHG-intensive production at current levels — would be the first to reduce production. (The last section of this paper reviews specific policy instruments that could be used to implement reductions in GHG emissions.)

A corollary here is that a given level of CO_2-emissions abatement could be achieved at least cost to the world economy as a whole if marginal emissions-abatement costs were also equalized across all countries.[26] Thus, countries that exhibit the highest use of energy for a given amount of output should be the first either to curtail production or to invest heavily in more carbon-efficient technologies. Because the poorer countries (in this context, the non–Annex I countries) are currently inefficient users of energy (that is, they have a higher usage of carbon-based fuel per value of output than richer countries), making reductions the least costly for world output would require them to make a greater relative contribution to the global objective of reducing the risk of climate change.

Abatement achieved in this fashion would, of course, raise important distributional issues. However, it would be possible in principle for developed countries to compensate non–Annex I countries for their greater effort — for example, through helping them to adopt more efficient technologies — and still leave all countries better off in terms of both reduced climate change risk and economic output.

Another way of making the process more equitable would be for entities in Annex I countries to contribute to projects improving the GHG efficiency of other, less efficient countries or investing in the maintenance of carbon sinks, such as forests, in those countries and to have this contribution count toward their own abatement targets. Such so-called joint-implementation schemes would involve net benefits for non–Annex I countries, while ensuring that abatement does occur in a way that is least costly for the global economy. (I consider equity in greater detail below when I discuss it as a policy criterion.)

Existing Economic Distortions

Given the economic benefits of tapping the least efficient producers first for implementing abatement policies, the cost of emissions-reduction policies is worsened by the existence of subsidies that distort consumers' and industries' decisions in favor of using carbon-intensive fuels. Studies by the OECD suggest that removing measures such as coal-producer grants and price supports, sales tax exemptions for electricity or other energy forms, barriers to trade in natural gas and electricity, and state-directed preferential contracts between electricity customers and suppliers would result in GHG-emissions reductions that would be cheap in terms of lost incomes and, in many cases, would constitute the perfect no-regret policy.

That is, redirecting the money saved to more productive use might actually increase incomes without disrupting overall employment, in addition to achieving a significant degree of abatement (and therefore also make less painful the cost of a specific abatement target).[27] One study estimates that removing all such energy subsidies worldwide would by itself reduce CO_2 emissions by up to 5 percent and have a positive impact on global incomes.[28]

Carbon Leakage

The term carbon leakage refers to the displacement of industries from a country (or a group of countries) with abatement policies in place to other regions where policies are not in place or are less stringent. Even if we ignore the income and employment implications of this shift for the countries implementing the stringent policies, such moves would be a problem in that they would lessen the effectiveness of those policies in reducing global GHG emissions. Consider, for example, a country that stopped refining oil itself and instead exported crude oil for refining abroad. That country might attain its own reduction objectives, but the risk of global warming would not be reduced at all and might even increase if the foreign refiner were less efficient in terms of output per emissions. The costs incurred by that country would, in this extreme case, be incurred to no avail.

On the assumption that reduction targets will be implemented in Annex I countries but not in developing countries, different economic models find that carbon leakage may or may not be important. The point depends essentially on the degree of product differentiation assumed between goods produced in Annex I countries and those produced in developing countries. Thus, the GREEN model of the OECD Secretariat finds this leakage to be small because it assumes low substitutability between goods produced in the OECD countries and in developing countries (firms in Annex I countries cannot easily continue to serve their markets simply by moving out). Australia's ABARE model, however, assumes a higher degree of substitutability and finds a significant leakage — up to 10 percent of GHG-emissions reductions in Annex I countries would simply reappear in non–Annex I countries.[29] It should be noted, however, that earlier models such as the OECD's may not properly capture the effects on leakage of the rapid growth in the amount and freedom of global direct investment flows, which may significantly increase the substitutability of goods produced in various countries and hence the possibility of carbon leakage.

The threat of carbon leakage could be considerably reduced by the introduction of schemes whereby the price put on emissions (through either a tax or emissions permit schemes, which I examine in detail later) was equalized across countries, removing the incentive for firms to move because of differences in the leniency of GHG-emissions policy.

International Trade and Capital Flows

Trade and capital flows will play a crucial role in the international distribution of the costs of abatement policies. First and most obviously, the relative costs incurred by any country will be positively linked to the trade specialization it exhibits in carbon-based fuels in all GHG-intensive or complementary activities, such as agriculture or the production of automobiles. The impact on the volume of trade flows of a GHG-abatement policy is relatively straightforward to estimate, at least for fossil fuels themselves, because in economic parlance they are Ricardian goods — that is, any country's comparative advantage or disadvantage in these commodities depends essentially on its endowment of natural resources or lack thereof (in contrast to goods, such as R&D-intensive products or services, for which comparative advantage can be influenced by policy and can therefore switch among countries). As a first approximation, the implication is that countries or regions with the highest degree of carbon-based fuel specialization are the ones that just happen to be sitting on them and thus have specialized in their production and exportation.

However, international modeling exercises also clearly show damaging second-round effects for countries that are not themselves implementing abatement policies but that have an export trade highly oriented toward countries that do, since the trade-oriented portion of their economies is then expected to suffer. This damage to the export industries of non–Annex I countries would not likely be fully

offset by the carbon leakage effect mentioned above (irritating as that effect would be for Annex I countries).

Beyond this potential impact on the volume of trade flows, the effect that specific global measures to reduce GHG emissions could have on a country's terms of trade (the price at which it can obtain imports in exchange for its exports on international markets and thus a key determinant of standards of living) could potentially overwhelm all other distributional issues related to GHG-abatement policies. This is because such policies, if they are to be effective, would generate large revenues by creating a significant wedge between the price at which suppliers are willing to bring a product to the market and the tax-inclusive price (whether the tax is explicit or implicit) at which it can be sold. In turn, the impact of this wedge on any country's terms of trade could differ vastly according to whether the fuel would be traded internationally at its supply price or its demand price. In addition, the manner in which any revenues arising from the policy were recycled internationally would matter a great deal for determining the ultimate economic effect in each country.

As a striking example of the importance of these effects, Whalley and Wigle have estimated that a worldwide carbon tax sufficient to reduce emissions by 50 percent would reduce world GDP by 4 percent. The authors show that whether a producer tax or a consumer tax were used to effect the emissions reduction would make a huge difference in the worldwide distribution of the economic impact of the policy.

The first option — equivalent to an export tax on producing countries — would feel like another crisis induced by the Organisation of Petroleum Exporting Countries (OPEC), with North American incomes dropping by about 4 percent, the world average, but with developing countries that lack a significant domestic source of fossil fuel suffering much more than that.

A consumer tax, on the other hand, would occasion a sharp decline in the incomes of oil-producing countries but be less hurtful overall for industrial countries, particularly Japan and the European countries, on the assumption that the tax revenues will be recycled within these economies (through income tax cuts, for example). Countries, such as Canada and the United States, that are both producers and consumers of carbon-based fuels would probably fare no worse or even slightly better than the world average under either scenario (both would suffer a decline in GDP of about 4 percent), provided revenues from the tax were recycled domestically. In contrast, if the proceeds of a tax on emissions-intensive activities were distributed across all countries (for example, according to population), Canada and the United States would be huge losers — not a surprising finding, given that this would be the equivalent of transferring a significant portion of their domestically produced consumption abroad. Although this last scenario is unlikely to take place for obvious political reasons, it nevertheless serves to remind us that international distributional consequences could potentially overwhelm the net impact of any abatement policy on world GDP.[30]

A similarly large redistributive impact could arise from the huge transfer of capital implicit in certain schemes to trade emissions permits (a point I discuss later in the section on policy instruments). This impact has been little noted, however, because international models have tend to concentrate on trade and direct investment rather than on financial markets' reactions to a global abatement scheme.

Domestic Redistribution and Revenue Recycling

Many of the distributional issues that would emerge on the international scene would find some parallels within countries themselves. In Canada, for example, few economic activities would remain unaffected (see Table 1). Although it is all too often asserted that dealing with GHGs would create an "Alberta problem," the table clearly shows why efforts to reduce

Table 1: GHG Emissions by Activity, Canada, 1995

Activity	Emissions
	(megatonnes of CO_2 equivalent)
Autos, motorcycles, and offroad vehicles	80
Trucks	60
Air, railway, marine, and miscellaneous transport	25
Upstream oil and gas	44
Power generation	103
Other industry: fuel combustion	77
Other industry: processes	47
Agriculture (excluding vehicles)	30
Residential heating	42
Commercial heating	25
Landfills and municipal incineration	19
Natural gas distribution	3
Miscellaneous	64
Total	*619*

Source: Canada, Department of the Environment, *Canada's Second National Report on Climate Change* (Ottawa, 1997), table 3.1.

emissions would affect economies and lifestyles in all regions of Canada.

Consider, too, that existing simulations of single-country impacts of GHG-abatement policies show that the distributional effect of a measure such as a carbon tax would not stop at the difference between fuels and all other industries. Within these other industries (and their consumers), the effects would fall heavily on the most carbon-intensive products, such as food and drink and transportation.

Thus, a carbon tax might well be regressive, falling proportionally more on the least well-off. This problem could be amenable to some corrective action, such as enriched tax credits for families with lower incomes, which could be paid for by the revenues raised from the tax.[31]

In this context, some economists also speculate that, by using emissions-reduction measures that raise revenues for the public purse, governments could cushion the impact on national output by, for example, reducing other, distorting taxes, such as payroll taxes (which many acknowledge to have a negative impact on employment). Other recycling scenarios envisage that the money raised could be used to reduce government borrowing, thus lowering interest rates and boosting investment. In fact, in some models and scenarios, emissions reduction generates a net economic benefit when the revenues are recycled in what the analysts indicate is a growth-promoting fashion.[32]

In my view, these suggestions for revenue recycling confuse two issues: first, the efficiency of applying relatively high rates of taxation to relatively immobile factors of production and to products for which consumption is not very price sensitive (which may well include energy-intensive goods); second, that of using the most efficient way of dealing with the environmental risk caused by GHG emissions. If a tax on energy-intensive activities is indeed a way to raise revenues that allows cutting taxes elsewhere or otherwise promoting economic activity, then such a policy ought to be implemented regardless of the threat of climate change. If, however, the stated goal of the tax is to reduce the risk posed by GHG emissions, then pumping revenues into stimulating the economy may produce perverse results, environmentally speaking. Rather, revenues should be used to reduce the risk posed by GHG emissions by, for example, reducing the taxes of firms that invest in maintaining carbon sinks or of individuals who choose particularly fuel-efficient modes of housing or transportation, or by encouraging research in more carbon-efficient technologies. Presumably, if GHG emissions continue to pose unacceptable risks to the point where they have to be taxed, such environmentally helpful uses for funds (or tax incentives) can be found.

Conclusion

Depending on how an analyst's model takes various economic features into consideration, the estimated cost of significant GHG abatement may be as high as 4 percent of world GDP or as low as 1 percent; some scenarios even show a small long-term benefit from stabilizing

of emissions at current levels. The magnitude of the effects found depends on assumptions concerning the structure of the economy, the stated or implied targets and time frames for reducing emissions, and the assumed policy instruments.

To summarize these effects in terms of output and incomes: the net cost to an economy would decrease with

- the period over which an acceptable concentration of GHGs in the atmosphere had to be reached (the longer the period, the more time for technological improvements to be fed through the normal capital stock turnover timetable);
- the extent to which a particular policy leans on the least efficient emitter;
- the extent to which existing distorting subsidies can be reduced; and
- the prevention of carbon leakage through firms' switching their investments to countries with lenient policies.

These last three features suggest broad participation of non–Annex I countries in any program to reduce GHG emissions and, if possible, the use of a single world price for any emissions permits scheme.

Reacting in the Right Measure

The previous section's discussion of linkages between and within economies makes it apparent that a particular measure's net effect on GDP does not provide an idea of all of its effects. Thus, key questions for every country are what would be the national or global costs of emissions reduction and what would be an equitable distribution of these costs? In this section, I examine the criteria and principles for effective action by Canada that takes these questions into account.

Criteria to Guide Policy

The issue of climate change provides, probably better than any other of today's policy problems, an example of Samuel Butler's point that "life is the art of deriving sufficient conclusions from insufficient premises." Nevertheless, we need criteria for treating the insufficient information at our disposal.

People worried about global warming and those worried about the economic impact of controlling GHG emissions agree on one thing: going down the wrong route would have severe costs — perhaps the equivalent for the world of losing two economies of Canada's size if fears about global warming are realized or if economically careless policies are implemented to deal with the threat — and the losses would be distributed unevenly among the populations of the globe. Governments seized with this issue must certainly do something to reduce the risk of over- or underreacting to the problem, either of which could turn out to be a mistake of significant proportion. Both sides must hedge their bets.

In order to achieve this, I suggest the use of four well-established criteria to guide Canadian — and global — policy:

- *environmental effectiveness* — the policy must have the unambiguous ability to eventually stabilize CO_2 and other GHG emissions at a nonthreatening level;
- *efficiency* — the policy must work at the least possible economic cost;
- *equity* — the policy must allocate the costs of reducing emissions fairly; and
- *feasibility* — the policy must be workable in both an administrative and a political sense.[33]

These criteria are consistent with the wording of the Rio Convention, which recognizes that policies and measures used by Annex I Parties to reduce emissions to 1990 levels by 2000 should embody efficiency and equity principles by taking into account differences in countries'

> starting points and approaches, economic structures and resource bases, the need to maintain strong and sustainable economic growth...as well as the need for equitable and appropriate contributions by each of these [Annex I] Parties to the global effort regarding that objective.[34]

They are also consistent with those used by the Canadian government in its 1992 evaluation of economic instruments for environmental protection, which formed part of the Green Plan.

Because these criteria are sometimes at variance with each other, it is important to have a sense of the tradeoffs between them. Taken together, they can form the basis of an approach that is fairly commonsensical, except to those who emphasize only one at the expense of the others and hence deny that there are tradeoffs to be made. (Logically, this last position can be taken either by those who believe that the urgency of the environmental problem is such that no amount of economic hardship, inequity, or democratic consideration should stand in the way of acting on it — a view that may be rooted in philosophical motives, such as back-to-nature beliefs — or by those at the opposite extreme who believe there is no risk in ignoring the possibility of a problem.[35]) Most others, however, should be interested in the interplay between these criteria.

Environmental Effectiveness

By environmental effectiveness, I mean the possibility of achieving at least some reduction in GHG emissions, relative to a given baseline scenario, that can hold at least for some time. I assume we want the ability to realize more than the improvements that have been made so far since it is fairly clear that these have not resulted in eliminating concerns.

Because of the prevailing uncertainty over the impact of global warming and whether it even exists, people will certainly argue about how much and how quickly emissions should be reduced before such a policy is to be considered "effective." However, this disagreement should not affect the choice of policy with which to reach the goals, only the speed and the extent to which it is applied.

Effectiveness could mean setting absolute targets, as currently contemplated for Annex I countries. But targets, as we know from the Rio experience, may not be met, especially in the short term when so many of the factors that influence emissions can be changed only with difficulty. In my view, a better mark of effectiveness would be to put in place a framework and instruments that left no doubt that needed reductions from projected levels eventually would occur, even if the effects were initially modest and took more time to reach their full measure. In other words, there may be a tradeoff between a set of costly, and hence breachable, promises by each country to effect immediate absolute reductions in emissions and more robust schemes that may result only in a global reduction relative to trends in the short term, but would do so with certainty and be powerful enough to deliver more in the future if this should be required.

In this respect, I note that there is no credible scenario in which even an absolute decrease in GHG emissions by Annex I countries alone would result in a reduction of world CO_2 emissions over the long run.

Efficiency

Efficiency means reaching a particular objective using the least possible amount of resources, leaving other resources free for other purposes. In the context of this Commentary, the criterion can be stated as a search among the policies that would ensure eventual stabilization of atmospheric GHG concentrations at an acceptable level for the one that would cost the least in terms of incomes or jobs throughout the economy, allowing the maximum pursuit of economic and other activities.

In the previous discussion of the economics of GHG abatement, we saw that efficiency obtains when certain key conditions are met: notably, when marginal abatement costs are

equalized across industries and countries, and in a dynamic sense, when economic agents have time and incentives to take advantage of normal capital stock turnover to install more carbon-efficient technologies.

Efficiency in reaching environmental goals is a key concern of the often-cited 2,300 economists (including eight Nobel laureates) who recently gave public support to action against climate change but argue that any policy should minimize the cost to the economy by relying on market-based mechanisms, which allow for flexibility in both the timing for individual firms and the location of emissions reductions.[36] I assume here, along with these other economists and presumably with organizations citing them approvingly, that we are aiming at a policy that would tackle the risk posed by GHG emissions in a way that would least affect the productive use of economic resources and specifically would least affect incomes and employment.

Equity

Even though it is by nature subjective, equity is an important criterion in the implementation of any policy. One reason is that a policy that is perceived as equitable is often politically feasible, even if it involves change or sacrifices for the public at large. Indeed, intergenerational equity — making sure that the resource use of current generations does not hamper the well-being of future generations — is at the very heart of the discourse about global warming.

In practical terms, the equity issue that arises most in discussions on how to control GHG emissions is about which countries should shoulder the costs of a policy that would benefit all. It is clear from the various proposals to reduce GHG emissions that the burden of the reductions for each country (and even regions or groups within countries) can be very sensitive to the choice of an abatement policy and, therefore, that various conceptions of equity have a bearing on the choice of a policy.

Some of the key equity considerations in this respect are

- Should the costs of a global emissions strategy be distributed according to capacity to pay (vertical equity) or focus on similar percentage reductions in economic welfare across countries (horizontal equity)?
- Should the definition of contributing to emissions rest on the consumption of fossil fuels and GHG-emissions-intensive goods and services or on the producers of these fuels and products? The two approaches can make quite a difference in how the costs are allocated internationally.
- What allowance should be made for circumstances calling for different speeds of adjustment to the policy? For example, should it accommodate an economy with a production structure that is particularly carbon intensive ("historical equity")?

Each of these concepts suggests one or more specific formulas for allocating reductions. Proposals that require an equal percentage reduction in countries' emissions or that call on countries to bear similar percentage declines in incomes focus on horizontal equity, while those that give developing countries more leeway than others, on account of their need to catch up economically with richer countries, apply a vertical equity criterion.

Proposals to take into account emissions embodied in imports are based on the user-pay principle, while many tradable emissions permits schemes embody the emitter-pay principle. This choice can have important consequences. For example, should emissions embodied in Canada's natural gas exports, which actually reduce emissions in the United States by replacing local coal, be debited to Canada or to the United States? Sweden is phasing out nuclear fuel and replacing it with Danish coal; should emissions embodied in those exports be debited to Denmark, the producer, or Sweden, the consumer?

Historical equity may mean striving for an equal percentage reduction in emissions by each country, or the concept can be adapted to yield proposals for any emissions targets to be adjusted for the effects of population growth, which has a strong influence on a country's projected GHG emissions. Or it can simply be invoked to remove from the calculation of emissions distortions that would skew comparisons between countries during a given base year, such as subsidies for carbon-based fuels or unusually low energy imports, both of which tend to inflate estimates of domestic emissions for the country incurring them (and hence to exaggerate estimates of its contribution to future reductions).

There can be tradeoffs between these various concepts of equity. Furthermore, the choice of one concept over another and of how far to push it is likely to have an impact on the effectiveness, efficiency, and even feasibility of the policy to which it corresponds.

It is clear that the Rio agenda, by absolving developing countries from specific commitments, embodies first and foremost a capacity-to-pay (vertical equity) criterion. What Canada should ask is, first, whether this choice shortchanges it from the point of view of some other equity criterion and, second, whether attaining the degree of vertical equity required by Rio affects the effectiveness, cost, and political feasibility of the whole project of reducing the risk of global warming. These two questions are closely linked.

Although Canada is, on the whole, affected by the choice of a user-pay, rather than emitter-pay, global criterion (since the latter seems to penalize a country simply for sitting on fossil-fuel resources), this situation is mitigated by the fact that it is also a significant importer of carbon-intensive products. Therefore, either criterion yields about the same net burden for the country (although a different domestic distribution of that burden).

Where Canada may have more problems with specific proposals is in terms of both horizontal and historical equity. With respect to the former concept, equity seems violated if many countries that are now contributing to the problem — and that will contribute to a growing share of it in the future — are not required to contribute anything to its reduction. No one can deny the existence of an issue of vertical equity involving the poorer countries, but this question can and must be dealt with as a separate topic within the global proposals; it is amenable to measures — such as encouraging technology or financial transfers and even permitting a different pace of adjustment between countries — that would make the whole project not only equitable vertically, but also more equitable horizontally and at the same time more effective and less costly.

Questions also arise with respect to the concept of historical equity embodied in certain proposals to control GHG emissions. The capital intensity and structure of Canada's economy suggest that an approach to emissions reduction that would not leave enough time for firms and consumers to adjust could be more detrimental to Canada than to many other countries. Apart from the equity issue raised here, ensuring that an adjustment period is built into the implementation of any emissions target is the most efficient global approach in any case, one that need not compromise the ultimate goal of effectively stabilizing GHG concentrations in the atmosphere.

In addition, Canada must ensure that any reduction plan takes into account population growth and is based on a proper calculation of base-year emissions because its population growth rate is high relative to that of other industrial countries and because it would face the threat of carbon leakage to those countries if the latter were allowed to calculate their base-year emissions without proper adjustments for carbon subsidies and other special circumstances.

Feasibility

As mentioned, the feasibility criterion can apply in both an administrative and a political

sense. The administrative or technical sense comes into play when measures that might be considered theoretically ideal by the efficiency and equity criteria need to be modified or even discarded because they are too difficult to implement in practice. An example is a tax or a fee that ideally would apply to one base (say, consumers of products embodying carbon fuels) but for which the cost of collection at that point would be prohibitive, so another base (say, the seller or the importer of the fuel) is substituted. (The criterion of administrative feasibility comes into play mostly in the next section of the paper, when I review the choice of particular policy instruments.)

Political feasibility is also important, particularly as domestic political support for a policy is likely to depend on its perceived effectiveness at solving a problem on the one hand, and on its tax, income, and distributional implications on the other. In the short term, political leaders can often implement measures whose implications later turn out to be disliked by their constituents, but I take the view that any sustainable policy on controlling GHG emissions must be understood by the electorate and have a broad base of political support, given the long-term dimension of the issue.

Environmentally and economically, such broad support would allow the implementation of tough policies — moves beyond what is called easy greenery — if they were needed at some point in the future. These choices essentially involve political tradeoffs between the risk that the electorate feels is posed by global warming and the perceived costs of a policy to address it. In turn, making proper and sustainable political choices requires that these costs be visible. Since the prices paid for regulations and standards are often concealed, taxes and fees are often a more desirable way of combating global warming, where they are also administratively feasible.

Operational Principles

From the criteria above, one can draw six operational principles for Canada's participation in global GHG-abatement efforts. Canada should hold fast to each of them when considering signing and implementing agreements on reducing GHG emissions.

Timing and Flexibility

The first principle, and the most general one, is that the more immediate the implementation, the more flexible the mechanism should be.

An effective reduction of the risk of global warming could be hampered by implementing fixed emissions targets over the short or medium term. Given the current assumption that increased GHG in the atmosphere pose a serious threat, governments need a view of where they see concentrations ultimately stabilizing. But they also should recognize the evidence that these targets can be met in many ways, some costlier than others, and that the least costly way involves introducing flexible short-term mechanisms compatible with long-term objectives.

In particular, given the costs to incomes of implementing immediate reductions in emissions, policy in the short term should focus on introducing incentives in the economy that will influence the marketplace — businesses and consumers — to make more efforts than they have so far in reducing the amount of GHG released and, over time, to switch to less-GHG-intensive products and technologies (which, as we have seen, need not reduce energy intensity to the same degree given the trend to decarbonization of energy sources over time).

Given the uncertainty of the link between GHG emissions and the warming trend — indeed, the uncertainty over whether a warming trend even exists — any such incentives built into the policy should be viewed as buying an insurance policy: the premiums (costs for the economy) are not meant to cover the entire cost of a still hypothetical event. Thus, they could begin at a modest level but could

quickly be jacked up or reduced according to whether accumulating evidence shows that the probability of a serious problem is increasing or was exaggerated.

This strategy would also allow businesses and consumers and, over time, the slower moving public infrastructures to find the optimal path toward eventual reductions in their emissions, the one that would least reduce incomes and investments in the short term and hence boost the chance that they would be able to cope with any reductions in the long term. This general approach would be consistent with the criteria of efficiency, historical equity, and political and administrative feasibility without sacrificing environmental effectiveness (understood as reducing environmental risk).

Economic Activity and Population Growth

The second principle is that the policy standard should be reduced GHG emissions in relation to economic activity and population growth, not simply fewer emissions. In other words, Canada should accept only policies that would give it the most "bang for the buck" in terms of control of CO_2 and other GHGs.

The relevance of this principle can be seen by using the stated goal of developing and former communist countries to reach, over time, standards of living more and more comparable to Canada's. Although developing countries are unlikely to emit as many greenhouse gases or to consume as many carbon-intensive goods and services per capita as Canada does, most emit far more GHGs per value of output than Canada does. To put the point another way, Canada is a relatively large but also relatively efficient user of fossil-fuel energy in that it creates a higher standard of living for the GHGs it emits than do, for example, the former communist countries.

Although equity will certainly require that, over time, the developing economies use a greater share of emissions as they catch up with developed countries, this could be devastating for the environment if they do so without reaching the level of efficient use of environmental resources that Canada has achieved. It is, therefore, clear that any global policy should reward, not punish, efficient users of carbon-based fuels and other sources of GHG emissions.

This approach is required on both efficiency and equity grounds and would promote environmental effectiveness as well.

Major Competitors

The next principle matters from the point of view of effectiveness, efficiency, and equity: Canada's participation must be conditional on that of its major competitors. We have seen that carbon leakage problems apply between most countries with highly substitutable production. One can easily envisage a scenario in which Canada signs and implements a multinational agreement to reduce GHG emissions, whereas the United States and others, such as the European Union, sign but do not implement. The US Senate has already unanimously passed (in July 1997) a nonbinding resolution calling on its members not to ratify any treaty on climate change that did not include "meaningful commitments" from developing nations, a stance that seems at variance with Canada's current position and hence opens up the possibility of differential implementation of a global treaty in the two countries.

If Canada were to strictly limit its emissions while the United States did not, a large gap would open in environmental standards and taxes between two countries that exhibit a high degree of substitutability in their production structures, a situation in which the danger of carbon leakage is at its highest. It could lead, for example, to Canada's importing, rather than exporting, polyethylene, even though Canada is an efficient producer, economically and environmentally. Thus, Canadians concerned with both loss of jobs to the United States and control of GHG emissions should vigorously oppose such a stance.

The Developing Countries

The next principle stems mainly from the effectiveness, efficiency, and feasibility criteria: Canada must ensure that developing countries participate in the GHG-reduction process.

This is another offshoot of the fact that developing countries are experiencing economic growth that is both very fast and very intensive in its use of fossil fuels. Yet because atmospheric gases do not respect national boundaries, any efficient scheme must be global. Theoretically, developed countries could choose to bear alone the direct costs of a GHG-reduction policy, but that option would become, over time, increasingly difficult to carry politically because it would occur at a high cost in global incomes, in emissions that rose faster than necessary, or in a combination of the two.

Granted, efficiency and equity may be at loggerheads here. Clearly, no scheme should be implemented at the expense of the developing countries' economic prospects. But neither should these countries' catch-up process make the environmental problem worse. Thus, any scheme to limit emissions must leave room for developing countries to grow, while giving them and the rich countries incentives to adopt less-emissions-intensive patterns of production and consumption.

Possibly, developing countries could be asked to join any such scheme at a later, albeit firm, date than Annex I countries; or the latter could institute compensatory schemes to mitigate the effect of GHG abatement on the developing world's prospects of catching up.

The importance of treating a global problem globally has recently been demonstrated by events following the Montreal protocol, an agreement to end the production of ozone-depleting chloro-fluorocarbons (CFCs). Under its auspices, the goal of phasing out CFC production in industrial countries by 1996 has been largely successful. However, the protocol gave developing countries, including Russia, until 2010 to eliminate the production of these chemicals. One result has been the development of what has been described as a "thriving" black market in CFCs, with illegally imported chemicals being passed off as pre–1996 stock (which can still be used legally). In the United States, the value of this black market is reportedly larger than that of the trade in illegal guns.[37]

The point here is not that criminality would be an offshoot of attempts at controlling GHG emissions (unless participating countries were to begin restricting the entry of certain goods from nonparticipating countries) but simply that the effect of a policy to restrict a substance can be substantially negated under a system whereby some countries impose the restriction on their territory while others do not.

Subsidies to Fossil Fuels

As a matter of effectiveness, efficiency, and historical equity, Canada's participation must be conditional on addressing subsidies to fossil fuels. Canada's interest here is akin to the interest it had in the development of internationally comparable measures of agricultural subsidies.

Both equity and efficiency demand that we do not confuse a reduction in distorting incentives for fossil-fuel energy with progress on global warming. That is, countries that have incidentally reduced emissions by reducing subsidies to industry should be treated like countries that excessively consumed energy before and therefore should not be rewarded for simply having removed these incentives. The United Kingdom, for example, has been able to reduce its emissions chiefly because it ended subsidies to the coal industry; since 1995, its emissions of CO_2 have actually begun to climb again.[38] Germany, which is currently in a seemingly enviable position because it counts in its 1990 statistics a rapidly improving situation (in terms of efficient fuel use) in eastern Germany, would be in a similar situation of easy greenery if it stopped subsidizing its coal industry.

One approach here is to calculate "producer-equivalent subsidies" to facilitate equitable comparisons between countries, as was done for agriculture before the Uruguay Round

of negotiations under the General Agreement on Tariffs and Trade. Canada should vigorously promote the work of the OECD here, including that of properly linking measures of distortion of domestic energy markets with the environmental damage caused.

Public Input

And finally: Canada should not implement reductions without substantial public input.

This principle stems from the criterion of political feasibility, which is important, given that any successful policy toward controlling GHG emissions would require long-term political support and likely involve economic redistribution issues within Canada and between Canada and other countries, and given the federal-provincial jurisdictional implications of proceeding with specific policy instruments, such as taxes, controls, or emission permits.

Ultimately, the success of any Canadian GHG-abatement policy would depend on agreement between political judgment and public evaluation of the cost-benefit equation, just as other major economic initiatives — free trade and deficit reduction, for example — have been the subject of extensive debates and even electoral contests.

Given the serious and multifaceted implications for Canadians of the choice of a proper emissions-control policy, I recommend that any agreement Canada enters into in Kyoto at least be subject to a full debate in the House of Commons, and to public parliamentary committee hearings followed by a free vote on the proposed measures in the Commons, considering that members were recently returned in an election in which this issue was never addressed. As a precursor, the relevant federal government departments should provide all interested parties with an in-depth review of the economic impacts of any treaty being contemplated.

Assessing the Available Instruments

The four criteria of effectiveness, efficiency, equity, and feasibility can also be used to evaluate specific instruments that are available to reduce GHG emissions, curtail their growth, or develop carbon sinks to offset emissions growth. Here, I briefly review six such instruments. For each, I start with a description and then provide an assessment of its likely effectiveness in controlling the emissions problem, comments on its efficiency in reaching that goal, remarks on whether it is equitable and feasible in the meanings discussed above, and a recommendation on whether it should be used.

Three Instruments that Do Not Provide Economic Signals

The first three instruments I consider have all been widely recommended for global reduction of GHG emissions. But to varying degrees, they share a problem: with any of them in place, it would still be difficult for emitters to evaluate properly the social costs of their actions — the risk they may pose to the environment — and to incorporate this evaluation into their day-to-day business decisions.

Voluntary Measures

Voluntary measures, which by definition are nonbinding, may involve actions as simple as individual producers' or consumers' choosing less carbon-intensive technologies or products. Or they may involve a formal agreement between government and firms (or a whole industry) whereby the latter commit themselves to specific types of energy efficiency or lowered GHG emissions and periodically report their progress, which may be made public.

Such voluntary agreements are becoming increasingly prevalent in industrial countries, especially — and perhaps not surprisingly —

since the adoption of the FCCC. (See Box 3 for a summary of the Canadian experience.)

Voluntary measures clearly depend on emitters' having an incentive to control — or to be seen as controlling — emissions. Such incentives may include a wish to avoid subjecting operational or investment decisions to regulatory measures that would be administratively or fiscally onerous (more so than the monitoring and reporting normally entailed by voluntary programs), a fear of public disapproval, a need for flexibility and predictability, and, for certain firms, an active interest in minimizing the risk to their business arising from the possibility of climate change.[39]

Effectiveness. Although 2000 will pass without Canada's and most other nations' having reduced their absolute emissions levels to the goal stated at Rio, it is clearly too soon to judge the ultimate success or failure of voluntary efforts, particularly given the lead time necessary for firms to make improvements through new capital investments.

Even so, it can be said that Canada's Voluntary Challenges and Registry (VCR) program and CIPEC in particular (see Box 3) have so far increased energy efficiency across a wide range of industries. These initiatives have resulted in a decline in the country's GHG emissions per amount of domestic industrial production, which partially offset the fast growth rate of GHG emissions from other sources. While economywide emissions rose by 8.2 percent between 1990 and 1995, the increase in the manufacturing and mining industry was only 4.2 percent, even as production in these industries increased by over 9 percent — a significant decline in emissions per unit of output in industry compared with the economy as a whole.[40] These data show that ascribing Canada's inability to meet the Rio targets to a failure of the voluntary approach is an unwarranted leap of logic.[41]

In general, however, the effectiveness of voluntary approaches can be limited by the free-rider problem: some firms and industries (as well as electorates and governments in general) may be worried about bearing the costs of an initiative whose benefits accrue to all, while their competitors are not duplicating their efforts. As a result, firms may tend to confine their voluntary actions to no-regrets measures, which are economically profitable for participants regardless of their positive environmental impact — measures such as reducing energy needs per unit of output and engaging in cooperative R&D efforts toward less emissions-intensive technology.

Clearly, without further prodding from governments, the effectiveness of the voluntary approach may have a built-in limit.

Box 3: *Canada's Voluntary Climate Change Programs*

In Canada, the National Action Program on Climate Change, as the national strategy on the global warming issue is called, includes a Voluntary Challenge and Registry (VCR) program, introduced in 1995, through which companies are encouraged, with the involvement of the federal Department of Natural Resources, to make nonbinding but public commitments to energy efficiency.

In addition, the Canadian Industry Program for Energy Conservation (CIPEC), created in 1975 in response to energy security issues and reorganized in 1992 in the wake of Canada's signing the FCCC, has developed the Industrial Energy Innovator (IEI) initiative, under which mining and manufacturing firms commit to develop targets and action plans to report their progress in energy efficiency (which, in the short term at least, reduces CO_2 emissions per unit of output). Companies registering under the IEI initiative are automatically registered in the VCR.

Industry groups also support Statistics Canada's annual surveys of about 2,000 establishments, which the federal Department of the Environment uses to calculate the amount of CO_2 emissions produced from these stationary industrial sources.

Efficiency. From an efficiency point of view, the voluntary approach is indeed good. The reductions are taking place where making them is least costly in economic terms.

Equity. The voluntary approach raises the equity issue normally associated with the free-rider problem: some may benefit from efforts of others while not contributing to solving the problem themselves. Moral suasion among peers and the possibility of the introduction of costly mandatory measures may help alleviate the problem. It is exacerbated, however, when certain segments of the economy (notably, industry in Canada) are singled out for action, whereas others (consumers, farmers, services, the public sector) are not pressed as hard to contribute.

Feasibility: The voluntary nature of the program minimizes administrative costs, but again the free-rider problem may limit participation, particularly in sectors where monitoring by peers is difficult or where small firms stand ready to gain a competitive edge by eschewing the type of commitments made by larger firms.

Recommendation. Voluntary action to reduce emissions probably still offers major untapped benefits. Time will likely result in even greater reductions in the carbon intensity of output from Canadian industries participating in the Industrial Energy Innovator (IEI; see Box 3) as new, more efficient investments have time to come on stream. The voluntary process is still not widespread across all industries and countries, and it has not truly reached a number of major contributors to Canada's GHG emissions. Challenging the services industries and the public sector to do as well as industry in voluntarily controlling emissions could yield significant results. Increasing international cooperation among firms may alleviate industry fears that investing in GHG-emissions-reducing technologies and processes will put them at a competitive disadvantage.

Moreover, although most industrial firms must by now be keenly aware of the GHGs they are releasing, more can be done to inform consumers and agricultural operators about the emissions their consumption, production, and transportation patterns entail. Improved information may assist individuals — at least those who wish to avoid creating more emissions than necessary — in making appropriate choices, even if they have to pay additional costs, in the same way that accurate product information can help us make choices based on other product characteristics.

All this being said, the inherent limitations of the voluntary approach suggest that it may not be sufficient to induce actions toward controlling the growth of GHG emissions to an extent sufficient to reduce the risks posed by global warming.[42] The need to improve effectiveness in reducing environmental risk then suggests the coming into play of mandatory instruments.

Although some of the latter may appear more effective at reducing emissions in the short run than the voluntary approach, they also often raise questions of efficiency, equity, and feasibility, as we will see below, a fact suggesting that the voluntary approach should remain central to a GHG-emissions-reduction strategy.

Mandatory Emissions Controls

Mandatory controls, also known as a command-and-control approach, involve both the setting of countrywide or global targets and the handing down of specific instructions about where in the economy these reductions should occur.

Effectiveness. Mandatory controls could be seen as effective in a single-minded pursuit of a narrow objective — such as ensuring the reduction or stabilization of GHG emissions in a particular country, area, or industry — because they would direct specific cuts in the economy in the amount deemed necessary.

Efficiency. In terms of the efficiency criterion, mandatory controls rank last among the possible approaches to controlling emissions. The objective would almost surely be attained in the way most costly for the economy as a whole

because nothing short of an army of regulators, collecting information from the private and public sectors, could likely identify specific instances of least costly reductions in terms of output, incomes, and employment. Furthermore, regardless of the information available to governments on current output, technologies, and processes, requiring firms or industry groups to effect specific reductions would be an inefficient strategy in dynamic terms, since those allotted a particular emissions target would lack an ongoing incentive to reduce their emissions by more than was required to comply with the regulation, while new or growing firms would likely face difficult odds in lobbying against established ones for a greater share of emissions allocations.

Equity. Lack of information and high administrative costs would also likely impede an equitable allocation of mandatory emissions reductions. Even if an equitable allocation could be found initially, equity would be unlikely to resist the passage of time, given the political battles that emerging firms and industries would have to wage against established emitters before they were allowed to operate.

Feasibility. As I have already suggested, attempting to circumvent the efficiency problems of such a command-and-control approach would be costly administratively and difficult politically because of the ongoing battles for allocation of reductions.

Recommendation. The negative static and dynamic impacts of inadequate public sector information on the economic costs, equity, and feasibility of mandatory controls are typical of those that contributed to the backwardness and ultimate demise of the planned economies. This is why mandatory emissions controls barely rate in most debates on reducing GHG emissions.

Mandatory Product Standards

Mandatory standards involve governments' specifying the features or performance of a particular type of product, such as cars, and requiring that a manufacturer or seller offer them to all its customers. In this case, one is talking about performance in terms of low emissions of CO_2 and other GHGs.

Effectiveness. This approach can be effective when the sources of emissions are too numerous for each to be monitored at a reasonable cost, automobiles being an often-cited example. Even then, however, it is often not the only approach possible. For example, since cars emit a predictable amount of CO_2 by burning fuel, abatement measures that would apply to gasoline supplies, by leading to an increase in the price of gasoline at the pump, could have the same effect on GHG emissions as emissions standards for automobiles.[43]

Efficiency. Like mandatory emissions controls, mandatory product standards suffer from their inability to provide an ongoing incentive to innovate by adopting technologies and processes more efficient than the minimum with which firms are required to comply. On the other hand, when local environmental considerations lead to product standards' being adopted that also reduce GHG emissions — for example, emissions standards for automobiles in order to reduce smog — the widespread adoption of such standards throughout the economy may be the least costly way to reduce emissions.

Equity. Mandatory product standards can also pose significant equity problems since, even though the standard is uniform, its economic cost may be distributed ad hoc between firms or people who have made recent investments in nonconforming plants, houses, cars, and so on and others who are just about to make these purchases and therefore can more easily

afford to comply with the standard. The usual way to correct this problem is to exempt older plants and products from the standard, but that approach creates an incentive to keep them going longer than would otherwise be useful, reducing the environmental impact of the standard.

Product standards also usually result in higher product prices, imposing a cost on every purchaser regardless of income. GHG-emissions standards' regressive effects on low-income individuals would not be easy to remedy with financial transfers because these effects, although real, would be difficult to quantify. (In contrast, consider the relative ease with which low-income individuals can be given credit for, say, a tax on fuel purchases.)

Feasibility. Standards are often seen as politically feasible since they seem equitable, and consumers bear the costs only indirectly. As the only approach to reducing GHG emissions, however, they would be extremely costly to administer, because emissions have so many sources, and hence different standards would have to be devised for different industries, businesses, and consumer goods and services.

Recommendation. Product standards have a role to play in an overall GHG-abatement strategy. However, this approach is to be recommended only when it is impracticable to charge businesses or consumers, even implicitly, for the emissions embodied in their activities, or when the widespread adoption of a standard that is already in place locally, for considerations other than climate change, would provide an economical way of reducing overall GHG emissions.

Three Instruments that Provide Economic Signals

I now turn to three options that would introduce into the economy an easy-to-understand signal in the form of a single price for GHG emissions.[44] Decisionmakers would have to react to the fact that, because emitting greenhouse gases is seen as imposing a certain risk on society, society has a stake in ensuring that these emissions be treated as if they had a cost.

Two possible basic approaches are possible here: essentially, tradable emissions permits, and either a carbon tax or an emissions fee. The first would involve the setting of a limit, by a country's government or by governments acting in concert, of a permissible quantity of emissions for the country, region, or world and then letting the market set a price for this suddenly valuable commodity (the emissions permit). The second approach would see governments intervene directly in the setting of a price or cost and letting the market work out the quantities that be produced or emitted at that price.

Tradable Emissions Permits

Under a tradable emissions permits system, governments would set overall targets for CO_2 emissions, to be distributed among them by treaty, and then allocate or auction permits to their national emitters. The owners of permits would be able to trade them. Each permit would allow a given amount of emissions, and the number of permits in any given year would be determined by the overall targets. The total number of permits allocated could diminish over time if and as emissions targets were reduced.

Effectiveness. A permit system could be effective in reducing emissions to a desired level over the area in which it is implemented, simply because it would put a legal, upper bound on them: emitters would have to hold the number of permits corresponding to their emissions. The emissions allowed by any one permit could decline over time in a manner tailored to the overall reduction commitments of the issuing country.

Obviously, the global effectiveness of this or any other emissions-control scheme would depend on how many countries, including non–Annex I countries, actually committed themselves to implementing it.

Efficiency. In terms of efficiency, a permit system, particularly one of internationally tradable permits in which non-Annex I countries would participate, would result in a single world price for emissions and thus ensure that pollution abatement was done everywhere at the least possible cost to the global economy; that is, firms everywhere that could clean up relatively cheaply would end up doing the abatement and selling their surplus permits to those who would find acquiring them at the world price less expensive than reducing emissions. Indeed, when tradable permits have been introduced for other pollutants in the United States, they have proven to be five to ten times less costly than programs involving direct regulations. In particular, the sulfur emissions trading scheme introduced by the 1990 amendments to that country's Clean Air Act has been termed a tremendous success.[45]

International tradable emissions permits would also reduce the threats of carbon leakage and of rich countries' imposing a tariff on carbon-intensive products imported from developing countries (a response governments of Annex I countries might be pressured into if their electorates felt that sacrifices made in the name of reducing global warming were being squandered by carbon leakage). If all countries participated in an emissions-permit scheme, even if the initial allocation of permits favored non–Annex I over Annex I countries, all permits would end up being sold at the same price worldwide. The result would be a price for carbon emissions that would be equalized across countries, removing the possibility for any one of them to attract firms through a more lenient GHG-emissions policy. In other words, as some analysts have noted, trading emissions permits could be a substitute for trading carbon-intensive goods,[46] improving efficiency generally and avoiding carbon leakage in particular.

Moreover, a permit system would allow many features that could enhance efficiency. Given the economic benefits of ensuring that the least efficient producers be tapped first to implement abatement policies, it would also be important to allow firms that wished to pay for it room to adapt to changing conditions that steered them away from their emissions targets. The freedom to "bank" and "borrow" permits would increase flexibility and lower costs by allowing firms to change the timing of their emissions reductions, albeit at a cost.

A recent Canadian example of a situation in which such flexibility could have been beneficial occurred when Ontario Hydro uncovered severe problems at some of its nuclear facilities. To offset this lost capacity, the utility is planning to increase electricity production from its fossil-fuel stations, a strategy that will likely put a dent in its current voluntary commitment to cut its GHG emissions to 1990 levels by 2000.[47] Under a trading scheme with banking and borrowing, Ontario Hydro would have had the flexibility to purchase emissions permits on the market and to borrow them until its nuclear capacity was back up or other options developed in the energy market.

As well, and importantly, agreements could be grafted onto a permits scheme whereby firms could receive credit in lieu of permits for abatement (or the maintenance of carbon sinks) in other countries if they perceive this to be a lower-cost avenue than purchasing permits.

Equity. The institution of tradable permits would raise questions of equity in their distribution. None of these is intractable in theory, since the system would offer substantial flexibility in the initial allocation, but they raise significant feasibility issues (which I discuss below) because of the potential magnitude of the transfers involved between countries, regions, firms, and even individuals. Permits could be distributed on the basis of existing emissions, respecting the principle of historical equity but creating valuable property rights for current emitters to the detriment of future emitters, thus potentially hurting economic growth. They could also be auctioned off peri-

odically, in which case emitters would be paying for a right that had previously been free.

Equity questions would, however, arise unless all current emitters were covered by the scheme. That situation could arise because the multiplicity of emissions sources would make it difficult for each to be subject to the permit scheme.

Feasibility. The sources of CO_2 emissions are many and diverse. Although tradable permit systems have proven successful for large and fixed sources, they would be extremely difficult to implement for the small business, transportation, and residential sectors, which are responsible for more than half of Canada's CO_2 emissions. Would drivers have to be issued permits, which they could then sell to other drivers or to their local small business? It would be more practical to allocate permits to suppliers, foreign and domestic, of fossil fuels on the basis of their carbon content, exempting supplies used for nonenergy purposes (such as petrochemicals or oil-based lubricants). Prices would rise, making consumers ration their use of carbon-intensive products.

Another feasibility issue relates to the political incentives countries would have to adopt the system, which is especially important since most of the gains would actually stem from the participation of non–Annex I countries. The scheme could in principle be turned into an international permit trading system (once countries had agreed on emissions targets), and it would have the efficiency properties of a national permits trading system — that is, producers in areas where reduction was least costly would end up selling permits to those in areas where it was costlier. But turning GHG-emissions permits into an internationally traded commodity would lead to massive changes to the existing global trade patterns, which might have unintended macroeconomic consequences. Under a plausible scenario for the initial allocation of emissions reductions, developing countries could be large sellers of permits on the international market, while Canada and the United States, among others, suffered a significantly worsening of their trade balance.

The developing countries would not particularly welcome this system. For them, massive exports of permits would lead to exchange-rate appreciation and quite likely a decline in other exports, a dubious strategy for long-term economic development and a strong reason for developing countries to participate. However, not having developing countries on board would eliminate one of the main reasons for having an internationally tradable permit system in the first place. (International trading would do little to lower abatement costs if the participating countries had fairly similar technologies.)

Furthermore, for the treaty to be viable, each participating country would need to be confident that all of the other participants were enforcing it. Surety would require an elaborate and expensive international mechanism for monitoring and enforcement. As McKibbin and Wilcoxen write,

> no individual government would have an incentive to police the agreement;...monitoring polluters is expensive, and punishing violators imposes costs on domestic residents in exchange for benefits that will accrue largely to foreigners. There would be a strong temptation to look the other way when firms were exceeding their emissions permits.[48]

Recommendation. A system of internationally tradable permits has much to recommend it: effectiveness in reducing emissions; the fact that it would result in a single price for emissions and thus abatement where it is least costly in economic terms; and obviation of the threat of carbon leakage if all participate.

Such a system would not, however, likely be flexible enough to deal with the issue of anthropogenic GHG emissions over the next few years. In particular, the market for permits could be subject to wide fluctuations, which would make planning difficult.

In addition, the system's equity properties, flexible in theory within a country where a

single government arbitrates their initial distribution, could founder in the international area as countries squabbled over the allocation. If horizontal and historical equity considerations held sway, developing countries would feel that vertical equity had been violated, and they would have no incentive to participate in the scheme, thus removing one of the main reasons for its existence. But if developing countries were given more than their historical share of permits, internal economic chaos would result from the rising exchange rate these countries would face as a result of strong global demand for the use of permits where they are most efficient — that is, in the developed countries.

Therefore, the question arises of devising a scheme that would remedy these defects while keeping the desirable properties of tradable emissions permits.

A Carbon Tax

A carbon tax is one that is applied on the basis of the carbon content of energy sources. It is expressed in dollars per tonne of carbon or CO_2, and different fuels would be taxed at different rates per unit of energy according to their carbon content; that is, the rate would be higher per unit of energy content for coal than for oil and higher for oil than for natural gas. In principle, the tax would apply to all purchases of fossil fuels by businesses and consumers, but users for nonenergy purposes could be credited for the tax paid on that portion of their purchase.

Effectiveness. A carbon tax could be used to reach a certain reduction target if it were set at a high enough rate. Because it would differentiate among sources of energy according to their carbon content, the overall emissions-reduction goal would, as in the case of emissions permits or quotas, be achieved through promoting the substitution of fuels with a lower carbon content for those with more carbon, of noncarbon energy sources for fossil fuels, and of nonenergy expenditures for energy spending.

Efficiency. A carbon tax could be efficient in the sense of encouraging reductions in GHG emissions where they are least costly in terms of output. However, this would be true of the impact on global economic output only if all countries agree on the same level of taxation.

Furthermore, because the tax would be implemented on all fuel consumption, rather than at the margin, over time it would raise significant revenues for governments, and its ultimate effect on economic efficiency would depend on their efficient use of that money.

Equity. A carbon tax would raise important equity considerations, again by virtue of its taxing not the marginal increase in emissions but the entire consumption of fuels in the economy. Thus, its redistributive effects would not likely be neutral; rather, they would most affect economic activity in regions of the country that produce and use carbon-intensive energy. Again, the ultimate effect would depend on how governments allocated the revenues raised. (As an example of the considerations involved, the Ontario CO_2 collaborative suggests extending the Ontario sales tax to include electricity, natural gas, home heating oil, and propane, but proposes making the move more equitable by lowering sales taxes on other items.[49])

From an international perspective, the tax would also have to apply to imports of refined petroleum products at a level equivalent to their carbon content. Otherwise, imports would begin to substitute for domestically produced refined petroleum products.

Feasibility. The type of carbon tax discussed here, applied on the sale of fossil fuels from domestic and foreign sources, would cover most anthropogenic sources of CO_2 emissions and would incur fairly low administrative costs because it would apply to existing transactions

and hence would be easy both to administer and to comply with.

The tax would, however, apply to the entire consumption of existing users of carbon-intensive fuels. For that reason, the tax would probably be least feasible in a political sense because it would be seen as penalizing industries that happen to depend on or be located near the these sources of fuel, relative to others. Furthermore, to be effective with respect to the global warming issue, it would still require other countries to follow suit, which its political unpalatability and the fact that the impact of such a tax on emissions would vary greatly by country would also make unlikely.

Recommendation. Although a carbon tax could effect reductions in emissions in a relatively simple-to- administer way, it would likely hit consumers and producers of energy more than necessary to control CO_2 and other GHG emissions, raising issues of equity and political feasibility. In any event, as a strategy to tackle the global risk that rising levels of CO_2 emissions may create, this instrument should be contemplated only as part of an international effort to tax CO_2-intensive fuels.

An Emissions Permit Fee

An emissions permits fee system, in essence the one proposed by McKibbin and Wilcoxen in a recent study,[50] would involve an international agreement to negotiate a world fee to be applied in every country to emitters only for emissions in excess of their level in an agreed base year, with that level adjusted downward if subsidies or nonrecurring events had had the effect of inflating a particular country's base-year emissions. The system would be administered by each country individually with all selling the permits at the agreed price. There would be no limit on the quantity of permits sold (although, as with tradable quota schemes, the amount of permits issued would have to match the amount of emissions produced). But the price of permits would be re-evaluated by the participating countries — for example every five years, which would then become the life of the excess emissions permit — and adjusted upward or downward in light of progress in controlling emissions and of new scientific findings on climate change.

McKibbin and Wilcoxen envisage a system whereby each country would be allowed to distribute emissions permits equal to its 1990 emissions, giving them away or auctioning them, as its government saw fit. In addition, they contemplate firms' buying, at the stated fee, permits for excess emissions not only from governments but also from other firms that had reduced their emissions and hence freed up permits. However, I prefer a scheme whereby countries would receive an initial allocation of permits to be distributed free during the year the scheme is announced — say, 2000, although it would not come into place for another ten or fifteen years, corresponding

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to their total emissions in that year. The permits for pre–2000 emissions could contain a clause that would gradually phase down the amount of emissions they authorize, thus allowing for the possibility that emissions would one day be cut back to, for example, 1990 levels or beyond. In addition, the tradability of existing permits would require that firms sell them at a price below that at which similar permits could be obtained from the government, which would then become the maximum price. The discussion below assumes these modifications of the scheme.

Effectiveness. A permit system that would control the price of marginal emissions, rather than the total volume, may seem less effective than one that would effectively cap the emissions. And indeed, from the viewpoint of environmental effectiveness, this policy would be the most flexible discussed here in that it would not say by how much emissions would be reduced each year. But I say "flexible," not "weak," because, as with a carbon tax, the fee could eventually be set at such a high level that increases in emissions would be impossible (and a decrease likely, given the gradual lessening of the value of the permits issued in the base year in terms of emissions). Thus, whether emissions were, in fact, stabilized or reduced to an acceptable level would depend on the price at which governments agreed to sell the permits. The economic considerations I have reviewed suggest that it would make sense to have an initially low price, perhaps rising steeply by the middle of the twenty-first century if scientific evidence and progress in abating GHG emissions warrant.

Efficiency. The scheme would ensure that any abatement would be done at minimum cost in a static sense. Moreover, firms would always have an incentive to reduce further, either to avoid paying the fee or to be able to sell excess permits to other firms (including internationally). These properties are not unlike what obtains in a tradable quota scheme. More important are the dynamic properties of this scheme compared with those of a tradable quotas system: the price of the permits for excess emissions could be adjusted up or down incrementally according to the situation.

Equity. The equity features of the emissions permit scheme at first appear controversial because, like some of the possible avenues for initially distributing emission quotas, it involves creating a property right for existing emitters, at least applying to their current emissions level. But it is worth remembering that these rights would initially be worth far less than they would under a tradable quota scheme because of the cap on the fee, making it easier under this scheme for growing firms and industries in developed as well as in developing countries to meet their needs (thus respecting vertical equity), while ensuring that all over the world emissions over those of the base year always attract a tax (thus respecting horizontal equity). In any event, to the extent that the initial allocation was seen as tilted too much toward existing firms, the fact that permits initially distributed free would contain a clause diminishing over time the emissions they were good for would alleviate this issue.

Feasibility. Although agreement among countries to measure emissions during a specified base year might be difficult to reach, this scheme would be relatively simple to administer. And each country would have an incentive to administer it because it would be a potential revenue generator over time, at least in developing countries, so the need for international policing should be minimal. Developing countries, which would probably see the fastest rise in revenues from this measure, could be further induced to participate by Annex I countries' agreeing to recycle some of their revenues from the fee.

Politically, the scheme would be acceptable because little redistribution of wealth

would be involved, at least initially (a potential problem of the carbon tax and of some tradable quotas schemes).

Recommendation. If a mandatory scheme is introduced to supplement voluntary efforts, as may well have to be the case, I recommend that countries work on adopting this simple but effective scheme. To quote the main authors of this proposal:

> A national permit and fee policy would be a modest but concrete step forward in protecting the environment from excessive climate change. It would not necessarily stabilize world carbon emissions [as we have seen, this depends on the fee; my parentheses], but it would certainly reduce them below the level that would exist without any policy or with a stronger but unimplemented policy. It would also provide valuable information about how much abatement can be done at low cost and how expensive it would really be to stabilize emissions.[51]

This last, "experimental" aspect of the scheme makes it particularly valuable in a situation where uncertainty continues to dominate.

Conclusion

At the United Nations General Assembly Special Session on Sustainable Development, in June 1997, Canada's prime minister said:

> In Canada, our experience is that the best way to deal with a large, intractable problem is to work out a practical step-by-step plan, with realistic interim, medium-term targets. That is how we eliminated our deficit...That is why our government supports the establishment of legally binding medium-term targets for post–2000 greenhouse gas emissions....The structure of our economy poses particular challenges in this regard.[52]

In the same spirit, in this Commentary I have summarized the evidence regarding the risk that anthropogenic emissions of GHGs pose for global warming and the cost of reducing this risk. The science of global warming is inconclusive, certainly as to the extent of the problem if not its existence. But there is at least the risk that increases in human-generated emissions of CO_2 and other greenhouse gases could mean a crisis down the road. The severity of that potential crisis suggests the need for credible action, although the costs of acting hastily, and especially unilaterally, could be quite harsh.

On this basis, I have developed six principles according to which I believe Canada should act while negotiating and implementing treaties on GHG abatement. With respect to the choice of instruments for giving effect to global action, I favor in the short run a continuation and extension of the voluntary approach but also the spur of a framework understanding among governments that, should this approach and other measures, such as product standards, that may be introduced not yield a satisfactory abatement of emissions, mandatory measures will follow by a certain date, which I suggest should be 2015. Among the latter measures, I believe the instrument most likely to curb emissions while respecting basic efficiency, equity, and feasibility considerations would be a single world emissions fee, negotiated among governments, that each would apply to its national GHG emissions exceeding those of an agreed-on base year, which I suggest should be soon — say, 2000.

The issues I have discussed are complex. If Canadians are to be induced to comply with measures that will seriously cope with them, they must understand and support the why of the measures, their costs, and whether they are equitable on both a domestic and global basis. In addition, the potential for a massive democracy deficit exists, given that the federal government has committed itself to signing some form of legally binding targets in Kyoto this December. The implications of such a commitment could be enormous, and no undertaking should be ratified before complete and open debate has occurred.

Notes

1 The preliminary annual report on CO_2 emissions in Canada in 1996 puts them at almost 11 percent above their 1990 level. See Anne McIlroy, "Canada falling short of greenhouse promise," *Globe and Mail* (Toronto), October 16, 1997, pp. A1, A10.

2 World Resources Institute, The United Nations Environment Programme, The United Nations Development Programme, and The World Bank, *World Resources: A Guide to the Global Environment* (New York; Oxford: Oxford University Press, 1996), box 14.3.

3 Conference Board of Canada, "Capital Stock Turnover and Greenhouse Gas Reduction Opportunities" (Ottawa, November 19, 1996, draft), p. 73.

4 Warwick J. McKibbin and Peter Wilcoxen, *A Better Way to Slow Climate Change*, Brookings Policy Brief 17 (Washington, DC: Brookings Institution, 1997).

5 See Intergovernmental Panel on Climate Change (IPCC), *IPCC Second Assessment Synthesis of Scientific-Technical Information Relevant to Interpreting Article 2 of the UN Framework Convention on Climate Change*, www.ipcc.ch, retrieved October 21, 1997, p. 15.

6 Ibid., pp. 5–6, where it is mentioned that the current "best estimate" of temperature increase is about one-third lower than the previous "best estimate," published in 1990.

7 As shown by T.M.L. Wigley, R. Richels, and J.A. Edmonds, "Economic and Environmental Choices in the Stabilization of Atmospheric CO_2 concentrations," *Nature* 379 (January 18, 1996): 240–243.

8 This result holds under a range of "business as usual" scenarios. See World Energy Council and the International Institute for Applied Systems Analysis (WEC-IIASA), *Global Energy Perpectives to 2050 and Beyond: 1995 Report* (London: World Energy Council, 1995), appendix C; and Australian Bureau of Agricultural and Resource Economics (ABARE), *Global Climate Change: Economic Dimensions of a Cooperative International Policy Response beyond 2000* (Canberra: Australia Foreign Affairs and Trade and ABARE, 1995), p. 9.

9 W. David Montgomery, *Developing a Framework for Short- and Long-Run Decisions on Climate Change Policies*, Special Report (Washington, DC: American Council for Capital Formation, Center for Policy Research, 1995), p. 2.

10 See "A Power for Good, a Power for Ill," in "Energy and the Environment Survey," *The Economist*, August 31, 1991, p. 4. Although costs may rise, the likelihood is that even rapid economic development will not lead to a scarcity of geological energy resources. See WEC-IIASA, *Global Energy Perspectives to 2050 and Beyond*, pp. 33–40.

11 See "Dirt Cheap," in "Energy and the Environment Survey," *The Economist*, August 31, 1991, p. 5.

12 [See "Debate Over Satellite data Heats Up!" *World Climate Report* 2 (13, 1997), retrieved from World Climate Report Features website, www.nhes.com, October 21, 1997.

13 The Ontario CO_2 Collaborative, *A CO_2 Strategy For Ontario: A Discussion Paper* (Toronto: Canadian Institute for Environmental Law and Policy, 1996), p. 10. The report was sponsored by such diverse organizations as the Ontario Ministry of Environment and Energy, Ontario Hydro, and the Ontario Natural Gas Association and was endorsed as a useful contribution by representatives from a wide array of business, labor, and government and nongovernmental organizations.

14 Ibid., p. 11.

15 Ibid., p. 10.

16 IPCC Working Group I, *Summary for Policymakers* (1995), quoted in The Ontario CO_2 Collaborative, *A CO_2 Strategy for Ontario*, p. 13.

17 See James P. Bruce, "Canada in the Global Climate System," in Michael Keating and the Canadian Global Change Program, *Canada and the State of the Planet: The Social, Economic and Environmental Trends that Are Shaping Our Lives* (Toronto: Oxford University Press, 1997), p. 9.

18 The range of estimates is provided by Gilles Rhéaume, who cites work by reputed economists William Cline and William D. Nordhaus, in *The Challenge of Climate Change: Policy Options for Canada*, Report 112-93 (Ottawa: Conference Board of Canada, 1993), p. 2.

19 Quoted in William K. Stevens, "Fossil-fuel producers see a different light," *Globe and Mail* (Toronto), August 6, 1997, p. A10.

20 A.R. Sawchuck, "Feasible Targets for Greenhouse Gas Emissions" (presentation to the Canadian Industry Program for Energy Conservation conference, Toronto, November 10, 1995), p. 6.

21 Data compiled by the International Energy Agency show that, over time, energy usage is highly responsive to its pricing. See International Energy Agency, *Statment on the Energy Dimension of Climate Change (Paris: IEA, March 1997), pp. 13–15.*

22 *As reported in McKibbin and Wilcoxen, A Better Way to Slow Climate Change*, p. 3. See also Standard & Poor's DRI, "Impact on Canadian Competitiveness of International Climate Change Mitigation," Climate Change Briefing, Ottawa, September 26, 1996, draft; and IPCC Working Group I, *Summary for Policymakers* (1995), pp. 28–29.

23 See the survey of the relevant literature in L. Alan Winters, "The Trade and Welfare Effects of Greenhouse Gas Abatement: A Survey of Empirical Estimates," in Kym Anderson and Richard Blackhurst, eds., *The Greening of World Trade Issues* (Ann Arbor: University of Michigan Press, 1992), pp. 95–114, particularly ta-

ble 5.1; the results of subsequent modeling exercises by ABARE, *Global Climate Changes*, esp. pp. 51–82; and Paul M. Bernstein, W. David Montgomery, and Thomas F. Rutherford, *World Economic Impacts of US Commitments to Medium Term Carbon Emissions Limits*, CRA No. 837-06 (n.p.: Charles River Associates, January 1997).

24 The classic works here are D.W. Jorgenson, "Capital Theory and Investment Behavior," *American Economic Review* 53 (1963): 47–56; and R.E. Hall and D.W. Jorgenson, "Application of the Theory of Optimum Capital Accumulation," in G. Gomm, ed., *Tax Incentives and Capital Spending* (Washington, DC: Brookings Institution, 1973).

25 Montgomery, *Developing a Framework*, p. 3.

26 See ABARE, *Global Climate Change*, pp. 52, 122.

27 See Laurie Michaelis, "Reforming Coal and Electricity Subsidies," Policies and Measures for Common Action Working Paper 2 (London: Annex I Expert Group on the UN FCCC, July 1996).

28 B. Larsen and A. Shah, "Global Climate Change, Economic Policy Instruments and Developing Countries" (paper presented at the International Institute of Public Finance 50th Congress, Cambridge, Mass., August 22–25, 1994). See also M. Grubb, *Energy Policies and the Greenhouse Effect*, Vol. 1: *Policy Appraisal* (Dartmouth: Royal Institute of International Affairs, 1990); R.H. Williams, *Will Constraining Fossil Fuel Carbon Dioxide Emissions Cost So Much?* (Princeton, NJ: Princeton University, Center for Energy and Environmental Studies, 1990); and Kym Anderson, "Effects on the Environment and Welfare of Liberalizing World Trade: The Cases of Coal and Food," in Anderson and Blackhurst, eds. *The Greening of World Trade Issues*.

29 See J.-M. Burniaux et al., "The Costs of Policies to Reduce Global Emissions of CO_2: Initial Simulation Results with GREEN," Working Paper 103 (Paris: Organisation for Economic Co-operation and Development, Economics and Statistics Department, 1991); and ABARE, *Global Climate Change*, pp. 57–60.

30 J. Whalley and R. Wigle, "The International Incidence of Carbon Taxes," in R. Dornbusch and J. Poterba, eds., *Economic Policy Responses to Global Warming* (Cambridge, Mass.: MIT Press, 1991).

31 See E.J. Symons, J.L.R. Proops, and P.W. Gay, *Carbon Taxes, Consumer Demand and Carbon Dioxide Emissions: A Simulation Analysis for the UK* (Keele, Staffs.: Keele University, 1990).

32 See, for example, reports by the World Resources Institute and by the Progressive Policy Institute, cited in "Clean and Green, or Lean and Mean?" *The Economist*, December 12, 1992, p. 73.

33 A somewhat different list of criteria — efficiency, environmental effectiveness, political acceptability, and equity are used in Kerry Turner, David Pearce, and Ian Bateman, *Environmental Economics* (Baltimore: Johns Hopkins University Press, 1993).

34 FCCC article 4.2 (a), as quoted in ABARE, *Global Climate Change*, p. 8.

35 As an example of the latter position, see "Global Warming Does Not Exist — Fraser Institute, Vancouver," *The Gallon Environment Letter*, August 18, 1997.

36 See "It's time Canadian voters turn up the heat," advertisement by the David Suzuki Foundation, *Globe and Mail* (Toronto), May 20, 1997, p. A6; and Janet Yellen, Statement by the Chair, Council of Economic Advisers, before the United States Congress, House of Representatives, Subcommittee on Energy and Power, July 15, 1997, p. 2.

37 See Catherine Arnst with Gary McWilliams, "The Black Market vs. the Ozone," *Business Week*, July 7, 1997, pp. 128–130.

38 See "Hot Air?" *The Economist*, August 9, 1997, pp. 48–49.

39 See Robert G. Skinner, "Voluntary Approaches: An International Comparison" (background paper for presentation at a Symposium on Energy Conservation by Long-Term Agreements, Amsterdam, January 1995). See also the list of incentives according to the Pembina Institute, cited in Patricia Beaulieu, "The VCR Doesn't Work," *Alternatives* (University of Waterloo, Faculty of Environmental Studies), Summer 1997, p. 4.

40 See Canadian Industry Program for Energy Conservation (CIPEC), *1995–1996 Annual Report* (Ottawa, April 1997), pp. 21–22, 137–138; and Mark Storey, "Demand Side Efficiency: Voluntary Agreements with Industry," Policies and Measures for Common Action Working Paper 8 (London: Annex I Expert Group on the UN FCCC, December 1996), Appendix II: Case Study, Canada, pp. 47–48.

41 Which Beaulieu nevertheless makes in "The VCR Doesn't Work."

42 Storey, "Demand Side Efficiency," p. 8.

43 Daniel Schwartz, "The Emission-Based Vehicle Charges: A Market-Based Solution to Canada's Automobile Pollution Problem," *Fraser Forum*, July 1997, pp. 41–42.

44 The description and analysis of the following three instruments relies particularly on Rhéaume, *The Challenge of Climate Change*; McKibbin and Wilcoxen, *A Better Way to Slow Climate Change*; Canada, *Economic Instruments for Environmental Protection* (Ottawa, 1992).; and C. Perroni and T.F. Rutherford, "International Trade in Carbon Emission Rights and Basic Materials: General Equilibrium Calculations for 2020" (Waterloo, Ont., Wilfrid Laurier University, Department of Economics, 1991, mimeographed).

45 See Canada, *Economic Instruments for Environmental Protection.*

46 See Perroni and Rutherford, "International Trade in Carbon Emission Rights"; and Burniaux et al., "The Costs of Policies to Reduce Global Emissions of CO_2."

47 See Martin Mittelstaedt, "Change 'unavoidable' for Ontario Hydro," *Globe and Mail* (Toronto), August 18, 1997, p. A1.

48 As discussed in McKibbin and Wilcoxen, *A Better Way to Slow Climate Change*, pp. 3–5.

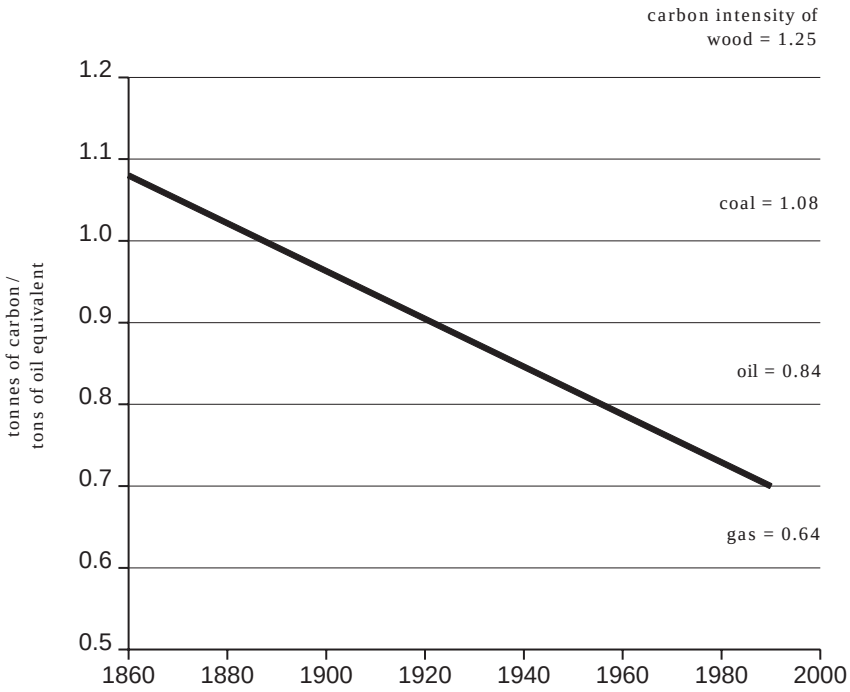
49 The Ontario CO_2 Collaborative, *A CO_2 Strategy for Ontario*, p. 96.

50 McKibbin and Wilcoxen, *A Better Way to Slow Climate Change*.

51 Ibid., p. 5

52 "Jean Chrétien: Some of our Rio goals elude us," *Globe and Mail* (Toronto), June 27, 1997, p. A17.

Carbon Intensity of Primary Energy Sources, World, 1860–1990



Note: Includes emissions from unsustainable uses of fuelwood.

Source: Adapted from World Energy Council and International Institute for Applied Systems Analysis, *Global Perspectives to 2050 and Beyond: 1995 Report* (London: World Energy Council, 1995), table 4-14.