leadership to make it possible to avoid the catastrophes of climate change and a global warming. This resolve was indicated more than a year ago. It should not be lost. The cause of hesitation is not scientific uncertainty. The cost of the countermeasures lie at the root of the hesitation.

There are no specific calculations of the response costs, but they may run up to billions of dollars. However, this should be seen as an input in the development of national economies and as an integral part of the overall development of societies.

The cost of inaction may rise even higher. As yet there are no calculations of what will be the costs of lost revenues, food shortages, loss of forests and agricultural land as well as destruction of human, animal and plant habitats. Human life and misery cannot be measured in monetary terms. New environmental refugees fleeing from lost arable land, destroyed habitation, and sea level rise may cause unforeseen social instability and lead to conflicts between and among nations. These costs may be much greater than the cost for action.

Representatives of some 140 governments agreed at the Second World Climate Conference that lack of full scientific evidence should not postpone action. Our policies should be based on prevention and precaution.

We have to understand that we are not negotiating arrangements dealing with environmental issues or the sustainable use of natural resources. We are working out a new regime which will not leave untouched our basic production and consumption patterns. We are considering the bases of global economic development. Changes will be required in our energy policies, forest management, agricultural policies and transportation. Prices, in particular energy prices, need to be reconsidered and the environmental costs included. Economic instruments have to be developed in order to avoid trade distortions.

No government wants catastrophe or uncontrolled change. Recent developments in the Middle East and Europe indicate that our international economic, political and ecological systems are vulnerable. We should work with determination for a controlled change which strengthens our economic, ecological, social and political security.

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Chapter Thirty-Seven

A CANADIAN PERSPECTIVE ON CLIMATE CHANGE*

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INTRODUCTION

In most parts of Canada, winters are long and cold. In Toronto, the average dates of the first and last “killing” frosts are October 5 and May 8, respectively. The average growing season is therefore only 149 days, and in many other regions of the country, it is much less. Whatever the adverse effects of climate change elsewhere, it is clear that for Canada, at least, there will be some mitigating benefits and opportunities as well as costs and risks. As might be expected, therefore, there are some members of the Canadian public who welcome the prospect of warmer weather. In 1990, 3 out of 10 Canadians polled believed that climate change would involve a net benefit for Canada (Standing Committee, 1991). At a scientific meeting in Windsor, Ontario, it was reported that the climate of southern Ontario may come to resemble that of Kentucky (Sanderson, 1988). The prospect is hardly displeasing. After all, short winters, blue grass, racehorses, and bourbon are by no means symbols of hardship, privation, or environmental destruction.

*The authors are solely responsible for the views expressed in this paper, which do not necessarily represent the position or views of the Government of Canada.
Nevertheless, the overwhelming weight of scientific opinion in Canada and elsewhere is that the net effects of climate change will be negative for Canada, and perhaps extremely detrimental (Standing Committee, 1991). Just how severe the effects may be, it is not possible to say with confidence but a series of impact studies by the Canadian Climate Centre has shown that some major costs are likely. The costs, benefits, and their causes vary regionally: sea level rise will be a main agent of change in the Atlantic region while changes in temperature and precipitation will cause most of the impacts expected elsewhere in Canada.

THE COSTS OF CLIMATE CHANGE IN CANADA

Well over 100 communities in the four Atlantic provinces are at some risk of flooding from sea level rise; Charlottetown, Halifax, and four other municipalities will require extensive protection to avoid serious damage (Stokoe, 1987; P. Lane, 1986). Although some communities on the Pacific coast, including Vancouver (Smith, 1989) but not including the important Fraser Delta, may be less vulnerable to flooding than those on the Atlantic coast, there will probably be an increase in winter precipitation, resulting in more frequent landslides and floods (Canadian Climate Program Board (CCPB), 1991).

Climate change will have a direct impact on Canada’s natural resource base, and this impact is likely to be negative. Natural resource industries account for a large share of the Canadian economy: agriculture is an important activity in most provinces, especially on the Prairies, and forestry accounts for almost as much export revenue as fisheries, mines, agriculture and energy put together. One of Canada’s most valuable assets is its abundance of rivers, lakes, and marine systems, providing water supply for consumption, agriculture, and hydro-electricity production. The impacts on agriculture, forestry, water resources, and hydro-electricity production in Canada, among others, have been estimated and are discussed below.

Climate change is likely to have a profound effect on Canada’s agricultural productivity and potential. While warmer temperatures and a longer growing season will enhance production potential in northern arable areas, production in the south, the current agricultural zone in Canada, may well be constrained by increased water stress and probability of drought (Arthur, 1986; Williams, 1988; Land Evaluation Group, 1985, 1986). Canadian forest resources may also be hard hit by climate change. Warmer temperatures and water stress will cause existing forest zones to shift northward; it is likely that forest area will be lost because die-out in the southern fringes of existing forest zones will occur faster than migration of new forests to replace them (Intergovernmental Panel on Climate Change, 1990). In fact, it has been suggested that the boreal forest zone in Canada may completely disappear west of James Bay (Rizzo, 1990). This will be exacerbated by an increased probability of forest fires in dry areas as well as by increased activity of pests and diseases (CCPB, 1991; Wheaton et al., 1987). Climate change will affect Canada’s water resources from both the demand and supply sides: increased temperatures will, other things being equal, induce greater consumption of water and will also increase evaporation (which may be nullified in some areas by increased precipitation) (Hove, 1986). Warmer temperatures and reduced stream flow may create anoxic conditions in some rivers and lakes and may increase pollution concentrations. A positive potential effect of climate change will be the reduction of sea and lake ice; it will facilitate expansion of shipping and transportation in the Great Lakes and Atlantic and Arctic Oceans as well as reduce the costs of offshore oil operations (Stokoe, 1987; CCPB, 1991; Hove, 1986). Impacts on hydro-electric energy production will vary from region to region, but it has been estimated that production at James Bay and Labrador plants will increase (Stokoe, 1987; Singh, 1988); this energy could be exported to areas, like the Great Lakes region, which experience a decrease in production (Hove, 1986).

Unfortunately, many of the impacts of climate change in Canada are unknown, or are highly uncertain. The information cited above is the result of several excellent impact studies; however, these studies are only useful first approximations of what Canadians should expect because they have typically focused on one or a few sectors in one particular region. Moreover, the studies have large uncertainties and are largely qualitative, primarily due to the lack of reliable climatic and economic forecasts. These studies have also concentrated on changes in climate means rather than climate variability or extremes.

CANADA’S COMMITMENT TO LESS DEVELOPED NATIONS

While the net costs for Canada may be considerable, they are likely to be much lower than for many other countries, especially some of the developing nations with large low-lying deltas (Egypt, Bangladesh, Vietnam, etc.) and the small island states. In addition to costs incurred in Canada, therefore, it is expected that Canada will also contribute to the international effort at mitigation of this global threat, perhaps by expanding assistance to developing countries on a direct bilateral basis and/or participating in international financial agreements. As an example of Canada’s commitment, the government of Canada has already pledged $1 million to enable developing countries to participate in understanding climate and climate change.

It is feared that a larger contribution to global greenhouse gas emissions will come in the future from countries such as India and China as they expand and accelerate their development, using domestic coal reserves. Canada is also a coal-rich nation, and one area where Canada may be of particular help in solving the problem of global warming is in the development and transfer to China and India of “clean coal” technology to reduce emissions of CO₂ from coal and to improve its efficiency in use.

CANADA’S CONTRIBUTION TO GREENHOUSE GAS EMISSIONS AND LIMITATIONS

In developing its policy on global warming and greenhouse gas emissions, Canada, like other nations, must take its own circumstances into account. Canada is a high
energy user. In fact, it has the highest per capita and per unit output levels of energy use of the major developed countries. There are three reasons for this. First, as previously mentioned, the climate of Canada is cold, which means that proportionally more energy must be used for space heating in Canada than in warmer regions. Second, the low density and scattered distribution of Canada's population mean that Canadians have high transportation requirements; until there is stronger penetration of alternative fuels in the energy market, fossil fuels will continue to be virtually the only fuels used for transportation in Canada. Third, and most importantly, Canada has large fossil fuel reserves as well as excellent hydroelectric sites. Because Canada is also rich in natural resources, it has been economically attractive to carry out primary processing of those resources, especially minerals, in Canada; these processing industries are more energy-intensive than other industries and have helped to create an energy-intensive economy. The abundant supply of fuel reserves at relatively low cost in Canada has also, until recently, served to encourage high consumer use of energy. Improvements in energy conservation and efficiency in Canada have been identified by many people as the least-cost method to reduce greenhouse gas emission levels in the short term.

Fortunately, the carbon content of Canada's energy use is lower than that for many other nations, because of the importance of hydroelectric and nuclear sources in Canada's energy use mix (the provinces of Ontario, New Brunswick, and Prince Edward Island depend on nuclear fuel for a significant portion of their energy requirements, and hydroelectricity supplies more than 50 percent of the energy needs of Newfoundland, Quebec, Manitoba, and British Columbia). Canada contributes 2 percent of the total global emissions of carbon dioxide, and, of the OECD countries, contributes the fifth highest total CO₂ emissions, and ranks second and eighth in terms of CO₂ emissions per capita and per unit of GDP, respectively (OECD, 1991).

Canada's shares of world emissions of the other important greenhouse gases are similar. Canada's share of nitrous oxide and methane emissions is estimated to be between 1 and 2 percent; its share of CFC emissions is about 2 percent. Canada ranks ninth and fourth out of the OECD countries in terms of total and per capita greenhouse gas emissions, respectively (OECD, 1991). Tables 1 and 2 provide a ranking of the top ten greenhouse gas emitters among the OECD member countries.

Both government and industry in Canada are committed in principle to controlling greenhouse gas emissions. Canada is a signatory to the Montreal Protocol on Substances That Deplete the Ozone Layer, and under that Protocol, has committed itself to fully phasing out CFC production and new consumption by 1997 (which is actually 3 years earlier than the date prescribed in the Protocol). At the Second World Climate Conference, Canada committed itself to stabilizing its greenhouse gas emissions at 1990 levels by the year 2000 (Government of Canada, 1990). Ultimately, the large proportion of energy-intensive industry in the Canadian economy (as well as the geographical and climate factors mentioned above) implies that further emissions restrictions might have a damaging effect on Canada's competitive position if they were taken on a unilateral basis. Eric Haite, who has extensively analyzed Canada's opportunities to reduce CO₂ emissions, stated that the World Conference on the Changing Atmosphere (Toronto Conference) goal of reducing emissions to 80 percent of 1988 levels by 2005 "can be achieved in Canada, but only by doing everything technically possible to reduce carbon dioxide emissions. It is a very ambitious target." (Haite, 1990).

There is scope within Canada to limit emissions through the development and commercial application of low-carbon fuels, such as natural gas and "clean" coal, and alternative fuels, such as hydroelectric, nuclear, and renewables as well as through improvements in energy use. Ontario Hydro, the government-owned utility which supplies electricity to the province of Ontario, estimates that it will need to build three new nuclear power plants, at a total cost of $15 billion, in order to supply forecasted electricity demand (in the year 2005) and observe the 20% reduction in

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**TABLE 1**

<table>
<thead>
<tr>
<th>Country</th>
<th>Emissions per Unit GDP (kg/$1000 US, 1985)</th>
<th>Emissions Per Capita (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>428</td>
<td>United States 5.8</td>
</tr>
<tr>
<td>Australia</td>
<td>404</td>
<td>Canada 4.8</td>
</tr>
<tr>
<td>Ireland</td>
<td>392</td>
<td>Australia 4.3</td>
</tr>
<tr>
<td>Netherlands</td>
<td>380</td>
<td>Finland 3.7</td>
</tr>
<tr>
<td>Belgium</td>
<td>370</td>
<td>Netherlands 3.4</td>
</tr>
<tr>
<td>United States</td>
<td>324</td>
<td>Denmark 3.4</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>317</td>
<td>Belgium 3.2</td>
</tr>
<tr>
<td>Canada</td>
<td>316</td>
<td>West Germany 3.2</td>
</tr>
<tr>
<td>Spain</td>
<td>302</td>
<td>United Kingdom 2.9</td>
</tr>
<tr>
<td>Finland</td>
<td>302</td>
<td>Sweden 2.5</td>
</tr>
</tbody>
</table>


**TABLE 2**

<table>
<thead>
<tr>
<th>Country</th>
<th>Emissions per Unit GDP (kg/$1000 US, 1985)</th>
<th>Emissions Per Capita (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>1375</td>
<td>Australia 11.0</td>
</tr>
<tr>
<td>Portugal</td>
<td>1231</td>
<td>United States 10.0</td>
</tr>
<tr>
<td>Greece</td>
<td>1200</td>
<td>New Zealand 9.3</td>
</tr>
<tr>
<td>Turkey</td>
<td>1132</td>
<td>Canada 9.2</td>
</tr>
<tr>
<td>Ireland</td>
<td>1037</td>
<td>Norway 8.5</td>
</tr>
<tr>
<td>Australia</td>
<td>1035</td>
<td>Netherlands 6.4</td>
</tr>
<tr>
<td>Spain</td>
<td>709</td>
<td>Ireland 5.9</td>
</tr>
<tr>
<td>Netherlands</td>
<td>705</td>
<td>Denmark 5.8</td>
</tr>
<tr>
<td>Canada</td>
<td>608</td>
<td>Finland 5.5</td>
</tr>
<tr>
<td>Belgium</td>
<td>604</td>
<td>United Kingdom 5.4</td>
</tr>
</tbody>
</table>

*Carbon dioxide, methane and CFCs; measured in Equivalent Carbon Dioxide Heating Effect.

CO₂ emissions recommended at the Toronto Conference (Ontario Hydro, 1989). According to another analysis, economically attractive measures to limit CO₂ emissions in Canada as a whole would reduce emissions by just under 12 percent of 1988 levels by 2005; these measures would also provide a net benefit (after recovery of the necessary investment) of $108 billion from energy savings (Haites, 1990).

In fact, the Canadian Petroleum Association, the Canadian Gas Association, and the Coal Association of Canada, which represent most enterprises involved in their respective industries, have each acknowledged the problem of global warming and have expressed that they are committed to research and policy to help ameliorate it (Government of Canada, 1989). Global warming may indeed represent an excellent trade opportunity for the Canadian energy sector: it is in the interest of the companies and associations involved to develop "cleaner" technologies, or commercialize existing technologies, and commercialize alternative fuels, because that technology can then be sold abroad, and, as mentioned earlier, transferred to countries like China and India. A good deal of valuable work in this area has already been undertaken by the industry itself.

DIRECTIONS OF RESEARCH AND POLICY IN CANADA

The National Action Strategy on Global Warming has been proposed by the Canadian Council of Ministers of the Environment as a framework for policy response to the issue. The National Action Strategy has three aspects: emissions limitation, adaptation to climate change, and reduction of the uncertainty of climate change through scientific research. Measures suggested by the proposed National Action Strategy to reduce greenhouse gas emissions include energy efficiency improvements, development of alternative forms of fuel, reforestation, dissemination of information to Canadians on how to lower their energy consumption, and reduction of emissions from agriculture (for instance, through measures to stabilize and increase the organic content of soil to reduce CO₂ levels in the atmosphere) (Canadian Council of Ministers of the Environment, 1990). The federal government has proposed new legislation in the form of the National Energy Efficiency and Alternative Energy Bill. The Bill specifies minimum efficiency standards and requires efficiency labelling for equipment which is traded across provincial and national borders, and provides for expansion of the National Energy Use Database (Government of Canada, 1991). A program, called Energuide, is already in place to label home appliances according to their energy efficiency. The federal government has also instituted a program to plant 325 million trees in Canadian communities over the period from 1991 to 1996 (Government of Canada, 1990).

The National Action Strategy pledges to assist Canadians "anticipate and prepare for the potential effects of any warming that might occur" (CCME, 1990). To fill in the gaps not yet covered by the Canadian climate change impact studies thus far undertaken, the National Action Strategy provides for three five-year multidisciplinary projects to assess the socio-economic impacts of climate change in the Great Lakes and St. Lawrence River Basin, the Prairies, and the MacKenzie River Basin (CCME, 1990). In addition, guidelines to be developed will ensure that the implications of climate change are considered in major projects (Government of Canada, 1990). Finally, the government will determine, by 1996, policy changes that may be needed to deal with a rising sea level at both the Atlantic and Pacific coasts of Canada (Government of Canada, 1990).

As outlined in the Green Plan, the federal government's central environmental policy package, and the proposed National Action Strategy, the Canadian government is increasing its commitment to research on global warming. In addition to the three five-year multidisciplinary projects, the government will publish annual reports on the state of the Canadian climate, operate a climate change detection network consisting of volunteer-run stations across all of Canada's climatic zones (to be in place by 1996), and initiate, by 1992, a national program of ocean research relating to climate change (Government of Canada, 1990).

The Canadian Climate Centre has, in addition to undertaking the climate change impact studies mentioned above, developed a General Circulation Model (GCM). It is one of three second-generation models in existence; it has higher spatial resolution as well as more accurate simulation of oceanic and sub-ice transport and optical feedback effects than earlier models (Canadian Climate Board, 1991). The Canadian Climate Board has also recommended that the Canadian Climate Centre GCM be augmented by a supercomputer and dedicated staff, but allocation of funds to this end is pending (CCPB, 1991). Canada continues to contribute substantially to international research on climate change.

PARTICIPATION OF ALL CANADIANS IN LIMITATIONS AND ADAPTATIONS

The National Action Strategy is a draft agreement for discussion and adoption. It proposes the full participation of all the provincial, territorial, and municipal governments as well as the private sector, environmental organizations, and citizens' and aboriginal groups (CCME, 1990). As jurisdiction over environmental issues is shared between the federal government and the provincial and territorial governments, the Government of Canada cannot unilaterally achieve a stabilization of greenhouse gas emissions. Furthermore, Canadian citizens, environmentalists, and aboriginals are important stakeholders in the climate change issue, and are insisting on full participation in determination of Canadian policy on the issue. Participation of such groups and organizations will help to ensure that the policy is effective, once it has been agreed upon. It is also understood that the majority of emissions reductions and adaptation strategies will be undertaken by the private sector. The National Action Strategy seeks to encourage private sector support by providing information to and asking for input from firms and individuals. Moreover, national and provincial Round Tables on Economy and Environment have allowed for interaction between government and the private sector on environmental issues (Government of Canada, 1990).

Since a changing climate means that past climatic norms will not be an accurate
guide to the future, the Climate Change Adaptation Branch has been established within the Canadian Climate Centre. The Branch is endeavouring to determine how Canadians can best adapt to changes in climate, climatic variability and extreme events. This information, along with climatic data for any area of Canada, will be transmitted to Canadians for use in investment and other decisions in which weather events and norms play a part.

CONCLUSION

Despite the cold climate of Canada, global warming is a cause for concern for most Canadians. Canada contributes to the international effort to ameliorate and understand the effects of climate change and has taken a large step towards domestic policy on the issue. These efforts will continue in some or all of the following directions. As high energy users, it is important that Canadians consider how to constrain their consumption of energy. Research and development activities toward this end have been undertaken in the private sector and are encouraged by governments. As a member of the world community, Canada will continue to play a role in negotiations for a Framework Convention on Climate Change. Existing information on the impacts of climate change in Canada is more qualitative than quantitative and certainly falls well short of what is needed. There is a role for adaptation to climate change and variability and to do this Canadians need to have the information necessary to incorporate climate variables into investment and operational decisions.

It is expected that, through the National Action Strategy, effective decisions will be taken to deal with climate change. If they are to be truly effective, such decisions will necessarily reflect the concerns of all groups and governments within and, to some extent, outside of Canada. In her book, Survival, Canadian author Margaret Atwood said that the essence of Canadianism is endurance and that survival is a Canadian’s idea of epic achievement. Climate change, as distinct from the harshness of today’s climate, is a threat to Canadian well-being; Canadians are already closely investigating what can be done now, in terms of adaptation and limitation responses, to mitigate the effects of this threat, and thus continue to be able to rely on Canada’s environment as an integral part of their lives and livelihoods.

REFERENCES


Chapter Thirty-Eight

UK POLICY ON CLIMATE CHANGE*

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THE GREENHOUSE EFFECT

The energy which drives our weather and climate comes from the sun. About a third of the energy that reaches the Earth is absorbed, heating the atmosphere, the oceans and the land. The warm Earth radiates infra-red energy back into space, but some of it is absorbed by gases in the atmosphere. This is similar to the effect of glass in a greenhouse, hence the gases involved are called the greenhouse gases, and the process known as the greenhouse effect. Greenhouse gases occur naturally in the atmosphere and keep the temperature of the Earth some 30°C warmer than it would otherwise be. Without them the Earth would be too cold to support life.

Water vapour is the most important natural greenhouse gas and its concentration depends on the Earth’s temperature. The other principal natural greenhouse gases are carbon dioxide (CO₂), methane, nitrous oxide and ozone. Their concentrations depend on the balance between processes which produce them and those which absorb them. Emissions resulting from human activities are adding to the production of these gases and at the same time reducing the sinks such as forests which absorb CO₂, so that atmospheric concentrations are increasing. In addition the chlorofluorocarbons (CFCs), powerful greenhouse gases, are entirely man-made.

The Inter-governmental Panel on Climate Change (IPCC) Working Group I on the science of climate change, chaired by the UK, brought together over 300 of the world’s leading scientists in this field, and reported in May 1990. Its report