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Regional Response Options to Global Climate Change

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A regional perspective on global climate change

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Global climate change has garnered some media attention, but has failed to gather the attention of most governmental decision makers and the public. In an effort to advance concerns about the issue, the New England Governors and Eastern Canadian Premiers sponsored a three-day symposium on climate change last May 19-21 in Portland. At the symposium, scientists and public officials from both the U.S. and Canada explored the science of climate change, the potential implications and impact of climate change on this region, and the possible policy responses. In the following analyses by James Bruce, Dean Marriott, and Mark Victor, reflecting the breadth of topics explored at the symposium, each author argues that the level of public and public policy decision makers' awareness about climate change issues must be heightened, and decision makers must begin to deal collaboratively with the many serious challenges climate change is presenting to the region.

Regional response options to global climate change

by James P. Bruce, Chair Canadian Climate Program Board

The potential response by the northeastern U.S. and eastern Canada to climate change falls in two categories: adaptation and limitation. Some writers seem to think that if adequate emphasis is placed on limitation, *i.e.*, the reduction of greenhouse gas emissions and increase of sinks, then we do not need to worry about adapting to changes. However, human activities have been changing the composition of the atmosphere in ways that change the radiation balance and climate at a very rapid rate. This rate will not be quickly slowed in light of the enormous inertia in the earth's economic systems. Thus, a significant climate change appears inevitable, even with best efforts at limitation of greenhouse gas emissions. So adaptation will be needed.

It should also be noted that while climatic models are typically based on a doubled carbon dioxide (CO_2) equivalent atmosphere, it is clear that with the amount of fossil fuel, especially coal, still buried to tempt human use, we could easily achieve a triple or even quadruple CO_2 equivalent atmosphere. Thus, adaptation and limitation measures must go hand-in-hand; both are essential. I will concentrate on only two aspects of adaptation that need some attention: adaptation to extreme climatic events, and the development of so-called second-generation climate impact adaptation studies.

Adaptation to extreme weather events

Probably, climate change will not be experienced through a relatively slow increase in temperature, slow rise in sea level, and slow change in precipitation patterns. Rather, climate change will be experienced as changes in the frequency and severity of extreme events: storms, floods, droughts, and extreme heat and cold. Unfortunately, the crystal ball for predicting changes in extremes, using the Global Climate Models, is very clouded. The Global Climate Models project shifts in the mean values of climate parameters (such as temperature and

rainfall), but changes in extreme events are either not predicted, or, the results have been very inconclusive.

The scientific community has, therefore, generally stayed away from consideration of future extremes and resulting natural disasters. Not so the insurance industry. The large reinsurance companies (who essentially insure insurance companies) have noted that from 1960 to 1987, they had no natural disasters with insured losses exceeding $1 billion. Since 1987, they have had 15, mostly due to storms, floods and droughts. They have carefully examined their records of the number and the nature of insured risks. They simply cannot explain this remarkable increase except by invoking the initial phases of global warming as the cause. Munich Re, one of the largest re-insurers has estimated total annual losses from large disasters, insured and uninsured, over the past few decades. Losses were running at $3 - $4 billion per year in the 1960s, $7 billion per year in the 1970s, and $12 billion per year in the 1980s, with a large increase in 1988 and 1989 and in the first three years of the 1990s. During the early 1990s, losses have been running at $40 - $50 billion per year, more than ten times those of the 1960s. These figures are in constant dollars.

These changes could be thought by some to be primarily due to earthquakes and volcanoes. The U.S. Office of Disaster Assistance categorizes disasters by type. In the period 1964-89, only two percent of people affected by disasters were victims of geophysical disasters, whereas more than 90 percent were affected by hydrometeorological disasters, i.e., ones that will be affected by climate change. The numbers of people dying in disasters are, however, about equal for (a) droughts, (b) geophysical causes, and (c) flood and storm disasters.

Some of this increase in loss is due to global change in its broadest sense. For example, many regions have experienced an increase in flood frequency because of increased paving of suburban watersheds and reductions of forest cover. In a watershed near Hamilton, Ontario, the hydrologic effects of urbanization changes have been measured. Runoff increased from 10 percent of precipitation to 43 percent, which creates much greater flash flood potential. Similar experience with removal of forests from watershed slopes and increased urbanization has been noted in many river basins in the world, which causes increased flood frequencies.

A scientific debate rages about tropical cyclones. On the one hand, such destructive storms occur and maintain themselves only over ocean areas with surface water temperature greater than 26^{o}C. The theoretical intensity of such storms is greater with higher sea surface temperatures since they are driven by the latent heat of condensation. On the other hand, the General Circulation Models (or Global Climate Models) tend to show development of a greater stability in the tropical atmosphere with global warming. Experts in the field are thus reluctant to make predictions of future intensity and frequency of tropical storms. However, it seems highly likely that as sea surface temperatures rise, the average position of the 26^{o}C isotherm will be pushed further north and south from the equator, which will result in a greater geographical range of these devastating storms.

In eastern North America, severe storms that travel up the eastern seaboard, of both tropical and non-tropical origin, are an often disturbing fact of life. Most likely, those of tropical cyclone origin will increase in frequency in New England and the Atlantic Provinces.

But it would be wrong to conclude that the increased disaster losses (cited earlier) are due mainly to an increase in frequency or severity of tropical storms. The statistical data are very ambiguous. An examination of Hurricane Andrew in 1992 indicates that a major factor involved in increasing losses was change in development patterns. The population of the Florida coastal counties, which was 1 million people by about 1940, was nine times that by 1985. Thus, the exposure of populations, their buildings and infrastructure has increased enormously, which turns nature's hazards into great disasters. Zoning to limit construction in hazardous zones, and strong building codes were either not present or not enforced. But, at the same time, loss of life in hurricanes in the U.S. has continued to fall, because warning and emergency preparedness systems continue to improve. Similar situations to Florida's are evident in many others parts of the world. The slow rise in mean sea level of the past century and the projected increase in the rate of sea level rise due to global warming will only make storm surges and wave damage from storms worse as time progresses.

In 1989, the U.N. General Assembly recognized that:

1. natural disaster losses are increasing world-wide at an alarming rate; and
2. where warnings, preparedness and long-term preventive measures have been taken, losses in both human and economic terms can be drastically reduced.

To promote the widespread use of disaster adaptation knowledge, the U. N. General Assembly declared the 1990s as the International Decade for Natural Disaster Reduction (IDNDR). The targets proposed by the Scientific and Technical Committee for IDNDR, and accepted by the General Assembly, call for all countries by the year 2000, as part of their plans to achieve sustainable development, to have in place comprehensive assessments of risks from natural hazards, and long-term and short-term mitigation plans, and to have ready access to warning systems and prompt dissemination of warnings.

As an important means of adapting to climate change, as well as natural extremes of climate and weather, the states and provinces in this region would do well to re-examine their disaster management systems. For longer-term loss prevention, are adequate land use zoning setbacks and building standards in place and enforced? Is there a good system for dissemination of storm and flood warnings, and are emergency preparedness plans well organized? Is there an adequate public awareness program? These are truly "no regrets" climate adaptation measures that will be of major benefit even within normal climate variations, but will be even more beneficial if the projected climate change does result in more extreme events.

The second aspect of adaptation measures is to make the connections between research studies of the impact of climate change and the adaptation options that arise from such studies. Most investigations to date around the world have been sectoral studies. For example, there are studies of the impacts on water resources, on the ski season, on agriculture and so on. In a few countries, more comprehensive and complex approaches are underway. These are studies of the climatic effects on many aspects of a regional economy, and of the various change factors at work. The question asked is, "Given all the likely changes over the next five or six decades in this region, what difference would climate change make?" Canada has two major studies of this type

underway: one in the Mackenzie Basin in Northwestern Canada, and the other, jointly with U.S. colleagues, in the Great Lakes/St. Lawrence Basin. Let me illustrate with the latter case.

Some earlier sectoral studies in both the U.S. and Canada have suggested major impacts of climate change on water quantity and quality in the Great Lakes/St. Lawrence Basin. With higher temperatures and little change in precipitation projected by most of the Global Climate Models for the basin, the increased evaporation would result in much lower flows of connecting channels and declining lake levels. Adverse effects on hydro power production at Niagara and on the St. Lawrence, on shipping, and on water quality on the Great Lakes and St. Lawrence would result. The importance of considering other changes, however, such as more intensive land use and urbanization of the basin, should lend a note of caution to these projections. For example, data for Lake Erie indicate a progressively higher percentage of the total basin precipitation since the 1920s appears as runoff to the lake due to basin land use changes. While global warming projections may be correct, the final effects on various economic sectors will depend upon many other changes as well.

The Great Lakes/St. Lawrence Basin Study involves not only the many other physical interactions, but the socio-economic interactions as well. Not only are the usual physical resource impacts being assessed, but effects on human and ecosystem health are priorities in the study. The study will use econometric models of the basin, or parts of it, to assess economic changes caused by climate change. Such comprehensive studies will allow development of much more realistic, and politically compelling, adaptation options.

Limitation measures

While much of the debate on limitation measures has been in international fora, the actual design and implementation of appropriate measures will rely strongly on state, provincial, and local actions. Since the Rio Earth Summit in June, 1992, (the U.N. Conference on Environment and Development), much of the focus of the international debate has been on implementing the Framework Convention on Climate Change. While falling short of some expectations, the Convention signed by 154 nations in June 1992, including Canada and the U.S., and now in the ratification process, has three important provisions. Firstly, the industrially developed countries made specific commitments to stabilize emissions of carbon dioxide (CO_2) at 1990 levels by the year 2000. Secondly, "the ultimate objective" is enunciated to stabilize atmospheric concentrations (not emissions) of greenhouse gases at a level that does not result in dangerous human-caused interference with the climate system. Thirdly, after ratification, the Conference of the Parties to the convention will begin to meet, probably by early 1995, and will review the adequacy of the present level of commitment to emission controls. Preparatory work to this end is going on within the continuing International Negotiating Committee, and is supported by technical studies underway in the three working groups of the Intergovernmental Panel on Climate Change.

Recently, the Clinton Administration welcomed the review of the adequacy of presently committed emissions controls and acknowledged the possible need to take further action "which may include the adoption of amendments." (U.S. Representative Ambassador Madelain K. Albright, to the Intergovernmental Negotiating Committee in March 1993.) President Clinton has

reaffirmed the commitment to emission stabilization by 2000, at 1990 levels, as has the Canadian Minister of Environment.

Whether these initial commitments can be achieved without serious economic losses, and whether a stabilized atmospheric concentration in a reasonable time frame is a realistic possibility has been widely debated. A global assessment of the available knowledge on these matters, i.e., the social and economic dimensions of climate change, has been assigned to a reorganized Working Group III of the Intergovernmental Panel on Climate Change, which has just begun its work. Global and regional costs of emission reductions or of inaction, allowing global warming to proceed, are to be estimated by the international group. The Working Group must consider questions of equity between North and South and the impacts of possible response options on both oil and coal exporting and importing countries. Its major report is due in 1995.

In the light of the latest assessments of the Intergovernmental Panel on Climate Change in its update report of 1992 and the goals of the Framework Convention on Climate Change, what are the contributions to climate forcing of the various atmospheric contaminants and what limitation strategies should be considered?

One analysis (Wigley 1992) conducted at East Anglia University indicated that the impact of sulfate aerosols has been to depress or mask the global warming effect. This effect nearly balances the combined radiative forcing (that is, solar heat retention) effects of methane (CH_4), nitrous oxides (N_2O) and the halocarbons (CFC's, etc.). From this perspective, the increase in radiative forcing due to CO_2 increases has been by far the most important. Therefore, reduction of CO_2 emissions and the possibility of greater CO_2 removals from the atmosphere has been the main focus of limitation strategies. However, methane emissions are significant contributors to greenhouse gas forcing of climate and require attention.

The economic sector that has received the greatest attention in limiting greenhouse gas emissions has been the energy sector. While the energy sector accounted for a little more than one-half of the greenhouse gas increases in 1990, by 2025, it will be responsible for two-thirds of the increased radiative forcing, through CO_2 emissions, about 20 percent of methane emissions and most of the nitrous oxides.

While these emissions have grown enormously in the past decades, they will in future increase at exponential rates if a "business as usual" approach is adopted. If no deliberate actions are taken to reduce emissions, global emissions would be expected to increase from 5.15 billion tons of carbon in 1985 to 12.54 billion tons by 2025, a 240 percent increase. Projected increases in North America with no policy intervention would be about a 180 percent increase from a very large base. Per capita CO_2 emissions from the energy sector in North America are more than 20 times those of South and East Asia and are projected to remain more than 12 times those of this part of Asia, even with the very rapid economic growth projected for the Asian countries. This disparity is a source of major concern by developing countries, who are being asked to take steps to steer their development into low emission pathways.

Reducing greenhouse gases

What steps can then be taken, and at what costs, to lower North American dependency on fossil fuels and to reduce contributions to the global burden of greenhouse gases? The two most obvious steps are to increase efficiency of energy use and to move away from heavy dependency on coal, oil and gas for energy. Macroeconomic modelers often model the system to calculate the likely impact of a carbon tax on reducing emissions and on the economy. Quite large taxes, of the order of more than $100 per ton of carbon, are estimated by some analysts to be needed if significant reductions in energy uses are to be achieved. On the other hand, the World Bank estimates that a $25 per ton carbon tax would be enough to encourage significant substitution of non-fossil fuels and renewable technologies. Some macroeconomists also estimate that a substantial carbon tax would reduce gross domestic product (GDP) by one to two percent. Other studies indicate that whether GDP is depressed or increased by a carbon tax depends upon the uses to which the tax funds are allocated. For example, allocation to reduce business taxes may give a significant boost to the GDP if most of the tax savings are re-invested. Other studies argue that GDP is a completely inadequate index to use for such evaluations, because it does not properly value environmental benefits or pollution control investments.

The economic benefits of pre-venting or reducing global warming have also been estimated by some economists. For example, Pearce and Fankhouser (1992) estimated very recently that the sum of all impacts from damages due to a doubled CO2 climate projection are of the same order as some cost estimates, one to two percent of world GDP. They point out, however, that damages would average twice this for developing countries. All of these estimates make little or no allowance for potential increases in severity and frequency of natural disasters, nor do they contemplate potential nasty surprises, *e.g.*, a re-routing or changing of the Gulf Stream or a collapse of the Antarctic Ice Sheet, remote but possible events.

Set beside these broad macro-economic analyses, so called "top-down" approaches, have been a number of engineering oriented, or "bottom-up," studies of the benefits of energy efficiency and fuel substitution technologies. A number of these have been done in both United States and Canada, and in many other countries. They all show that significant reductions in CO_2 emissions can be achieved at no net costs, or, even net benefits, to national economies if barriers to introduction of such technologies can be overcome. One recent potential energy efficiency study by Peat Marwick for Energy, Mines and Resources, Canada, was bound by quite severe assumptions about the technologies that could be considered. They had to be both available now and available in Canada. This study concluded that energy demand and CO_2 emissions could be reduced by 6-8 percent by 2005, relative to 1988 at no net cost, as compared to increasing by 15-28 percent as in various projections. If small investments were made, reductions of the order of 30 percent may be achievable.

How could such fuel and cost savings be achieved? The measures include improved lighting efficiency with much greater penetration of compact fluorescents, reduced energy consumption of appliances, more efficient cars, better building insulation, better windows, and many energy savings in various industries. For electrical energy, one of the best ways to overcome the barriers, especially of initial capital investments, against achieving these economical and environmental benefits is to encourage or regulate utilities to practice demand side management.

For the transportation sector, a return to slowly improving corporate-average-fleet efficiency (CAFE) standards in the inter-linked U.S.-Canada automotive industry would appear from past history to have major benefits.

If the initial obligations of the U.S. and Canada under the Framework Convention on Climate Change could be largely met by energy efficiency measures, fuel substitution is probably the longer term pathway. Costs of renewables are rapidly falling. Solar energy, photo-voltaic and solar thermal, wind, and biomass energy will be competitive by early next century with coal-based power (at approximately five cents per kilowatt hours in U.S.). They are much cheaper than natural gas peaking power, now. Nuclear power remains a promising alternative, but recent cost problems will probably slow further penetration. Hydro- electric power, especially small hydro, may be able to fill an important niche when built close to consumption and with little environmental damage. Small hydro may be especially attractive for communities in New England and adjacent Eastern Canada. Many economists urge that the very large subsidies of various kinds provided for fossil fuel exploration and development in both the U.S. and Canada be removed to provide a more level playing field for development of renewables.

Reducing CO_2 emissions by reducing energy demand and fossil fuel use has other environmental benefits as well. In Canada, more than 40 percent of acid rain causing sulfur oxide emissions, 65 percent of toxic lead emissions, 23 percent of mercury emissions, and most of the nitrous oxides come from energy production and consumption.

Methane emissions, on a global basis, come substantially from agriculture, especially rice cropping. Recent studies do suggest that this is not as large a source as once thought. However, in North America, one of the major sources is landfill sites. In Canada, this source of methane is more than double that of large animals, the second largest source. World-wide, landfill sites are 5-6 times as great a source of methane in developed as in developing countries. Much could be done locally and regionally to reduce emissions from such sites.

Briefly, I will consider the question of sequestering more greenhouse gases, especially CO2, from the atmosphere. One must consider the benefits of reforestation and afforestation. (Sequestering involves storing the gases in some non-atmospheric form.) Growing trees will, of course, absorb substantial quantities of CO2, at least for their first thirty years of life. The regional average costs of appropriate forest management measures in the U.S. is estimated at about $20 per ton of carbon sequestered, 250 percent of the cost in tropical regions, and about equal to the estimate of climate change damages due to one ton of carbon (Pearce and Fankhouser). To move towards the longer-term goal of the Framework Convention on Climate Change, *i.e.*, stabilization of greenhouse gas atmospheric concentrations, hopefully at less than a doubling of CO_2, a mix of the above strategies and a long-term odyssey towards energy efficiency and fuel switching will be required. One approach would be to reduce net CO_2 emissions by one percent to two percent per year over a thirty-year period. The sooner such a course is embarked upon, the lower will be the stabilized atmospheric concentrations achieved.

The early technological advantages in energy substitution and efficiency measures held by Canada and the U.S. have largely been lost, with a major decline in research and development devoted to energy efficiency over the past decade. There are, of course, a few successes. For

example, President Clinton in his Earth Day Speech of April 21, 1993, noted that "American companies sell over $500 million worth of long-lasting energy-saving light bulbs with sales expected to reach $10 billion by the year 2000 creating thousands of new jobs." The potential European Community market for renewable technologies over the next two decades has been estimated at $240 billion. This presents a remarkable opportunity. It appears possible to help meet North America's world obligation, to help protect the global environment and climate, and to create jobs doing it.

Regional and local policy options

What can or should be done within Eastern Canada and the northeast U.S.? Let me summarize the six main implications for possible action:

1. To reduce disaster losses, each state, province and community should examine its progress towards meeting the three targets of the International Decade for Natural Disaster Reduction: comprehensive assessment of risks, long and short term mitigation measures, and good warning systems.
2. Research support should be given to regional, second generation, climate impact studies that lead to adaptation strategies, such as the U.S.-Canada Great Lakes/St. Lawrence Basin Study.
3. Energy efficiency measures should be encouraged through public information, regulation of utilities and other means.
4. Barriers to introduction of non-fossil fuel technologies should be removed, and research and development supported on efficiency and alternative technologies.
5. Companies should be encouraged to exploit such technologies for both domestic and export markets.
6. Forest management practices that lead to net afforestation should be pursued.

Although these six steps would all contribute effectively to the issue of climate change, they also produce other benefits. In the provinces and states of this region, some of these approaches have already been initiated. I urge similar actions and a broadening of the range of initiatives in all jurisdictions and in the private sector.

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