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Canada's Second National Report on Climate Change

Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change

1997

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Canada

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AIJ	activities implemented jointly
APEC	Asia-Pacific Economic Cooperation
ARNEWS	Acid Rain National Early Warning System
bbl	barrel
BOREAS	Boreal Ecosystem Atmosphere Study
C_2F_6	carbon hexafluoride or perfluoroethane
CAFE	corporate average fuel economy
CANMET	Canada Centre for Mineral and Energy Technology
CAPP	Canadian Association of Petroleum Producers
CCCGCM	Canadian Climate Change General Circulation Model
CCS-CIA	Canada Country Study: Climate Impacts and Adaptation
CCTF-GE	Canadian Consultant Trust Fund for the Global Environment
CEC	Commission on Environmental Cooperation
CEIS	Canadian Environmental Industry Strategy
CEPA	Canadian Energy Pipeline Association
CES	Canadian Environmental Solutions
CETACs	Canadian Environmental Technology Advancement Centres
CF_4	carbon tetrafluoride or perfluoromethane
CFCs	chlorofluorocarbons
CGCP	Canadian Global Change Program
CH_4	methane
CIBS	Canadian International Business Strategy
CIDA	Canadian International Development Agency
CIPEC	Canadian Industry Program on Energy Conservation
CJII	Canadian Joint Implementation Initiative
cm	centimetre
CO	carbon monoxide
CO_2	carbon dioxide
CoP	Conference of the Parties
CTI	Climate Technology Initiative
EMAN	Ecological Monitoring and Assessment Network
EPA	Environmental Protection Agency
eq.	equivalent
FCCC	Framework Convention on Climate Change
FCM	Federation of Canadian Municipalities
GCM	general circulation model
GCOS	Global Climate Observing Systems
GDP	gross domestic product
GHG	greenhouse gas
GLSLB	Great Lakes–St. Lawrence Basin
GST	Goods and Services Tax

Gt	gigatonne
GWh	gigawatt-hour
GWP	global warming potential
HCFCs	hydrochlorofluorocarbons
HFCs	hydrofluorocarbons
HNO_3	nitric acid
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
K	thousand
kg	kilogram
km	kilometre
kt	kilotonne
kWh	kilowatt-hour
L	litre
LPGs	liquefied petroleum gases
m	metre
m^2	square metre
M	million
MBIS	Mackenzie Basin Impact Study
mcf	thousand cubic feet
MJ	megajoule
mm	millimetre
MOU	Memorandum of Understanding
Mt	megatonne
MW	megawatt
N_2O	nitrous oxide
NA	not applicable
NAFTA	North American Free Trade Agreement
NAPCC	National Action Program on Climate Change
NEUD	National Energy Use Database
NH_3	ammonia
NMVOCs	non-methane volatile organic compounds
NOx	nitrogen oxides
NRCan	Natural Resources Canada
O_3	ozone
OECD	Organisation for Economic Co-operation and Development
PERD	Program on Energy Research and Development
PFCs	perfluorocarbons
PJ	petajoule
ppbv	parts per billion by volume
ppmv	parts per million by volume
pptv	parts per trillion by volume
R&D	research and development
REEAC	Regional Ecosystem Effects of Atmospheric Change
SF_6	sulphur hexafluoride
SMEs	small and medium-sized enterprises
SO_2	sulphur dioxide
t	tonne
TPC	Technology Partnerships Canada
UQCN	Union québécoise pour la conservation de la nature
UV-B	ultraviolet B
VCR	Voluntary Challenge and Registry
ZEVs	zero-emission vehicles


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Executive Summary

In 1992, Canada and more than 150 other nations signed the United Nations Framework Convention on Climate Change (FCCC), which has as its objective for developed countries to aim to return net greenhouse gas emissions to 1990 levels by the year 2000. In 1994, Canada tabled its first National Report to the Conference of the Parties of the FCCC, outlining its responses to climate change. In 1995, Canada tabled its National Action Program on Climate Change (NAPCC), which outlined the strategic directions for governments and the private sector to address climate change science, greenhouse gas emission mitigation, and adaptation to climate change. This Second National Report, dated May 1997, provides an update of Canada's situation and responses to climate change, as required by the FCCC.

If climate change occurs to the extent predicted by current models, there will be a significant risk to Canada's environment, with potentially serious consequences for the health of the Canadian economy, particularly agriculture, forestry, and fisheries.

As a modern industrial nation, Canada depends on energy production, transformation, and consumption to maintain economic growth and meet the needs of its fast-growing population. Canada is also a northern country, with climate extremes, vast distances to cover, and a heavy dependence on energy-intensive natural resource development, most of which is destined for export to other countries. These unique features of Canada, and the relative importance that energy plays in Canada, help explain why emissions associated with energy use accounted for 89% of the country's greenhouse gas emissions in 1995. The balance of emissions arose from certain industrial, agricultural, and waste management processes. Energy's contribution to both the economy and greenhouse gas emissions necessitates that mitigative responses to the challenges of climate change adhere to the precepts of sustainable development. Canada's environment and economic interests both need to be protected.

Canada (i.e., federal, provincial, territorial, and municipal governments, the private sector, and other stakeholders) has made progress since 1990 in taking mitigative actions to reduce greenhouse gas emissions from the principal source, energy production and consumption. For example, in the secondary energy use sector (i.e., energy used by the final consumer), improvements in energy intensity have meant that despite an increase in energy consumption, primarily as a result of population growth and an expanding economy, carbon dioxide emissions were 3.5 percentage points lower than they otherwise would have been over the period 1990–1995. Nevertheless, growth in economic activity has meant that total greenhouse gas emissions from all sectors were about 9% higher in 1995 than in 1990, rising from 567 Mt of carbon dioxide equivalent in 1990 to 619 Mt in 1995, or about 2% of the world's total.

It is projected that Canadian greenhouse gas emissions will decline slightly from 1995 levels by the year 2000 but will remain above the 1990 stabilization level. Current response strategies will be offset by continued population and economic growth. When the NAPCC was tabled in 1995, it was projected that greenhouse gas emissions for Canada would be 13% higher in the year 2000 than in 1990. Progress is being made in lowering the projected "gap" to 8% by 2000, as a result

other forecasting assumptions. Most other industrialized countries, like Canada, are forecasted not to stabilize their greenhouse gas emissions at 1990 levels by the end of the decade.

Canada is continuing to take action in the areas of improving our understanding of the science of climate change, its potential impacts on the country, and how to address climate change through mitigative and adaptive responses.

Global climate change modelling suggests greater average warming trends over land than over oceans, in high latitudes than in low latitudes, and in winter than in summer. The projected rate of warming is from 0.1 to 0.45°C per decade, but this could be reduced to 0.1–0.35°C as a result of increases in aerosol concentrations. The average rate of global sea rise is projected to be between 1.5 and 9.5 cm per decade.

For Canada, most models project greater warming in interior regions than on the coasts and greater winter warming in the Arctic than in the south, with increased average winter precipitation across the country and decreased net soil moisture and water resources in the Canadian interior in the summer. The frequency and intensity of storms are also projected to increase. The confidence of model projections for regions is low, but to date they suggest net average warming for central and northern Canada of 4–6°C by 2050 and 3–4°C along the east and west coasts. Canada's agricultural, fishery, and forestry sectors could be adversely affected, as could human health and the nation's infrastructure. Canadians would face important socioeconomic repercussions should these changes materialize as predicted.

Canada has also been studying the tactical, strategic, and policy foundations for adaptive responses to climate change. It is currently conducting the Canada Country Study: Climate Impacts and Adaptation to further assess the impacts of climate change on the regions and sectors of the economy and to assess adaptive responses.

Canada is active in supporting international climate change research and actions under the FCCC. Especially important is the research, development, and dissemination of new technologies for greenhouse gas abatement through a number of multilateral and bilateral initiatives. Canada launched its program in support of the international pilot program on activities implemented jointly by opening the office of the Canadian Joint Implementation Initiative in 1996. Canada is also active in researching historical changes to the climate, modelling future climate scenarios, understanding greenhouse gas fluxes in the natural environment, and developing the necessary databases for scientific research and indicators to explain trends in energy use. As well, Canada plans to augment its activities with respect to public education and information on climate change.

The prospect of climate change and the need for measures to address it make this the preeminent global sustainable development challenge for decades to come. The problems of, and the solutions to, climate change are integral to the environmental, economic, and social well-being of all Canadians. Canada will continue to work both internationally and domestically to develop timely and appropriate responses to this challenge.

CHAPTER 1: Introduction

Climate Change

The atmosphere is essential for life on Earth. For more than three billion years, Earth's atmosphere has been shaped and modified by interactions with living things. Until the coming of the industrial revolution, however, human beings did not have much of an effect on these processes. Since then, human activities have resulted in increasingly significant changes to the composition of the atmosphere. In 1995, Canadians released an estimated 619 Mt of greenhouse gases (GHG) (on a carbon dioxide, or CO_2, equivalent[1] basis) into the atmosphere.

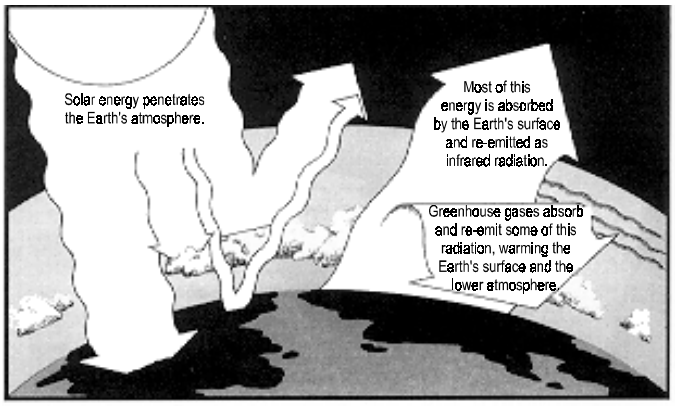

FIGURE 1.1 THE GREENHOUSE EFFECT

Heat-retaining greenhouse gases, such as water vapour, carbon dioxide, methane (CH_4), and nitrous oxide (N_2O), warm the Earth by allowing solar energy to reach the Earth's surface, where it is absorbed and re-emitted as heat. Greenhouse gases trap some of this heat in the atmosphere and prevent its escape into space (Figure 1.1). Known as the greenhouse effect, this heat-trapping process keeps the average temperature of the Earth at about 15°C. Without it, the average temperature would be -18°C, and life as we know it would not exist.

Numerous human activities have an impact on greenhouse gas emissions, but by far the most important is the combustion of fossil fuels, which contributed approximately 89% of Canada's total emissions in 1995. The combustion of fossil fuels for the production of electricity and for industrial use (including production of transportation fuels) generated about 54% of the greenhouse gas emissions in 1995, whereas the transportation sector generated 27%.

Land and water surfaces have a considerable influence on climate processes, absorbing and reflecting solar radiation and affecting the flow of air across the Earth's surface. Vegetation produces carbon dioxide through respiration, removes it through photosynthesis, and releases moisture through transpiration. In a balanced system, all removal of carbon dioxide by photosynthesis is offset by emissions through respiration and decay. Human activity has affected this precarious balance.

[1] In order to compare emissions of different gases, global warming potentials (GWPs) are used to develop carbon dioxide equivalent emissions (Table 3.2 in Chapter 3 summarizes current global warming potentials; IPCC, 1996).

TABLE 1.1 CHANGES IN CONCENTRATIONS OF KEY GREENHOUSE GASES SINCE PRE-INDUSTRIAL TIMES

Gas	Pre-industrial Concentration	Concentration in 1992	Concentration Change	Remarks
CO_2	280 ppmv	355 ppmv	19.64%	Increase is almost entirely due to human activities
CH_4	700 ppbv	1 714 ppbv	144.86%	Natural and anthropogenic causes
N_2O	275 ppbv	311 ppbv	13.09%	Natural and anthropogenic causes
CFC-12	0 pptv	503 pptv	NA	Entirely human origin
HCFC-22 (a CFC substitute)	0 pptv	105 pptv	NA	Anthropogenic; low concentrations now but rising
CF_4 (a perfluorocarbon)	0 pptv	70 pptv	NA	Anthropogenic; very long lifetime; effectively a permanent atmospheric resident

ppmv = parts per million by volume
ppbv = parts per billion by volume
pptv = parts per trillion by volume
NA = not applicable

Source: IPCC (1995, 1996).

Globally, greenhouse gas emissions have risen significantly since pre-industrial years. Atmospheric contaminants of human origin range from common substances, such as oxides of carbon, nitrogen, and sulphur, to more exotic, often synthetic substances, such as chlorofluorocarbons (CFCs). Table 1.1 indicates how much the atmospheric concentrations of some of the main greenhouse gases have risen from those of pre-industrial years.

In 1995, total Canadian emissions of greenhouse gases reached 619 Mt, composed primarily of carbon dioxide (81%), methane (12%), and nitrous oxide (5%).

Canada's Commitments Under the Framework Convention on Climate Change (FCCC)

The ultimate objective of the United Nations Framework Convention on Climate Change (FCCC) is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.

While the FCCC does not include legally binding targets and schedules to control greenhouse gas emissions, it does require governments to undertake a number of actions within a range of options. Governments have an opportunity to choose the climate change mitigation measures that are the most environmentally effective and economically cost-effective. Under the FCCC, Canada is committed to:

- implement policies and measures that mitigate climate change by limiting anthropogenic emissions of greenhouse gases and by protecting and enhancing natural sinks;
- adopt policies and measures that will facilitate its ability to adapt to the possible future impact of climate change;

- develop and implement educational and public awareness programs on climate change and its effects both nationally and internationally;
- promote and cooperate in the exchange of information related to climate change by working nationally on data collection, research, and systematic observation to further the understanding of climate change and reduce the scientific uncertainties surrounding it;
- take into account climate change in economic and environmental decision making to support a sustainable development approach;
- provide new and additional financial resources to developing countries to help them meet their own commitments under the FCCC;
- promote, facilitate, and finance the transfer of environmentally sound technologies while working to enhance the technological capacity of developing countries; and
- cooperate with other countries to ensure that the policy instruments they adopt to mitigate climate change complement, rather than counteract, measures taken elsewhere.

National Communications Under the FCCC

Canada's First National Report on Climate Change — 1994

Canada's First National Report on Climate Change, produced in 1994, was a snapshot at that time of what had been done by governments, communities, and the private sector with respect to Canada's commitments in areas of climate change mitigation, adaptation, research, education, and international cooperation. The report evaluated Canada's efforts to meet its commitments under the FCCC and gave Canadians a basis for planning future action.

Canada's National Action Program on Climate Change (NAPCC)

Canada's National Action Program on Climate Change (NAPCC), outlines the principles and strategic directions on climate change. It was agreed to by all federal, provincial, and territorial energy and environment ministers in February 1995 and was presented at the first Conference of the Parties (CoP) to the FCCC, held in Berlin in the spring of 1995.

Canada's Second National Report on Climate Change — 1997

This Second National Report on Climate Change was drafted under a detailed set of guidelines provided by the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation under the FCCC. These guidelines have three principal purposes:

- to assist Member Countries in their commitments to develop, update, publish, and make available to the CoP national inventories of anthropogenic emissions by source, and removal by sink, of all greenhouse gases not controlled by the Montreal Protocol using comparable technologies;
- to facilitate the process of developing national communications (i.e., national reports), including the preparation of useful technical analysis documentation, by encouraging the presentation of information in ways that are consistent, transparent, and comparable; and
- to ensure that the CoP has sufficient information to carry out its responsibilities to review the

implementation of the FCCC and the adequacy of the commitments.

This report addresses actions to implement the FCCC's obligations, including those relating to adaptation, research, and education, in addition to those to limit emissions and enhance sinks. It has been prepared by officials in the federal government with input from officials from provincial and territorial governments and non-government stakeholders.

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CHAPTER 2: National Circumstances

As a northern-latitude country, Canada is particularly vulnerable to the potential impacts of climate change. At the same time, Canada's northern and diverse climate, sparsely populated land mass, regional differences, high rate of population growth, resource-based and export-oriented economy, lifestyles, and high standard of living all serve to create a high demand for energy, with its associated greenhouse gas (GHG) emissions. The responsibility for public policy on climate change is shared among all orders of government in Canada — federal, provincial, territorial, and municipal.

Canada's economy relies in large part on its renewable and non-renewable resources. The importance of agriculture, forestry, fisheries, water resources, and energy and mineral resources to our nation is well known. Although the magnitude, timing, and regional impacts of climate change are uncertain, current predictions are that climate change could have far-reaching and mostly negative implications. Climate change during the next century is projected to bring about warming trends, precipitation changes, and a greater frequency of storms and unusual weather patterns. This has ramifications for coastal communities, the vulnerable ecosystems of our far north, and the health of some Canadians. Droughts, hot spells, and insect infestations may become more frequent on the prairies, water resources in southern regions of the country may come under stress, the boreal forest may be unable to adapt to relatively rapid changes in climate, and coastal fisheries may be adversely affected. Likewise, given Canada's dependence on international trade, the nation's energy-intensive industries and energy resource sector could also be adversely affected if the mitigative policies and measures chosen to address climate change and greenhouse gas emissions do not adequately take into account Canada's economic interests. While the magnitude of impacts of climate change continues to be assessed, there is a risk that the general well-being of Canadians could be jeopardized if greenhouse gas emissions are not curbed on a global basis.

In Canada, energy production, transformation, and consumption are the major producers of carbon dioxide (CO_2) and methane (CH_4), which together accounted for 93% of Canada's total greenhouse gas emissions in 1995. Carbon dioxide is the dominant greenhouse gas, accounting for 81% of emissions in 1995, and fossil fuel combustion and production are the dominant sources, accounting for about 89% of greenhouse gas emissions in the same year. Other greenhouse gas emissions (mainly methane, nitrous oxide [N_2O], and fluorocarbons) come mostly from non-energy sources, such as industrial processes, agriculture, and waste disposal.

Physical Characteristics

Canada is a land of extremes and contrasts. Its surface area (land plus fresh water) of 9 970 620 km^2 occupies 7% of the world's land mass and is second only to that of the Russian Federation. Canada extends roughly 5 300 km east to west, the distance between Paris and New York, and nearly 4 600 km south to north. As a consequence, Canada faces long freight haulage demands, which contribute to greenhouse gas emissions in the transportation sector.

Many nations are shaped to a large extent by their climate, but few can match the climatic diversity of Canada. The size and variety of Canada's land mass and the effects of its three ocean boundaries help to characterize many of its 15 terrestrial ecozones, from the Arctic Cordillera, with its extremely cold and dry climate and continuous permafrost, to the Mixedwood Plains, with its cool to mild and moist climate.

Overall, Canada is characterized by short, intense summers with wide temperature variations and long, cold winters, which place a heavy demand on energy consumption, especially for heating buildings. Table 2.1 presents the annual heating degree-day values for several Canadian cities and other cities around the world.

TABLE 2.1 AVERAGE ANNUAL HEATING DEGREE-DAYS IN CITIES IN CANADA AND OTHER NORTHERN-LATITUDE COUNTRIES

City	Heating Degree-Days[a]
Winnipeg	5 923
Helsinki	4 930
Moscow	4 840
Montreal	4 540
Stockholm	4 160
Toronto	4 140
Berlin	3 300
Beijing	3 050
Vancouver	3 030
Paris	2 720
Washington	2 160
Tokyo	1 620

[a] Calculated by multiplying the number of days the average temperature is less than 18°C by the number of degrees the average temperature is below 18°C over a year-long period.

Heating degree-days can vary from year to year, which may lessen or increase the demand for energy in the residential and commercial sectors. In Canada in 1994, 61% of the energy demand for the residential sector was used for space heating, as was 55% of the energy demand for the commercial sector. Energy required for summer cooling places a growing demand on energy systems.

Socioeconomic Context

Despite its geographic immensity, Canada supports only a relatively modest population — more than 29 million in 1995, or 0.5% of the world's people — but emits 2% of the global greenhouse gas emissions. Average population density is low — about 3.0 persons per square kilometre — but this figure is misleading, as the population is highly concentrated in major urban areas in the south near the Canada–U.S. border.

Developed countries, including Canada, represent only about 20% of the world's population but use about 80% of the world's resources. Canada has the second highest population growth rate among industrialized countries (due mainly to net immigration). Over the period 1973–1993, Canada's population grew at an annual rate of 1.22%, compared with 0.98% for the United States, 0.14% for the United Kingdom and Germany, and 0.69% for Japan. This population growth puts a demand on the production of goods and services. Infrastructure changes in the number of dwellings, commercial buildings and services, roads, and vehicles all contribute to increasing demands for energy, with its associated greenhouse gas emissions.

Canada is a highly urbanized country. In terms of land area, occupied urban areas account for less than 20 000 km^2, or roughly 0.2% of the country's total land area. In terms of population, however, about 80% of the people live in urban areas. Increasingly, Canadians have congregated in the largest cities; nearly 60% of Canada's urban population lives in centres of 500 000 or more.

Despite Canada's low population density, cities provide more opportunities for environmental protection and resource conservation than dispersed patterns of settlement. Potentially, at least, the city permits economies and efficiencies in the provision of water, sewage, and waste disposal; in energy use; and in the use of land. The city also provides opportunities to substitute walking, bicycling, and public transit for car use, but personal automobile use is heavy, owing in part to urban sprawl. Canada's low population density and long distances between population centres contribute to high energy use in Canada's transportation sector. Canada moves five times as much freight (measured in tonnes per kilometre) as France, Germany, and Japan.

Canadians, in general, enjoy a high quality of life, as measured on a variety of social and economic scales. Gross domestic product (GDP) is one measure of a country's ability to generate wealth. From 1990 to 1995, Canada's GDP rose by 8.2% (Table 2.2). Canadians use energy at rates similar to those of residents of other developed countries, but countries like Japan, with a slightly higher GDP per capita, use much less energy. Part of the reason is that Canada exports energy-intensive products. Greenhouse gas emissions associated with the production of these products are attributed to Canada, not the importing country. This raises the per capita emissions attributed to Canadians, even though they do not consume these products. Canada's natural gas exports play a significant role in the increased use of high-efficiency cogeneration in many areas of the United States, resulting in reduced overall air emissions within North America.

Greenhouse Gas Emissions

Following a small reduction in 1991, Canada's greenhouse gas emissions increased steadily from the 1990 level of 567 Mt of carbon dioxide equivalent to 599 Mt in 1994 and 619 Mt in 1995. This represents an increase of 9.0% over 1990 levels in 1995 while the population grew by 6.5% over the same period, representing a per capita increase of almost 3%. Canada's GDP increased by 8.2% over the same period (Table 2.2), leading to an increase in emissions per unit of GDP of 1.2%.

TABLE 2.2 CHANGES IN CANADA'S GREENHOUSE GAS EMISSIONS AND RELATED FACTORS

Year	GHG Emissions (kt CO_2 eq.)	% Change from 1990	Population (000s)	% Change from 1990	GDP (1986 $M)	% Change from 1990	Energy (PJ)	% Change from 1990
1990	567 000	0.0	27 790.6	0.0	565 000	0.0	7 866	0.0
1991	559 000	–1.4	28 119.6	1.2	555 052	–1.8	7 765	–1.3
1992	575 000	1.4	28 542.2	2.7	559 305	–1.0	7 930	0.8
1993	581 000	2.5	28 940.6	4.1	571 722	1.2	8 191	4.1
1994	599 000	5.6	29 248.1	5.2	597 936	5.8	8 307	5.6
1995	619 000	9.0	29 606.1	6.5	611 300	8.2	8 587	9.2

Political Context

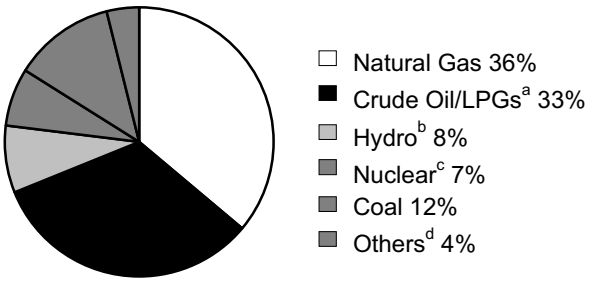
Addressing climate change is the shared responsibility of all Canadian governments, industries, and citizens. Each government has certain responsibilities as defined by the division of powers under the Constitution. Each jurisdiction has its

own priorities and needs. All levels of government are currently facing financial restraint and are prioritizing expenditures. Consistent with the principle of sustainable development, initiatives to limit greenhouse gas emissions have to complement other priorities, such as job creation and economic growth. This is an ongoing challenge.

Energy Sector's Role in the Economy

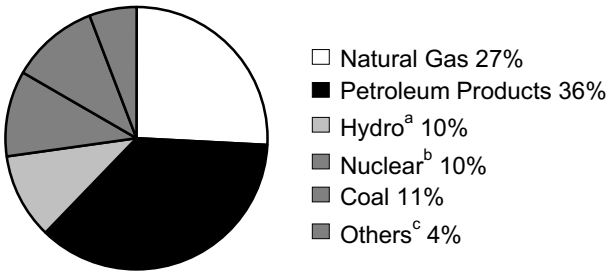
Canada's energy production and demand are dominated by fossil fuels, as shown in Figures 2.1 and 2.2. Energy production and consumption are integral to a modern economy such as Canada's. Employment in the energy sector and energy-intensive industries (e.g., pulp and paper,[1] iron and steel, smelting and refining, cement, and chemicals) totalled close to 500 000 people in 1995; the energy sector contributed 2.7% of the country's total employment, and energy-intensive industries contributed 2%. These sectors also accounted for $77 billion of GDP — the energy sector contributed 7.5% of total GDP, and energy-intensive industries contributed 3.9%.

Energy contributed 16.1% to total investments in Canada in 1995 and 9.5% of the value of exports. Energy's contribution to the trade balance was 42.3%. In 1995, over 50% of Canada's crude oil/liquefied petroleum gases (LPGs) and natural gas production were exported. Together, they accounted for 6 236 PJ, resulting in a net export of 4 538 PJ (see Figure 2.4). These exports, particularly natural gas, often reduce emissions elsewhere by replacing more carbon-intensive fuels. Greenhouse gas emissions associated with the production and transportation of these resources for export are attributed to Canada.



[a] LPG = liquefied petroleum gas.
[b] Hydro included at 3.6 MJ/kWh.
[c] Nuclear included at 11.6 MJ/kWh.
[d] "Others" includes wood and other renewables.

FIGURE 2.1 CANADIAN ENERGY PRODUCTION, 1995



[a] Hydro included at 3.6 MJ/kWh.
[b] Nuclear included at 11.6 MJ/kWh.
[c] "Others" includes wood and other renewables.

FIGURE 2.2 CANADIAN PRIMARY ENERGY DEMAND, 1995

[1] The pulp and paper industry currently gets about 56% of its energy requirements from biomass and biofuels, which are part of the natural carbon cycle and not included in greenhouse gas emission estimates.

The energy sector is important to Canada's economic well-being and is relatively larger than other natural resource sectors, such as forestry, agriculture, and fisheries. New measures to limit or reduce greenhouse gas emissions could affect the fossil fuel sector, which meets over 70% of Canada's primary energy demand and which is responsible for the majority of greenhouse gas emissions in Canada (Figure 2.2). Sector demands for energy in 1990 and 1995 are illustrated in Figure 2.3. More detailed end-use energy information may be found in Energy Efficiency Trends in Canada: 1990–1995.

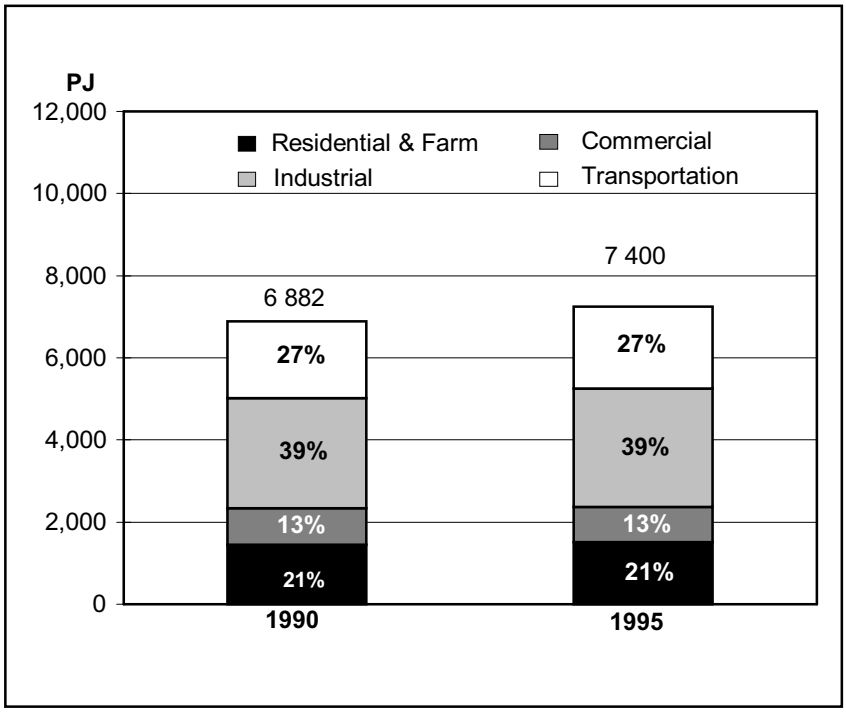


FIGURE 2.3 END-USE ENERGY DEMAND BY SECTOR, 1990 AND 1995

Performance Indicators

Key Determinants of Greenhouse Gas Emissions

There are five major factors that, through their interaction, determine the nature and extent of anthropogenic greenhouse gas emissions: (1) population size and growth, (2) economic activity, (3) energy intensity (i.e., amount of energy consumed by a given population or level of economic activity), (4) greenhouse gas intensity of energy requirements (i.e., the extent to which carbon-based fuels are used in energy consumption), and (5) land use (i.e., urban development, agricultural and forestry practices). Understanding these factors or indicators helps to reveal why greenhouse gas emissions are rising or falling for a particular sector over a specified time period. Proper understanding of indicators can reveal trends and aid in determining appropriate mitigative and adaptive responses.

The production and consumption of fossil fuels (petroleum products, natural gas, and coal) are the main sources of the chief anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide). Therefore, both the extent to which and the way in which Canadians use energy or produce it for export are pivotal for Canada's greenhouse gas emissions.

Population and GDP Indicators

Our modern economy and lifestyles are energy dependent. As population grows, a higher demand for goods and services has traditionally followed. Meeting these needs requires energy, much of which is fossil fuel based (especially the transportation sector, as well as electricity production in certain regions). Canada's population grew by 6.5% over the period 1990–1995, outpacing that of all other G-7

countries, and it is projected to grow at an annual rate of 0.9% to 2020, raising the population from 29.6 million to 36.8 million. Canada's GDP increased by 8.2% from 1990 to 1995 and is projected to be 12% higher in 2000 than it was in 1995, and 70% higher in 2020.

Given this historic link between population, economic growth, and energy demand, energy intensity and the greenhouse gas intensity of fuels are key indicators of where progress, or the lack thereof, is being made in reducing emissions, and where potential for reduction may lie.

It should be noted, however, that even if certain trends are identified, there can be sudden short-term shifts in emissions as a result of other factors. A recent example is what happened in the electricity-generating sector in 1995. In that year, power production from several units of nuclear stations was interrupted for between 2 and 12 months. This disruption meant that, for the most part, electricity was instead generated from fossil fuels, which resulted in a 6- to 8-Mt increase in greenhouse gas emissions above normal. Likewise, weather changes (e.g., fluctuations in temperature with respect to heating and cooling demands, and precipitation changes with respect to maintaining hydroelectric reservoir levels) can influence emissions from fossil fuel use on a year-to-year basis.

Energy Export Indicators

Greenhouse gas emissions from energy production and use can be divided into emissions resulting from energy used in the domestic market and those resulting from energy produced for export. The bulk of exported energy resources are crude oil and natural gas — over 50% of domestic production in 1995 — followed by coal (about 45% of domestic production) and electricity (about 6% of domestic production, much of it hydroelectric) (Figure 2.4).

Between 1990 and 1995, oil and gas production increased by 35%, and exports doubled. The emissions associated with this production were the single most important cause of the increase in Canada's greenhouse gas emissions over the 1990–1995 period, accounting for 31% of the total increase in emissions. Despite the very significant decrease in the amount of energy consumption required per unit of production, the sheer volume of export activity overwhelmed any energy efficiency improvements insofar as greenhouse gas emissions were concerned.

As the review of the National Action Program on Climate Change (NAPCC) concluded, had it not been for the growth in oil and gas exports, the petroleum industry's emissions in Canada would have been approximately stable over the 1990–1995 period. This raises important, and as yet unresolved, questions about the attribution of emissions between exporters and importers of energy. Canada's natural gas exports are playing a significant role in the increased use of high-efficiency cogeneration in many areas of the United States, resulting in reduced air emissions within North America. Although Canada does not consume these energy resources bound for export and so important to our economy, the emissions associated with their production, partial processing, and transportation to the United States and elsewhere are attributed to Canada.

Secondary Energy Use and Emission Indicators

Changes in energy-related greenhouse gas emissions arise from changes in the principal factors that influence energy use and emissions over time. Natural Resources Canada (NRCan) has developed some notable indicators of changes in energy use at the secondary level as a

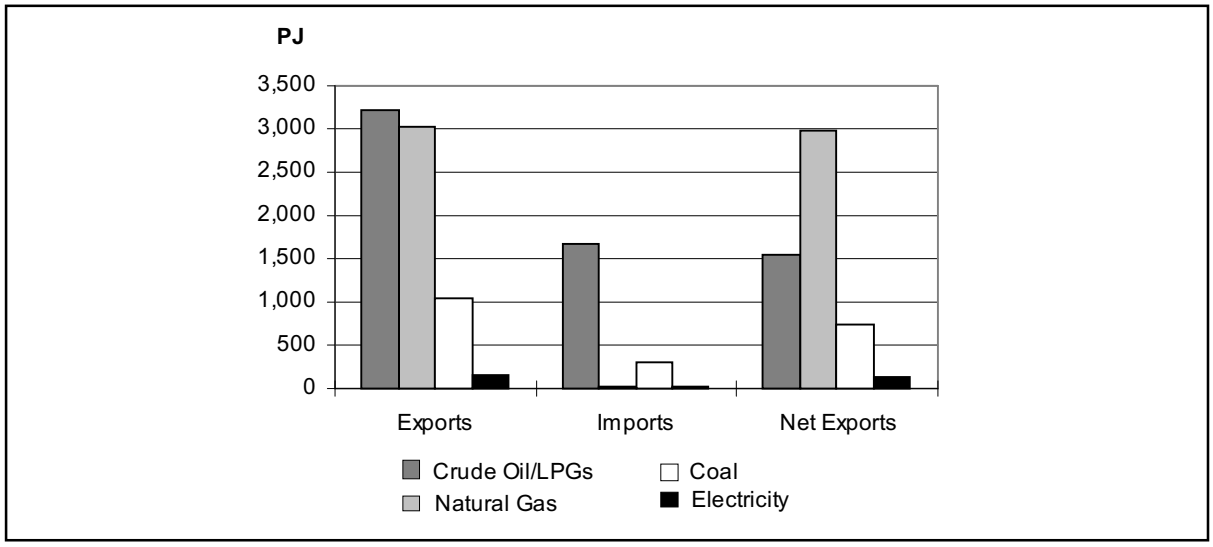


FIGURE 2.4 CANADIAN ENERGY TRADE, 1995

result of changes in these factors. Some of the key conclusions from this decomposition and analysis of such indicators are reported here. A more comprehensive and detailed presentation of these indicators by sectors can be found in Energy Efficiency Trends in Canada 1990 to 1995. This report is an update of Energy Efficiency Trends in Canada, which was published by NRCan in April 1996. The 1997 report also addresses energy-related carbon dioxide emissions, which serve as a proxy for greenhouse gas emissions. These reports and the accompanying national database place Canada among the world leaders in this type of analysis.

Secondary energy is defined as the sum of energy used in five end-use sectors: residential, agriculture, commercial, industrial, and transportation. Secondary energy use accounts for about 70% of total energy requirements in Canada; the remainder is energy used for transforming one energy form into another (e.g., coal to electricity) or lost in the transportation process, energy used by suppliers to get energy to markets (e.g., pipeline fuels), or intermediate or non-energy uses.

From 1990 to 1995, carbon dioxide emissions from secondary energy use increased by 5.1%. Increases in emissions were registered in all end-use sectors. In each sector, changes in energy use (7.5% increase at the total secondary level) had a significant upward influence on the trend in carbon dioxide emissions. The carbon dioxide intensity of energy use declined 2.3% for total secondary, although it showed large variations between sectors. Table 2.3 summarizes the changes in carbon dioxide emissions, energy use, and carbon dioxide intensity of energy use from 1990 to 1995 for total secondary and each sector.

TABLE 2.3 CHANGES IN MAJOR EMISSIONS-RELATED INDICATORS, 1990–1995

	% Change		
Sector	Carbon Dioxide Emissions	Energy Use	Carbon Dioxide Intensity of Energy
Secondary	5.1	7.5	–2.3
Residential	3.0	3.9	–0.8
Agriculture	2.2	0.9	1.3
Commercial	5.4	9.0	–3.5
Industrial	2.5	9.1	–6.0
Transport	7.9	8.0	–0.03

The following two subsections explain the evolution of secondary energy use and the trend in the carbon dioxide intensity of secondary energy use. In these subsections, reference will be made to sectoral trends where these trends have had a significant effect.

Evolution of Secondary Energy Use and Its Major Determinants

Table 2.4 presents the effect of growth in ***activity***, ***structure***, ***weather***, and ***energy intensity*** on growth in secondary energy use from 1990 to 1995. The table's columns attribute the change in sectoral energy use (shown in column 1 and measured in petajoules) to four separate effects: ***activity***, ***structure***, ***weather***, and ***energy intensity***. This table shows that growth in secondary energy use was most influenced by growth in ***activity*** levels in each end-use sector. This effect is particularly large in household activity and transport (both passenger and freight).

Had only the level of ***activity*** changed in each sector from 1990 to 1995, while ***structure***, ***weather***, and ***energy intensity*** remained at their 1990 levels, secondary energy use would have increased by 637 PJ, rather than the actual 518 PJ.

In aggregate, ***structural*** shifts within sectors have increased secondary energy use since 1990; however, on a sector-specific basis, this effect varied. The largest structural effects occurred in the industrial and freight transportation sectors.

In the industrial sector, the shift in activity towards more energy-intensive industries (especially smelting and refining and mining) increased energy use by 68 PJ. In freight transport, the mode shift from marine and rail to road transport had a similar effect, increasing energy use by 104 PJ. In aggregate, the results show that structural shifts in the mix of activity within sectors increased energy use by 193 PJ.

Weather also contributed to the increase in secondary energy use, as 1995 was colder than 1990. The effect of this colder weather is most relevant in the residential and commercial sectors, where space heating represents a major part of energy use. Combined residential and commercial space heating requirements increased by 52 PJ as a result of colder weather.

Energy intensity was the only factor that kept secondary energy use from increasing more than it actually did from 1990 to 1995. Had ***energy intensity*** remained at its 1990 level and only ***activity*** levels, ***structure***, and ***weather*** changed, secondary energy use would have been 308 PJ higher in 1995 than it was. Energy intensity declined in all sectors, except for industry, where it increased. However, the increase in intensity in industry hides a significant decline in the intensity of energy use for the manufacturing sector, which accounts for 86% of industry energy use. The increase in industry energy intensity can be attributed to a relatively large increase in mining sector energy intensity.

The energy intensity effect is due to many factors, one of which is energy efficiency. It is important to note that when analyzing the factors that underlie changes in energy intensity and the energy efficiency improvements over a given period, it is necessary to extend the analysis of causal factors beyond the period under review. For example, although steps have been taken to realize energy efficiency gains in the products available to consumers over the 1990–1995 period, these improvements have not had enough time to have had a significant impact on the change in energy intensity over this period. Only a small fraction of today's capital stock is composed of products that have entered the market since 1990. On the other hand, the energy efficiency improvements in

TABLE 2.4 FACTORS INFLUENCING GROWTH IN SECONDARY ENERGY USE, 1990–1995

Sector	Secondary Energy Use (PJ)					
	Increase in Energy Use from 1990 to 1995	Activity Effect	Structure Effect	Weather Effect	Energy Intensity Effect	Interaction
Residential	51	134.8	15.8	40.2	–125.3	–14.1
Commercial	77	87.7	3.3	11.5	–22.7	–1.6
Industry	241	156.5	68.3	NA	11.3	4.6
Transportation	146	257.6	105.9	NA	–171.4	–37.7
Passenger	105	175.6	1.6	NA	–55.5	–9.6
Freight	42	82.0	104.3	NA	–115.9	–28.1
Agriculture	2	NA	NA	NA	NA	NA
Total	**518**	**637**	**193**	**52**	**–308**	**–49**

NA = not applicable

products purchased during the years preceding this period are important. The majority of the stock is composed of products that have penetrated the market over the last two decades. It will take some years for more recent energy efficiency improvements to significantly affect the average efficiency of the stock of appliances/equipment used in Canadian households.

Notwithstanding the above, some examples of recent product improvements for which energy savings are now being realized include electric household refrigerators, which were 35% more efficient in 1995 than those sold in 1990; and mid- to high-efficiency natural gas furnaces, which accounted for only 37% of sales in 1990 but for all sales in 1995.

The two Energy Efficiency Trends in Canada reports, which were mentioned above, describe in more detail the impact of energy intensity improvements and other factors that have influenced energy use.

Trend in the Carbon Dioxide Intensity of Secondary Energy Use

The change in the carbon dioxide intensity of secondary energy demand resulted from a shift in the mix of fuels used to meet this demand. Figure 2.5 presents the change in secondary energy fuel shares from 1990 to 1995.

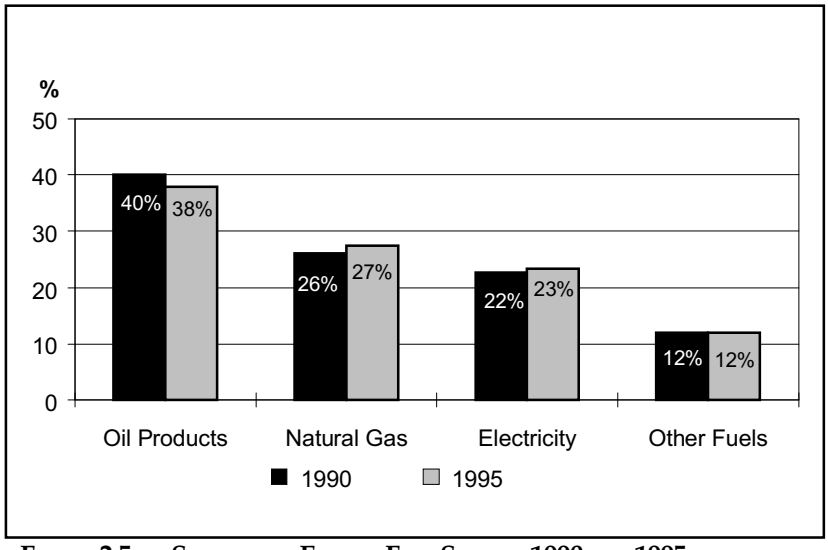


FIGURE 2.5 SECONDARY ENERGY FUEL SHARES, 1990 AND 1995

In interpreting the impact of shifts in fuel shares on the carbon dioxide intensity of energy use, it is important to remember the following:

- The carbon intensities of natural gas and wood waste are lower than those of most oil products.

- No carbon dioxide is emitted from the use of electricity at the end-use level. Thus, a shift from fossil fuels, such as fuel oil or natural gas, to electricity will result in a reduction in carbon dioxide intensity at the end-use level. (However, depending on the generation source of electricity, there may be a corresponding increase in emissions from electricity production.)

- For wood wastes and pulping liquor, emissions are reported as zero, as Canada's forests are considered to be managed in a sustainable manner. Thus, a shift to biomass reduces carbon dioxide intensity at the secondary level.

From 1990 to 1995, there was a significant increase in the shares of natural gas and "other fuels." The share of electricity increased marginally, while the share of oil products declined (Figure 2.5).

While the share of electricity increased only slightly, this trend hides offsetting changes in the industrial and residential sectors. Industry's share of electricity increased largely because of the significant output growth of the aluminum industry, which is responsible for the bulk of the smelting and refining industry's energy use and relies almost solely on electricity, most of it hydro power. Primary production of aluminum increased by more than 40% since the beginning of the 1990s. In the residential sector, the share of electricity decreased, owing mainly to a shift from electricity to natural gas to meet water-heating needs. The share of natural gas also increased because of the shift from oil products to natural gas to meet space-heating needs.

The decline in the share of oil products reflects a continuing trend that began in the early 1980s in the residential, commercial, and industrial sectors. However, the above-average growth in energy used in the transport sector, which uses mostly oil products, slowed the decline in the share of oil products at the secondary level.

The share of other fuels increased from 1990 to 1995, especially in industry. This is mainly a result of a shift from oil products to other fuels in the pulp and paper sector. Almost 90% of "other fuels" in the industrial sector are wood wastes and pulping liquor used in the pulp and paper industry.

Summary and Conclusions

In conclusion, from 1990 to 1995, carbon dioxide emissions from secondary energy use increased by 5.1%. Increases in emissions were registered in all end-use sectors. While the ***carbon dioxide intensity*** of energy use declined, emissions increased, because energy use increases more than offset this change.

The increase in secondary energy use was largely driven by ***activity*** growth, ***structural*** shifts, and ***weather*** Of these factors, the increase in activity was the most significant force pushing energy use upward in each sector of the economy over the period.

Although improvements in ***energy intensity*** (a proxy for energy efficiency in this study) mitigated the increase in energy use and carbon dioxide emissions, other factors more than offset this impact, and secondary energy use continued to increase over the 1990–1995 period.

However, in the absence of ***energy intensity*** declines, secondary energy use would have increased by 308 PJ more than it actually did from 1990 to 1995 — energy use would have increased by 12 % rather than 8% from 1990 to 1995.

Carbon dioxide emissions from secondary energy use would also have been higher in the absence of the decline in ***energy intensity*** Rather than increase by 5.1% (about 15 Mt) from 1990 to 1995, these emissions would have risen by 8.6% (about 26 Mt).

Agriculture

Net greenhouse gas emissions from Canadian agriculture are expected to decrease slightly as a result of the increased use of a number of economically viable practices and measures. The total area in cultivation (cropland plus summer fallow in a given year) has remained relatively stable: 41 million hectares in 1991 versus an estimated 42 million hectares in 1995 (Agriculture and Agri-Food Canada, 1996).

The major contributions to reductions in greenhouse gas emissions are projected to arise from the continuation of several sectoral trends: increased use of no-till seeding, reduced summer fallowing of cultivation lands, increased biomass through higher rates of fertilizer use, additional land in forage crops, introduction of crop strains with higher yields, improved efficiency in fossil fuel use and greater use of ethanol, and reduced methane emissions from livestock and manure owing to improved feeds and management practices. It should be noted that the net effect of increased fertilizer use requires further study: carbon dioxide emissions are reduced by enhanced plant growth, but nitrous oxide emissions increase. The production of fertilizer, particularly nitrogen fertilizers, requires energy and natural gas as a raw material.

Summary

In summary, from the above analysis of overall performance indicators, it is possible to have a better understanding of the factors affecting greenhouse gas emissions. This will aid in appropriate policy responses. Canada is continuing to develop databases and analyses so that long-term, sustainable solutions can be developed to address greenhouse gas emissions and climate change.

References

Agriculture and Agri-Food Canada (1996). Medium Term Estimates.

NRCan (Natural Resources Canada) (1996). Energy Efficiency Trends in Canada.

NRCan (Natural Resources Canada) (1997). Energy Efficiency Trends in Canada 1990 to 1995.

CHAPTER 3: Canada's National Greenhouse Gas Emission Inventory

Under the United Nations Framework Convention on Climate Change (FCCC), specifically Article 4(1)(a), Article 12(1)(a), and Decision 3/CP.1, which requires annual reporting of inventories, national communications (i.e., national reports) must include an inventory of anthropogenic (human-induced) emissions by sources, and removals by sinks, of all greenhouse gases (GHGs) not controlled by the Montreal Protocol. This chapter provides a summary of trends in net anthropogenic sources (emissions) of and sinks (removals) for greenhouse gases in Canada, as well as a brief description of the methodologies used to estimate them and the associated uncertainties.

Greenhouse Gas Emission Estimates, 1990–1995

Changes to Canada's 1992 Greenhouse Gas Inventory

As science identifies trace gases that affect climate change and methods are developed for estimating emissions, the emissions are added to our national inventory. Since 1992, the last year in which our inventory was published, the new gases that have been added include sulphur hexafluoride (SF_6) (from magnesium manufacture) and hydrofluorocarbons (HFCs) (used for climate control, solvents, propellants, and fire extinguishers). In addition, more accurate estimates of the perfluorocarbons (PFCs) carbon tetrafluoride (CF_4) and carbon hexafluoride (C_2F_6) (from primary aluminum smelting) have been made.

Emissions from wastewater treatment and composting (sources of methane [CH_4] and nitrous oxide [N_2O]) have been added, the former based on the methodology developed by ORTECH International (1994). Environment Canada conducted a survey on composting in 1993, which allowed its inclusion in the inventory. An Agriculture Canada model to calculate carbon dioxide (CO_2) from soils ("Century") has allowed this source to be incorporated. Studies currently under way on nitrous oxide from manure and soils may reveal additional emissions that need to be accounted for.

Inventoried values for methane emissions have improved as a result of a number of new studies. King (1994) updated the methodology for fugitive emissions from coal mines. A Canadian Gas Association (1995) study of emissions from pipelines allowed the calculation of new "natural gas distribution" numbers. A soon to be released study of methane losses from natural gas distribution and transmission systems indicates that current emission estimates may be low. Canada's landfill model has been modified since 1992 to incorporate new regional data, including, most recently, emissions from landfilled wood wastes. Newer agricultural studies, showing lower generation rates of methane from farm animals, have changed our estimate for "livestock/manure" emissions.

The recent introduction in 1996 of an updated model for determining emissions from mobile sources has improved the overall accuracy of transportation sector estimates. It incorporates more recent research data from Environment Canada and the U.S. Environmental Protection Agency (EPA) and primarily affects inventoried values for nitrous oxide. A new methodology for calculating

emissions of nitrous oxide from propellant use has been incorporated into the inventory as well.

The 1995 Guidelines for National Greenhouse Gas Inventories (Inventory Guidelines) of the Intergovernmental Panel on Climate Change (IPCC, 1995) have also required some adjustments to be made. International air and marine bunker emissions, formerly included in the national totals, have been removed from the inventory and are now listed under a separate category. The 1996 IPCC Inventory Guidelines, completed only a few months ago, contain a number of new methodologies. Thus, additional emission sources may be identified and added to the Canadian inventory in the near future.

Finally, updates to the 100-year global warming potentials (GWPs) (IPCC, 1996) have caused large changes in the effective carbon dioxide equivalent emissions of methane and nitrous oxide, resulting in a significantly different greenhouse gas emission total for Canada.

More extensive information on the inventory is provided in the background document Trends in Canada's Greenhouse Gas Emissions (1990–1995) and associated appendices (Jaques et al., 1997). This document provides detailed sectoral breakdowns and additional information on the methodologies and assumptions used in compiling the emission estimates. For the most part, emission inventory methodologies utilized are the same as or similar to those provided in the 1995 IPCC Inventory Guidelines and in some cases include methodologies outlined in the Revised 1996 Guidelines for National Inventories of the Secretariat to the FCCC. Where methods differ from the IPCC Inventory Guidelines, explanations and references are provided.

The radiative gases for which emission estimates have been made are carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, carbon tetrafluoride, carbon hexafluoride, and HFCs. A summary of emission estimates by sector for the period 1990–1995 is provided in Table 3.1. A complete inventory in standard IPCC format, including estimates of "precursor gases," nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs), carbon monoxide (CO), and sulphur dioxide (SO_2), is provided in a separate addendum.

In 1995, Canadians contributed about 619 Mt of greenhouse gases to the atmosphere, about 2% of total global emissions. Carbon dioxide contributed the largest share, about 81% or 500 Mt, methane the next largest share, 12%, followed by nitrous oxide, 5%, perfluorocarbons (PFCs), 1%, and sulphur hexafluoride and HFCs the remainder (Figure 3.1).

Approximately 89% of the total greenhouse gas emissions in 1995 were attributable to fossil fuel production, transportation, and consumption. On a sectoral basis, energy industries accounted for about 34%, industry (fuel combustion and process emissions) 20%, transportation 27%, residential 10%, commercial and institutional 5%, and agricultural sources 5% of the total greenhouse gas emissions in 1995.

TABLE 3.1 GREENHOUSE GAS EMISSION ESTIMATES IN CANADA BY SECTOR, 1990–1995

Source	Emission Estimates (kt CO_2 equivalent)					
	1990	1991	1992	1993	1994	1995
Global Warming Potential Multiplier						
Industrial Processes						
Natural Gas Distribution	2 200	2 400	2 600	2 800	3 000	3 200
Upstream Oil and Gas	31 600	33 000	36 600	38 400	41 100	43 600
Cement/Lime Production	7 720	6 570	6 180	6 580	7 220	7 350
Undifferentiated Industrial Processes	23 100	25 600	25 100	27 800	27 300	25 700
Coal Mining	1 900	2 100	1 800	1 800	1 800	1 700
Chemical Production	11 000	11 000	11 000	9 900	12 000	12 000
Subtotal	78 000	80 900	82 500	87 400	92 400	93 400
Fuel Combustion — Stationary						
Power Generation	94 800	96 100	104 000	93 300	94 800	103 000
Industrial	75 700	73 500	71 700	72 900	73 800	77 400
Pulp and Paper and Sawmills	11 500	11 700	11 200	11 000	11 200	10 200
Iron and Steel	14 100	15 200	15 600	15 200	14 500	15 000
Other Smelting and Refining	3 470	2 880	3 070	3 060	2 960	2 790
Cement	3 790	3 330	2 880	2 720	3 090	3 690
Petroleum Refining	3 290	3 620	2 950	2 470	2 640	2 070
Chemicals	7 830	7 740	7 560	8 160	8 800	7 580
Commercial	24 100	23 900	24 300	26 600	25 300	27 200
Residential	40 800	39 000	38 600	42 900	43 500	42 000
Agriculture	2 480	2 700	5 170	2 950	2 400	2 580
Public Administration	2 060	2 000	2 130	2 150	2 820	2 780
Steam Generation	379	309	256	369	666	656
Producer Consumption	40 300	38 800	41 000	41 800	42 700	44 000
Other	6 850	7 560	9 740	10 200	10 600	11 800
Firewood (Residential)[a]	760	820	760	750	700	700
Fuel Wood (Industrial)	372	362	372	330	372	489
Spent Pulping Liquors	0	0	0	0	0	0
Subtotal	289 000	285 000	298 000	295 000	298 000	313 000
Fuel Combustion — Mobile						
Automobiles	56 100	55 100	56 100	59 600	61 600	62 000
Light-Duty Gasoline Trucks	23 000	23 000	24 800	24 600	26 100	26 900
Heavy-Duty Gasoline Trucks	2 370	2 250	2 280	2 170	2 140	2 050
Motorcycles	179	177	182	184	189	187
Off-Road Gasoline	5 380	4 610	4 000	3 840	3 940	3 960
Light-Duty Diesel Automobiles	839	841	856	861	892	898
Light-Duty Diesel Trucks	952	904	928	941	1 020	1 090
Heavy-Duty Diesel Vehicles	24 300	23 500	24 100	25 400	27 800	29 900
Off-Road Diesel	11 500	10 300	9 610	10 800	12 400	13 900
Air	10 600	9 570	9 720	9 030	10 100	10 800
Rail	6 610	6 130	6 410	6 380	6 610	5 980
Marine	5 990	6 440	6 390	5 550	5 850	5 600
Other	1 680	1 870	1 890	2 090	2 290	2 360
Subtotal	149 000	144 000	147 000	151 000	161 000	165 000
Incineration						
Municipal Solid Waste	749	759	770	777	786	796
Subtotal	749	759	770	777	786	796
Agriculture						
Livestock/Manure	19 000	19 000	19 000	20 000	20 000	21 000
Fertilizer Use	3 300	3 400	3 700	4 000	4 100	4 100
Soils (Net Source)	7 090	5 820	5 000	3 940	3 490	2 480
Subtotal	29 400	28 200	27 700	27 900	27 600	27 600
Miscellaneous						
Prescribed Burning[a]	1 160	1 480	1 160	1 050	400	400
Wastewater/Compost	361	361	371	381	391	411
Landfills	17 000	17 000	17 000	18 000	18 000	18 000
Anaesthetics/Propellants	420	420	430	440	440	470
HFCs in Refrigeration/ Air Conditioning/Foam	0	0	0	0	0	500
Subtotal	18 800	18 900	19 800	19 800	19 600	20 100
National Totals [a]	567 000	559 000	575 000	581 000	599 000	619 000

Note: Individual values may not add up to totals owing to rounding.

[a] National totals do not include carbon dioxide from the combustion of biomass.

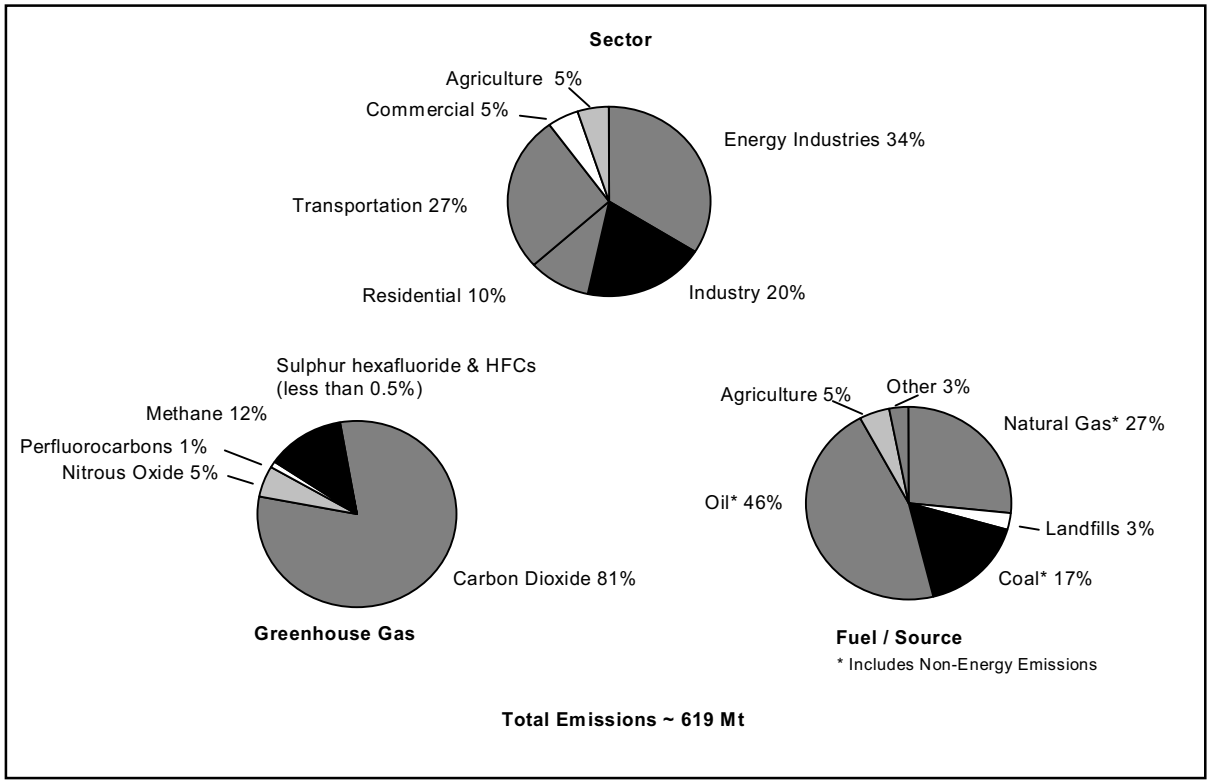


FIGURE 3.1 CANADA'S GREENHOUSE GAS EMISSIONS, BY GAS, BY SECTOR, AND BY FUEL/SOURCE, 1995

Recent Trends in Emissions

While carbon dioxide's share of the total greenhouse gas emissions in 1995 declined one percentage point from 1990's share of 82%, overall greenhouse gas emissions rose about 9% over the 1990 level of 567 Mt. Although carbon dioxide is the dominant greenhouse gas, the increase in emissions of carbon dioxide was overshadowed by increases in emissions of methane and nitrous oxide. Over the period 1990–1995, carbon dioxide emissions increased about 8% from a level of 464 Mt to 500 Mt, methane emissions almost 16%, from 3 200 kt to 3 700 kt, nitrous oxide emissions about 28%, from a level of 86 kt to 110 kt, while PFCs and emissions of sulphur hexafluoride remained relatively constant at levels of 6 and 2 Mt of carbon dioxide equivalent, respectively. Emissions of HFCs were 0.0 Mt in 1990 and 0.5 Mt of carbon dioxide equivalent in 1995. Table 3.1 illustrates the trends in emissions over the period 1990–1995. Although total emissions declined between 1990 and 1991, they have been on a steady rise since and are currently about 9% higher than the target level of 567 Mt. Although there are a number of factors responsible for this trend, emissions have increased largely due to an increase in economic activity (Figure 3.2).

Greenhouse Gases and Global Warming Potentials (GWPs)

Naturally occurring greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, and ozone (O_3). Chlorofluorocarbons (CFCs) and their substitutes, HFCs and hydrochloro-fluorocarbons (HCFCs), and other compounds, such as PFCs and sulphur hexafluoride, are also greenhouse gases. The FCCC excludes those gases covered by the Montreal Protocol (CFCs

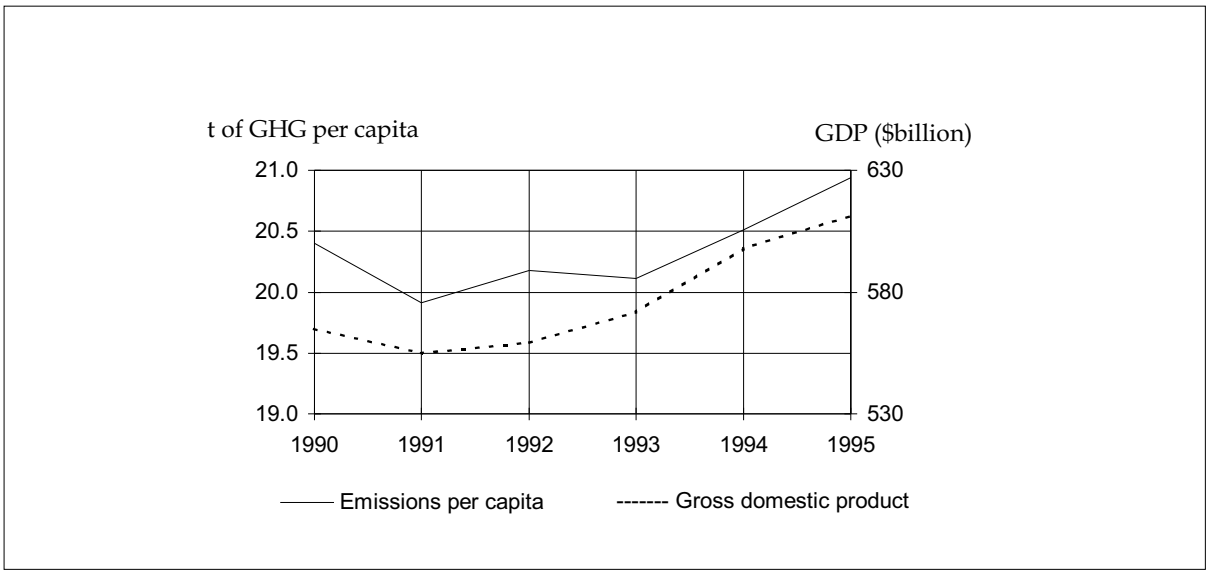


FIGURE 3.2 TRENDS IN PER CAPITA CARBON DIOXIDE EMISSIONS AND GROSS DOMESTIC PRODUCT, 1990–1995

and their substitutes). However, other photochemically important gases, such as carbon monoxide, oxides of nitrogen, and NMVOCs, although not direct greenhouse gases, do contribute indirectly to the greenhouse effect by creating tropospheric ozone and, as such, are included under the FCCC. Direct effects occur when the gas itself is a greenhouse gas, whereas indirect radiative forcing occurs when chemical transformation of the original gas produces a gas or gases that are greenhouse gases, or when a gas influences the atmospheric lifetimes of other gases.

The concept of GWP has been developed to allow scientists and policy-makers to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. By definition, a GWP is the time-integrated change in radiative forcing due to the instantaneous release of 1 kg of a trace gas expressed relative to the radiative forcing from the release of 1 kg of carbon dioxide. In other words, a GWP is a relative measure of the warming effect that the emission of a radiative gas might have on the surface troposphere. The GWP of a greenhouse gas takes into account both the instantaneous radiative forcing due to an incremental concentration increase and the lifetime of the gas. Although any time period can be chosen for comparison, the 100-year GWPs recommended by the IPCC are used in this report (IPCC, 1996) (Table 3.2).

Structure of the Inventory

Canada's national greenhouse gas emission inventory has been structured to match the reporting requirements of the IPCC and has been divided into six major categories: Energy, Industrial Processes, Agriculture, Land-Use Change & Forestry, Waste, and Solvents & Other Products (Figure 3.3). Each of these categories is further subdivided within the inventory — for example, energy into fuel combustion and fugitive fuel-related emissions, and industrial processes into non-combustion-related emissions from the production, processing, and use of various mineral, chemical, metal, and non-energy products — and care has been taken to ensure that no double-counting of emissions has taken place between or within categories. For

TABLE 3.2 GLOBAL WARMING POTENTIALS OF VARIOUS GREENHOUSE GASES

Species	Chemical Formula	Lifetime (Years)	GWP (Time Horizon in Years)		
			20	100	500
CO_2	CO_2	Variable	1	1	1
Methane	CH_4	12±3	56	21	6.5
Nitrous Oxide	N_2O	120	280	310	170
HFC-23	CHF_3	264	9 100	11 700	9 800
HFC-32	CH_2F_2	5.6	2 100	650	200
HFC-125	C_2HF_5	32.6	4 600	2 800	920
HFC-134a	CH_2FCF_3	14.6	3 400	1 300	420
HFC-152a	$C_2H_4F_2$	1.5	460	140	42
HFC-143a	$C_2H_3F_3$	48.3	5 000	3 800	1 400
HFC-227ea	C_3HF_7	36.5	4 300	2 900	950
Sulphur Hexafluoride	SF_6	3 200	16 300	23 900	34 900
Perfluoromethane	CF_4	50 000	4 400	6 500	10 000
Perfluoroethane	C_2F_6	10 000	6 200	9 200	14 000

Note: Global warming potential referenced to the updated decay response for the Bern carbon cycle model and future CO_2 atmospheric concentrations held constant at current levels.

Source: IPCC (1996).

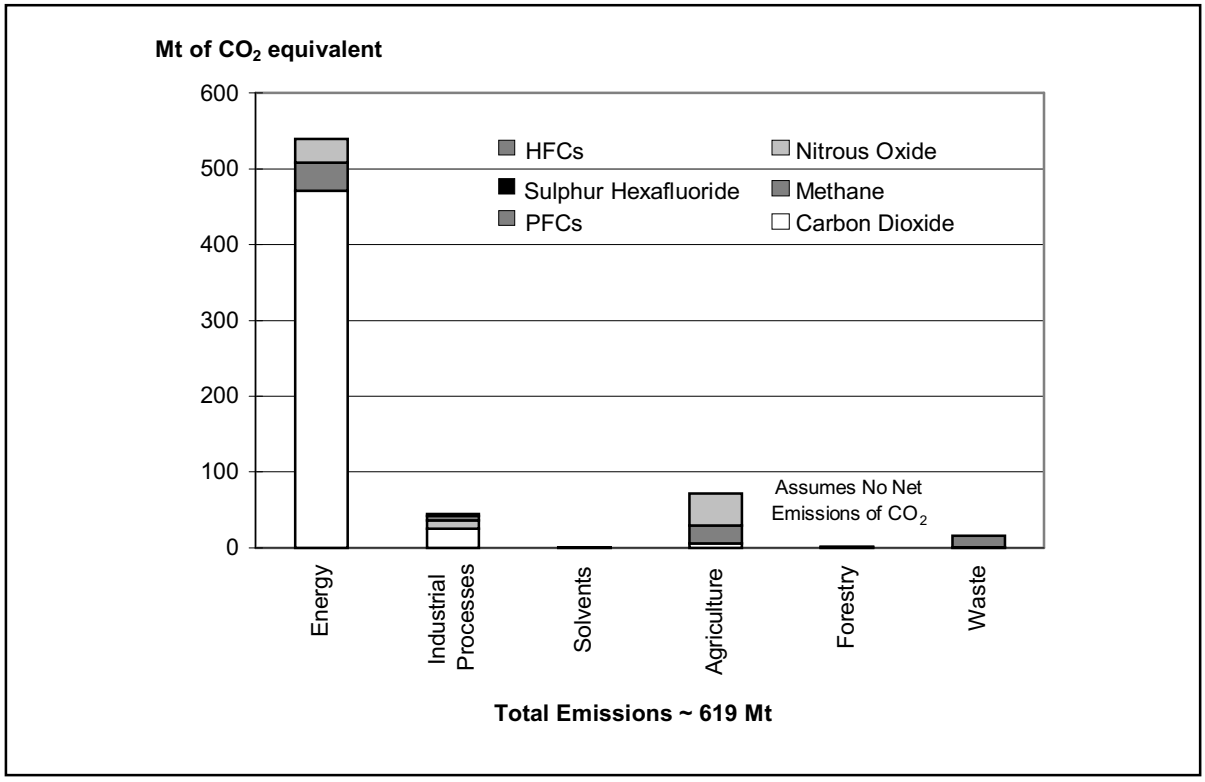


FIGURE 3.3 CANADA'S NATIONAL GREENHOUSE GAS EMISSION INVENTORY, 1995

purposes of discussion here and for simplification, emission sources are divided into two general categories: energy and non-energy.

Energy Sources

Emissions from energy activities, as defined by the IPCC Inventory Guidelines (IPCC, 1995), include total emissions of all greenhouse gases from all combustion activities[1] as well as all fugitive fuel-related emissions. For combustion-related emissions, a methodology upon which the IPCC Reference Approach is based was used. Carbon dioxide emissions were estimated in a top-down[2] format by multiplying emission factors[3] specific to the fuels used in Canada by the quantities of fuels consumed in various sectors of the economy. Emissions of methane and nitrous oxide from combustion activities were estimated in a similar fashion, using emission rates derived from source test measurements reported in the IPCC Inventory Guidelines (IPCC, 1995) and from a number of studies conducted in the United States and Canada (U.S. EPA, 1985; DeSoete, 1989; Ballantyne et al., 1994).

Fugitive emissions associated with the production, processing, transmission, and distribution of fossil fuels were estimated based on emission rates specific to Canada and are described in more detail in the published national inventory (Jaques et al., 1997). Specific studies were undertaken in Canada that examined greenhouse gas emissions from the upstream oil and gas sector, coal mining, oil sands mining, and natural gas distribution (Picard et al., 1992; Augsten et al., 1994; CGA, 1995). Although the results of these studies indicated that emissions from all sources were well within the bounds of the emission rates provided in the IPCC guidelines, they also served to illustrate the importance of using country-specific information when and where it is available, especially in cases where reported emission rates cover extremely wide ranges. Aggregated emission rates, activity data, and associated emissions have been summarized and are provided in a separate addendum in the standard IPCC reporting format.

A summary of emissions from energy-related sources, by gas and by sector for the period 1990–1995, is shown in Table 3.3.

Bunkers

Emissions from bunker fuels (fuels not consumed in the country of origin) have been excluded from the national inventory (as per IPCC guidelines) and are reported here separately. The emission estimates are based on reported fuel sales to air and marine vessels of foreign registration and include emissions from the three main greenhouse gases (i.e., carbon dioxide, methane, and nitrous oxide) (Table 3.4).

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1 Carbon dioxide emissions from the combustion of biomass fuels are not included in totals from the energy sector.

2 Top-down and bottom-up are terms used to describe the level of detail within an inventory. Here, bottom-up is defined to include point or establishment-level discrete sources, whereas top-down usually refers to a sectoral level of detail.

3 Emission factors can be defined as the rate at which a pollutant is released to the atmosphere as a result of some process activity or unit throughput and, for carbon dioxide, are mass balance derived and based on the carbon contents of the fuels and the quantity of the carbon in the fuel oxidized upon combustion (generally 99%).

TABLE 3.3 CANADA'S GREENHOUSE GAS EMISSIONS FROM ENERGY SOURCES, 1990–1995

	1990	1991	1992	1993	1994	1995
CO_2 (thousand kt)						
Stationary Combustion						
Power and Steam Generation	94 500	95 700	103 000	93 000	94 800	103 000
Industrial	75 300	73 100	71 300	72 500	73 400	77 000
Residential and Agricultural	43 200	41 600	43 700	45 700	45 800	44 500
Commercial	26 000	25 800	26 300	28 600	28 100	29 900
Refined Petroleum Products	345	429	629	609	641	649
Producer Consumption	40 300	38 800	41 000	41 800	42 700	44 000
Pipelines	6 670	7	9 550	10 000	10 400	11 600
Mobile Fuel Combustion	140 000	134 000	136 000	139 000	147 000	150 000
Total CO_2	426 000	417 000	431 000	431 000	443 000	461 000
CH_4 (kt)						
Stationary Combustion						
Power and Steam Generation	1	0.8	0.8	0.7	0.7	0.8
Industrial	2	1.6	2.7	1.6	1.7	1.7
Residential and Agricultural	2	1.6	1.4	1.7	1.7	1.5
Commercial	1	0.5	0.5	0.5	0.5	0.6
Other	0	0.2	0.0	0.1	0.2	0.2
Producer Consumption	1	1.0	0.0	1.1	1.2	1.2
Prescribed Fires	38	48	37	34	13	13
Wood/Wood Waste	19	20	18	18	17	18
Upstream Oil	1 200	1 200	1 300	1 400	1 500	1 600
Gas Transmission	110	110	130	130	140	150
Coal Mining	91	99	87	87	84	82
Mobile Fuel Combustion	23	21.0	20.0	20.0	20.0	20.0
Total CH_4	1 500	1 500	1 600	1 700	1 800	1 900
Total CH_4 (kt CO_2 eq.)	30 000	32 000	34 000	35 000	37 000	39 000
N_2O (kt)						
Stationary Combustion						
Power and Steam Generation	2	2	2	2	2	3
Industrial	1	1	1	1	1	1
Residential and Agricultural	0	0	0	0	0	0
Commercial	0	0	0	0	0	0
Producer Consumption	0	0	0	0	0	0
Other	1	1	1	1	1	1
Prescribed Fires	1	2	1	1	0	0
Wood/Wood Waste	2	3	2	2	2	3
Mobile Fuel Combustion	29	31	35	40	45	48
Total N_2O	37	40	43	48	52	56
Total N_2O (kt CO_2 eq.)	11 000	12 000	14 000	15 000	16 000	17 000
Sum: Energy GHGs (kt CO_2 eq.)	468 000	461000	479 000	481 000	496 000	517 000
Sum: Energy and Non-Energy [a]	567 000	559 000	575 000	581 000	599 000	619 000
Change from1990		–1%	1%	2%	6%	9%

[a] See Table 3.5.

Non-Energy Sources

In 1995, emissions associated with non-energy[4] activities were estimated to be about 102 Mt, or about 16.5% of the total. As a category, they can be defined as total emissions of all greenhouse gases from industrial processes, agriculture, forestry, and waste management processes, where greenhouse gases are a by-product of the various production processes, and exclude greenhouse gas emissions from the

[4] Non-energy emission sources also include emissions associated with the use of fossil fuels as feedstocks, as reported in Canada's "Energy Statistics Handbook" (Statistics Canada, 1990–1995), including emissions associated with the production and use of chemicals, lubricants, and various products used in the production of commodities such as steel and aluminum. However, if the fossil fuels used as feedstock are excluded from this category, the non-energy emissions are reduced substantially, representing about 12% of the total greenhouse gas emissions.

TABLE 3.4 EMISSIONS FROM BUNKER FUEL USE IN CANADA, 1990–1995

	Emissions (kt CO_2 equivalent)					
Bunker	1990	1991	1992	1993	1994	1995
Aviation	2 949	2 536	2 773	2 506	2 536	2 681
Marine	2 164	2 248	2 039	1 934	2 175	2 133

combustion of fuels for energy purposes. The sources that contribute to the non-energy sector are shown in Table 3.5.

Industrial Processes

Cement and lime production

Carbon dioxide is emitted during the process of cement manufacture and lime production. These sources together accounted for about 8% of the total non-energy greenhouse gas emissions in 1995. Carbon dioxide is produced during the production of clinker, an intermediate product from which cement is made, whereas calcined limestone (or quicklime) is formed by heating limestone to decompose the carbonates. As with cement production, this is usually done at high temperatures in a rotary kiln, and the process releases carbon dioxide.

Limestone and soda ash consumption

Limestone is used in a number of industries. In addition to its consumption in the production of cement and lime for resale, two other processes requiring the material are metallurgical smelting and glass making. As these industries

TABLE 3.5 CANADA'S GREENHOUSE GAS EMISSIONS FROM NON-ENERGY SOURCES, 1990–1995

	1990	1991	1992	1993	1994	1995
CO_2 (kt)						
Lime Production	1 850	1 880	1 880	1 880	1 930	1 990
Cement Production	5 870	4 690	4 300	4 700	5 290	5 360
Raw Limestone Consumption	371	362	389	235	216	216
Soda Ash Consumption	68	56	64	64	64	64
Soils	7 090	5 820	5 000	3 940	3 490	2 480
Municipal Solid Waste Incineration	691	700	710	720	728	737
Undifferentiated Non-Energy Petroleum Uses	21 200	23 200	24 000	26 500	27 700	27 800
Total CO_2	37 200	36 700	36 300	38 000	39 400	38 600
CH_4 (kt)						
Landfills	821	812	826	845	855	869
Animals	646	650	641	671	701	725
Manure	246	248	247	257	263	271
Wastewater Treatment	17	17	17	17	18	18
Composting	0	0	1	1	1	2
Municipal Solid Waste Incineration	1	1	1	1	1	1
Total CH_4	1 730	1 730	1 730	1 790	1 840	1 880
Total CH_4 (kt CO_2 eq.)	36 300	36 300	36 400	37 600	38 600	39 600
N_2O (kt)						
Anaesthetics & Propellants (Non-HFC)	1	1	1	1	1	1
Municipal Solid Waste Incineration	0	0	0	0	0	0
Wastewater Treatment	0	0	0	0	0	0
Nitric Acid Production	3	2	3	3	2	3
Adipic Acid Production	35	32	32	29	35	35
Fertilizer Use	11	11	12	13	13	13
Total N_2O	49	47	48	46	53	52
Total N_2O (kt CO_2 eq.)	15 300	14 600	14 900	14 300	16 400	16 100
CF_4 (kt)	1	1	1	1	1	1
C_2F_6 (kt)	0.08	0.08	0.08	0.09	0.08	0.07
SF_6 (kt)	0.1	0.1	0.1	0.1	0.1	0.1
HFC — all uses (kt CO_2 eq.)	0	0	0	0	0	500
Total Other Gases (kt CO_2 eq.)	9 000	10 000	9 000	10 000	9 000	9 000
Sum: Non-Energy GHGs (kt CO_2 eq.)	97 700	97 600	96 600	100 000	103 400	102 300

utilize limestone at high temperature, the limestone is calcined to lime, producing carbon dioxide by the same reaction as described above. Carbon dioxide emissions are associated with the use of soda ash in industries such as chemical and glass manufacturing. In Canada, soda ash is used in the glass industry's high-temperature production processes. Carbon dioxide is emitted as the soda ash decomposes in the glass furnace. In 1995, emissions attributable to the use of limestone and soda ash contributed less than 0.5% of the total non-energy emissions and have remained relatively stable over the last few years.

Non-energy uses — Undifferentiated

A number of petroleum-based products, considered non-energy uses or by-products from combustion, sequester carbon and should not be considered as emission sources of carbon dioxide. These include plastics, rubber, asphalt, bitumen, and formaldehyde (Okken and Kram, 1990). On the other hand, there are a number of non-energy sources that release carbon relatively quickly, including naphthas, lubricants, liquefied petroleum gases (LPGs) and natural gas used as feedstocks (e.g., ammonia [NH_3] production and carbon black), and coke and coals.

Emissions were estimated for these products using the following assumptions about the percentage of carbon not sequestered in the product: for petrochemical feedstocks, LPGs, and naphthas, 20%; for lubricants, 50%; and for non-energy uses of natural gas, 67%. For coals, coke, and coke oven gases used for non-energy purposes, it has been assumed that 100% of the carbon is emitted. Total emissions from non-energy uses of these feedstocks and substances, including emissions associated with ammonia and aluminum production, were estimated to be about 13.6 Mt in 1990 and 16.7 Mt in 1995, an increase of about 27%.

Nitric acid manufacturing

Nitric acid (HNO_3) is an intermediate product formed during the manufacture of nitrogen fertilizers. During its production from ammonia, a large amount of nitrous oxide is emitted. Over the period 1990–1995, emissions from this source remained relatively constant at about 780 kt of carbon dioxide equivalent.

Adipic acid production

A major technology change in Dupont's manufacturing process will reduce the emission rate of nitrous oxide from the adipic acid production process by 95%. The projected phase-in period for this new technology, between 1997 and 2000, was obtained from the sole producer, and this initiative represents an emission reduction in the non-energy sector of about 10 Mt, or about 11% of total non-energy-related emissions.

Primary aluminum industry (source of CF_4 and C_2F_6)

Primary aluminum is produced in two steps. First, bauxite ore is ground, purified, and calcined to produce alumina, which is imported by Canada. Following this, the alumina is electrically reduced to aluminum by smelting in large pots. Three greenhouse gases — carbon dioxide, carbon tetrafluoride or perfluoromethane, and carbon hexafluoride or perfluoroethane — are known to be emitted during the reduction process. In 1995, these by-product emissions were responsible for about 6 Mt of (carbon dioxide equivalent) greenhouse gas emissions. This figure represents approximately 7% of total non-energy emissions. The Canadian industry is currently in the process of upgrading and improving its technology. This will gradually reduce the emission rate.

Technology penetration rates were deduced from statements made by Alcan and the Association de l'Industrie de l'Aluminium de Québec (Unisearch Associates, 1994).

Magnesium production (source of SF_6)

Sulphur hexafluoride is used as a cover gas in the manufacture of magnesium and is emitted. Emissions are based on the quantities of sulphur hexafluoride reported consumed by the magnesium industry.

Forestry and Land-Use Change

Although it is not possible to report Canada's net greenhouse gas emissions from the forestry sector in a fashion that fits the IPCC inventory framework, it is important to provide some information on the results of the work that has taken place, which are currently being used to develop forest sector indicators in Canada. Canada has a total land area of 997 million hectares, of which the total forest area is about 418 million hectares. Of the total forested area, approximately 82% is in the boreal forest zone and 18% in the temperate zone (Vineberg and Boyle, 1991).

Statistics for the mid-1970s to the mid-1980s indicate that the change in forested area due to changes in land use was negligible. Canadian forests cover approximately 50% of Canada's land surface and represent 10% of the Earth's forested area. Analysis of the carbon budget for all Canadian forests is not yet complete; however, results for various forest zones, including the boreal and sub-Arctic forests, which represent about 75% of Canada's forest area, are available. Estimates of the carbon currently stored in Canadian forests and changes in the carbon budget for the boreal and sub-Arctic zones over the period 1920–1990 have been developed by Kurz and Apps (Apps and Kurz, 1991; Kurz et al., 1991) and are reported here. Year-to-year trends for the period 1990–1994 are not yet available.

In Canada, the amount of carbon stored in all Canadian forests is estimated to be approximately 221 Gt. This includes 14.5 Gt in standing vegetation biomass (trunks, branches, roots, etc.), 70.6 Gt in forest soils, 135 Gt in peatland soils, and approximately 0.6 Gt in forest products. Forest products (i.e., lumber, furniture, etc.) represent the total carbon accumulated from forest harvesting over the last 40 years; although it is a small carbon pool relative to the other forest carbon pools (0.3% of the total), it is important in terms of the annual flux, or movement of carbon between pools.

Agriculture

Emissions from all anthropogenic activities within the agriculture sector, excluding fuel combustion, are covered in this section. Ongoing research suggests that in 1995, emissions from the agriculture sector, as defined by the IPCC were about 5% of the total greenhouse gas emissions in Canada. However, ongoing research suggests that emissions may be higher. Nitrous oxide was the primary greenhouse gas in 1991, accounting for 45% of the total agriculture sector emissions, followed by methane (30%) and carbon dioxide (25%). The major sources of emissions were direct soil emissions, enteric fermentation, and soil oxidation.

Carbon dioxide from agricultural soils

In order to develop an estimate of carbon dioxide emissions that adequately reflects the diverse and myriad complexities that affect carbon fluxes in agricultural soils, a computer modelling approach (the Century model) was used. This model contains inputs for multiple soil organic

matter compartments, estimates decomposition rates that vary as a function of soil temperature and precipitation, and provides data for both carbon and nitrogen flows (Smith et al., 1997). Carbon loss from agricultural soils is approaching zero (equilibrium), and soils may become a small sink by the year 2000.

Methane production from herbivores

Methane is produced by herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream. This process results in methanogenesis in the rumen, and the methane is emitted by eructation and exhalation. Some methane is released later in the digestive process by flatulation. Animal eructation and manure methane emissions are directly proportional to animal populations. Emission estimates have been made based on animal populations and emission rates that reflect conditions in Canada.

Fertilizer use

Nitrous oxide can be released from soils under either anaerobic or aerobic conditions. Liberation of nitrous oxide from soils is associated with the oxidation of mineral nitrogen. When either organic or inorganic nitrogen fertilizers are applied, most of the nitrogen is oxidized to nitrates before it is taken up by the plants**.** This oxidation process is known as nitrification. Emissions from the use of fertilizers increased about 18% over the period 1990–1995.

Waste

This section discusses emissions from all sources of waste, including landfills, incineration, wastewater treatment, and composting. Carbon dioxide emissions attributable to biomass are not included in this section, as in theory there may be no net emissions if the biomass is sustainably produced.

Municipal solid waste incineration and wastewater treatment

Several municipalities in Canada utilize solid waste incinerators to reduce the quantities of waste sent to landfills and the impact of toxics on the environment. Typical municipal solid waste incinerators are either refractory-lined or water-walled with a grate on which refuse is burned. The details of the emission factor derivation are contained in a previous publication (Jaques, 1992). Carbon dioxide emissions are influenced mainly by the carbon content of the waste, whereas methane and nitrous oxide emissions are affected more by the type of incinerator and any emission control technologies that may be installed. Data were obtained on the quantities of waste generated, the percentage derived from organic matter, and the quantities incinerated. The IPCC methodology has been followed, in that emissions of carbon dioxide exclude emissions from organic waste combustion but include emissions derived from fossil-fuel-based products.

Methane is produced in domestic wastewater when the organic material that is present is allowed to decompose in an anaerobic environment. Nitrous oxide can also be produced in wastewater through the microbial denitrification of the organic matter present. The methodology utilized, although similar to that outlined by the IPCC, has been derived for conditions specific to Canada.

Landfills

Landfill gas, which is composed mainly of methane and carbon dioxide, is produced

by anaerobic decomposition of organic degradable wastes. This process begins after the waste has been in the landfill for 10–50 days. Although the majority of methane and carbon dioxide is generated within 20 years of landfilling, emissions can continue for 100 years or more. Methane emissions from landfills in Canada were estimated using the U.S. EPA landfill gas generation (Scholl Canyon) model and data on the quantity of refuse deposited each year in Canadian landfills over the past 50 years.

Landfills are a significant source of methane emissions in Canada and account for about 18% of current non-energy greenhouse gas emissions. In keeping with the IPCC methodology, emissions of carbon dioxide from organic waste decomposition in landfills were excluded from the inventory.

Composting

Emissions from composting are a relatively small component of the inventory and represent, along with wood waste landfills, a new source to Canada's inventory. Anaerobic decomposition of food and yard waste from composting results in the formation of methane. Emission estimates were derived based on the quantities of waste diverted from landfills and an emission rate of 7.2 kg of methane per tonne of waste composted (Proctor & Redfern Limited and Ortech Corporation, 1993).

Solvents and Other Products

Nitrous oxide is used in medical applications, primarily as a carrier gas. Although it has anaesthetic and analgesic properties, nitrous oxide is primarily used in carrier gases with oxygen to administer more potent inhalation anaesthetics for general anaesthesia. It is also used as an anaesthetic in various dental and veterinary applications. Nitrous oxide is used as a propellant for pressure and aerosol products, primarily in the food industry. It is often used in conjunction with carbon dioxide, as it helps to neutralize the acidic taste imparted by the carbon dioxide. In addition, it stabilizes the product so that it is not ejected as a thin stream.

Uncertainties

Of particular concern with emission inventories is their accuracy. Although there are many causes of uncertainties, most are due to the following:

- differences in the interpretation of source and sink category definitions, assumptions, units, etc.;
- inadequate and incorrect socioeconomic activity data used to develop the emission estimates;
- inappropriate application of emission factors to situations and conditions for which they do not apply; and
- actual empirical uncertainty of measured emission data and the basic processes leading to emissions.

Use of the mean and standard deviation of the normal distribution of sectoral expert estimates (obtained from industry experts across Canada) for each sector and then for each case permitted the addition of sectoral emissions to develop the overall uncertainty. A full discussion of the methodology can be found in McCann et al. (1994). Overall uncertainties for the three main greenhouse gases were developed based on a stochastic model and are estimated to be about 4% for carbon dioxide, 30% for methane, and 40% for nitrous oxide. It should be noted that individual sector

uncertainties can be even greater. Nevertheless, the overall uncertainties associated with the carbon dioxide emission estimates, which dominate the greenhouse gas inventory, are considered extremely low.

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CHAPTER 4: Policies and Measures

The National Action Program on Climate Change (NAPCC)

The National Action Program on Climate Change (NAPCC) is Canada's response to the United Nations Framework Convention on Climate Change (FCCC). This program, which was developed as a federal, provincial, and territorial government initiative and was approved by federal, provincial, and territorial ministers of energy and environment on February 20, 1995, sets the strategic directions for pursuing the nation's objective of meeting its current commitment of stabilizing greenhouse gas (GHG) emissions at 1990 levels by the year 2000. The program also provides guidance for actions beyond 2000.

The NAPCC is a living plan — one that pursues sectoral and broad-based opportunities through the development of appropriate actions and measures by private and public jurisdictions. It includes a formal review process, which will allow adjustments to be made as required. The NAPCC recognizes Canada's three-pronged approach to addressing the issue of climate change. This approach includes taking actions to mitigate greenhouse gas emissions (including sequestrations), improving our scientific understanding of the issue, and taking action to adapt to potential climate change.

The NAPCC reflects Canada's intention to manage climate change within the overall context of sustainable development. Such an approach demonstrates an ability to take effective action on environmental issues while pursuing economic development. This can also serve as an important example to stimulate further international action.

This emphasis on sustainable development is manifested through several principles that help describe the environmental, economic, social, and political considerations that need to be taken into account in formulating a plan on climate change and in providing guidance in the selection of measures. These principles are the precautionary principle, shared responsibility, effectiveness, competitiveness, transparency and accountability, flexibility, and international cooperation.

In addition to these principles, the NAPCC is based on several process-related "strategic directions" that are intended to guide Canada as it works towards meeting its climate change commitments. The strategic directions provide parameters for judging the quality of the program itself. They include a dynamic program, an open and transparent review, building on successes, identifying new opportunities, removing barriers, supporting voluntary actions, developing technologies and expertise, and covering a wide range of actions.

Based upon the above principles and strategic directions, the following broad-based mitigative actions have been identified: the Voluntary Challenge and Registry (VCR) program, Joint Implementation (JI), a national communications program, and international cooperation. The NAPCC also outlines the mitigation activities planned or under way in a number of different sectors, including government, industry, residential, commercial, agricultural, and forestry sectors. The NAPCC also sets the strategic directions for actions related to science and adaptation.

Built into the NAPCC is a review process that aims to inform stakeholders and policy-makers of progress being made and to identify areas of opportunity for further actions. These reviews will utilize indicators of progress and other analysis to:

- track changes in Canada's greenhouse gas emissions;
- identify broad-scale factors influencing changes in emissions;
- assess the impacts of mitigative actions on greenhouse gas emissions;
- assess the economic implications of actions to limit emissions; and
- identify areas of opportunity for further action to address climate change.

The first review of the NAPCC was published by the National Air Issues Coordinating Committee in late November 1996. It is entitled 1996 Review of Canada's National Action Program on Climate Change. Canada's Second National Report on Climate Change to the FCCC reflects the findings of this review of the NAPCC.

Governments are undertaking initiatives in the areas of energy efficiency, renewable and alternative energy, education, electricity policy, and waste management. Besides these government initiatives, an important component of the NAPCC is the VCR program, which engages the private sector, governments, and other organizations to undertake, on a voluntary basis, initiatives to limit or reduce greenhouse gas emissions. These commitments and action plans are registered with the VCR for public scrutiny and information sharing. The VCR, which is less than two years old, has over 619 companies and organizations registered (as of December 1996), and they account for over half of the greenhouse gas emissions in Canada. Of those registered with the VCR, 319 have action plans that generally address energy efficiency, energy demand-side management, fuel substitution, process redesign, management practices, or carbon offsets. Details of progress of the VCR program may be found in the report Voluntary Challenge and Registry, December 1996 Progress Report. Further details of individual companies' actions can be found on the Internet site http://www.vcr-mvr.ca. Individuals (homeowners, drivers of vehicles) are not registered with the VCR but are addressed through government programs and VCR action plans of electric and natural gas utilities on the abatement of greenhouse gas emissions.

For more details on policies and measures, refer to Appendix I, Table 1. It gives an overview of some of the policies and programs in effect among federal, provincial, territorial, and municipal governments in Canada. It is not an exhaustive list (over 475 policies and programs were identified, and these involved thousands of initiatives), but it is meant to be a representative list of the types of activities taking place. Most of the programs had their origin primarily as energy efficiency programs and were not designed to account for reductions in greenhouse gas emissions.

The most probable impact of initiatives through the year 2020 has been estimated in the Natural Resources Canada (NRCan) publication Canada's Energy Outlook: 1996–2020 (NRCan, 1997). In developing this estimate, rather than attributing specific impacts to each initiative, an approach was adopted that provides an assessment of the impact of sets of measures on segments of energy use. This approach was chosen in order to avoid the double-counting that characterizes the attribution of unique impacts to complementary initiatives.

Measuring the Impacts of NAPCC Initiatives

The reference case outlook produced by NRCan incorporates estimates of the impact of announced and likely to be announced federal, provincial, and municipal initiatives focused on energy efficiency, alternative energy, and reductions of greenhouse gas emissions. These initiatives include all measures either directly related to or reflecting the objectives of the NAPCC, in particular the commitments to the VCR program by the private sector and other organizations for greenhouse gas abatement initiatives.

The methodology to develop the impact of initiatives is complex. In brief, however, the process involves three steps: an understanding of the characteristics of each initiative, a translation of this information into a judgement about market effects, and a calculation of the ultimate impact of each initiative on energy use or levels of emissions.

The review of the NAPCC identified over 475 policies and programs among federal, provincial, territorial, and municipal governments geared primarily to promoting energy efficiency, which also could have impacts on greenhouse gas emissions. NRCan has reviewed several thousand initiatives under these policies and programs and identified 272 that can reasonably be expected to achieve definable energy efficiency and/or emission reduction results. In addition, 235 VCR submissions with quantifiable action plans were examined. These initiatives are categorized by type and sector in Table 4.1.

It is evident that the bulk of the initiatives identified are voluntary in nature. It should be noted, however, that the small number of regulatory measures along with VCR commitments account for a large percentage of the total impact of NAPCC initiatives.

TABLE 4.1 NAPCC: IDENTIFIED QUANTIFIABLE INITIATIVES

Major Sectors	*Initiatives*				
	Information & Suasion	*R&D*	*Regulations*	*Financial Incentives*	*VCR*
End Use					
– Residential	46	16	19	6	–
– Commercial	87	18	11	2	–
– Industry	24	17	6	4	127[a]
– Transport	11	4	0	0	–
Fossil Fuel	–	–	–	–	86[b]
Electricity	–	–	–	–	11[c]
Non-Energy	–	1	–	–	1[d]
Total	*168*	*56*	*36*	*12*	*235*

CIPEC = Canadian Industry Program on Energy Conservation
CAPP = Canadian Association of Petroleum Producers
CEPA = Canadian Energy Pipeline Association

[a] CIPEC commitment of 1% energy efficiency was reflected.
[b] CAPP, CEPA, and Oil Sands Operation proposed GHG emissions were used.
[c] Canadian Electrical Association submission was used.
[d] Dupont Chemical's commitment to reduce N_2O emissions from adipic acid production process.

The impacts of initiatives, or groups of related initiatives, were developed by identifying the major drivers, such as regulations governing the increased energy efficiency of purchased equipment and the consequences of this increased efficiency as the stock of equipment turns over.

Several points should be noted in the assessment of the impact of initiatives on emissions:

- Conceptually, the estimates are incremental, in the sense that the results would not be expected to occur in the absence of the initiative.
- In general, the results reflect the incremental impact from 1995. Initiatives in place prior to 1996 are assumed to be already embodied in the historical data. Only additional activity associated with a particular initiative (e.g., a further ratcheting up of energy efficiency standards or additional funding for an ongoing program) is included in the impacts.
- Given the complementarity of many initiatives, the results typically reflect the impacts of related measures rather than the individual effect.
- The VCR, in particular, is viewed as a mechanism that complements other initiatives and accelerates their take-up. The exceptions are the fossil fuel production, electricity generation, and non-energy VCR commitments, which are the only initiatives in these sectors and are separately identified.
- All initiatives are assumed to remain in place (or be replaced by similar measures) and continue to receive the same level of funding throughout the projection period.

Emissions from Direct End Use of Energy

Emissions from the direct end use of energy are those generated from the combustion of fossil fuels in the four end-use subsectors: residential, commercial (including institutions and public administration), industrial,[1] and transportation.[2] Carbon dioxide (CO_2) accounts for the overwhelming share of these emissions, with small volumes of nitrous oxide (N_2O), principally from road transportation.

Figure 4.1 shows the projections for greenhouse gas emissions by the end-use sectors. The emissions portrayed are those associated with the direct combustion of fossil fuels (principally refined petroleum products and natural gas). Emissions from the generation of electricity to satisfy end-use demand are discussed in the next section.

End-use emissions are projected to increase from 315 Mt in 1990 to 348 Mt in 2000 and 412 Mt in 2020, an overall growth of just over 30%. The largest source is the transport sector, obviously linked to the levels of gasoline, diesel, and other motive fuels. Emissions from the industrial sector grow despite significant declines in energy intensity. The commercial sector contributes a constant and the residential sector a declining share.

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1 Emissions from non-combustion uses of energy (feedstocks, asphalt, etc.) and from fuel use in petroleum refining are included in the industrial sector.

2 Transportation includes emissions from road, railway, air, and marine traffic. Energy used for transportation in 1995, by fuel type, was as follows: 60% gasoline (automobiles and light-duty trucks), 26% diesel (heavy trucks, railway, buses), 9% aviation fuels, 3% heavy fuel oil (marine), and 2% other.

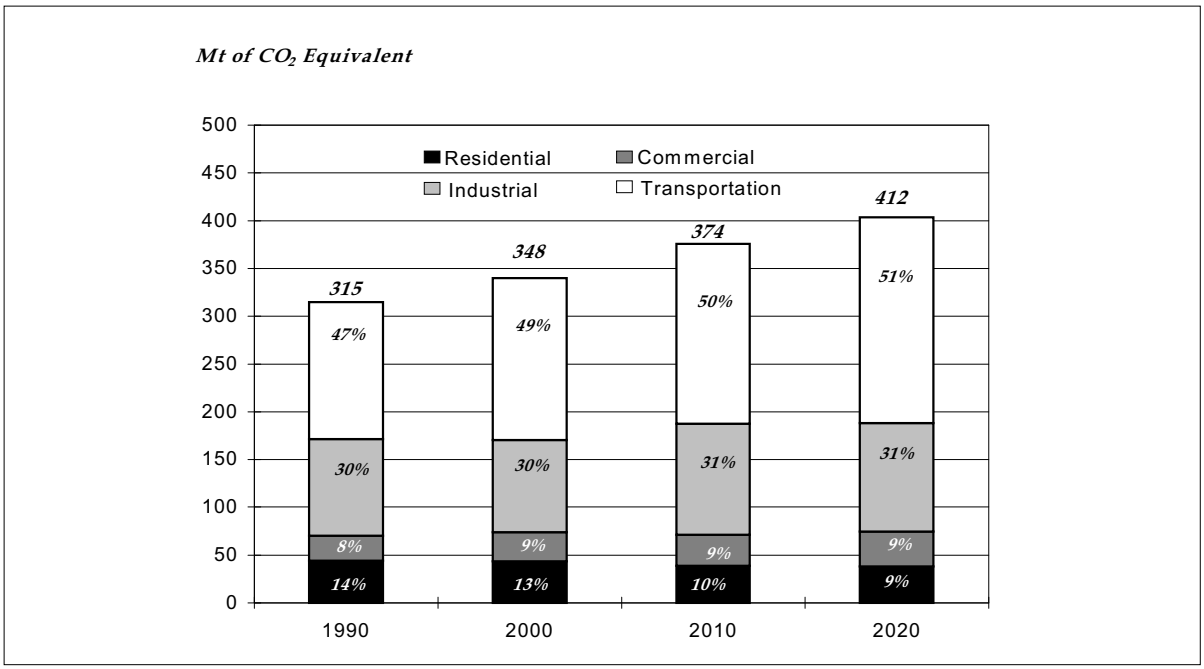

FIGURE 4.1 GREENHOUSE GAS END-USE EMISSIONS, 1990–2020

TABLE 4.2 END-USE SECTOR: IMPACT OF INITIATIVES ON GREENHOUSE GAS EMISSIONS

	Emissions (Mt of CO_2 equivalent)			
	1990	*2000*	*2010*	*2020*
Pre-Initiatives Level	315	360	401	475
Impact of Initiatives from Residential, Commercial, and Industrial Sectors[a]	–	10	22	54
Impact of Transportation Initiatives	–	2	5	9
Post-Initiatives Level[a]	315	348	374	412

[a] Includes impact of initiatives that reduce electricity use by these sectors.

The projections in Table 4.2 reflect the impact of the many initiatives targeted to the end-use sector and the VCR commitments by the industrial sector. The table also provides the estimates of the impact of these measures on greenhouse gas emissions.

The level of emissions for the end-use sector, in the absence of initiatives, is estimated to grow from 315 Mt in 1990 to 360 Mt in 2000 and 475 Mt by 2020. Initiatives directed at the residential, commercial, and industrial sectors, including associated reductions in electricity requirements, would reduce these levels by 10 Mt in 2000 and 54 Mt in 2020. Transportation initiatives would reduce levels by a further 2 Mt in 2000 and 9 Mt in 2020. The overall impact of initiatives in this sector is to reduce emissions by about 3% in 2000 and 14% in 2020 over projected emissions.

Emissions from Electricity Generation

Over 80% of Canada's electricity production is generated by non-emitting sources: principally hydro and nuclear power, but also biomass and other renewables. Of the greenhouse-gas-emitting sources, coal (14% of electricity production and 82% of emissions) accounts for the largest component, followed by natural gas (3% and 10% of emissions) and fuel oil (1% and 8% of emissions).

The Canadian electricity industry is currently responding to increasing competitive pressures and will likely

undergo significant restructuring over the next decade, which may change fuel choices.

In its VCR submission, the Canadian Electricity Association, representing Canada's electrical utilities, announced planned reductions in greenhouse gas emissions from operations of approximately 3 Mt by 2000 as a result of mitigative actions.

Emissions from Fossil Fuel Production

Greenhouse gas emissions in this sector are derived from two principal sources:

- from fossil fuel use in the exploration, development, production, and transport of crude oil, natural gas, and coal; and
- from fugitive emissions (e.g., carbon dioxide and methane, or CH_4) from the production and transport of these raw materials.

Trends in both sources are closely related to the volume of oil and natural gas production. They can also be modified by improved monitoring and the application of technology.

The carbon dioxide and methane emissions associated with fossil fuel production and transport are presented in Figure 4.2. As expected, the increase in production volumes generates significant increases in levels of emissions. Carbon dioxide emissions, largely related to natural gas and oil sands production, would grow from 49 Mt in 1990 to 72 Mt in 2000 and to 88 Mt in 2020. Consistent with increased gas production, especially for the export market, methane emissions, which grew 25% between 1990 and 1995, would increase further by 2000 before plateauing at about 45 Mt after 2010 (a 55% increase over 1990 levels).

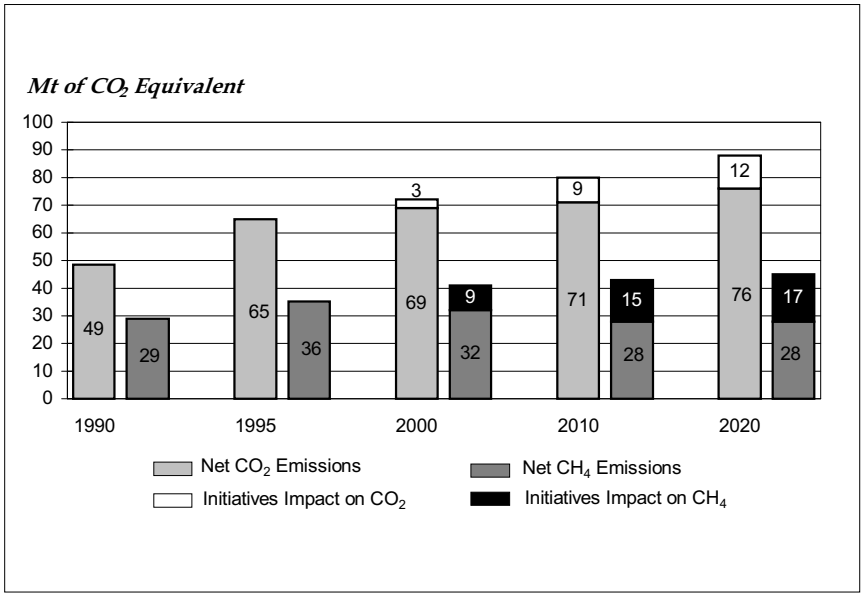

FIGURE 4.2 FOSSIL FUEL PRODUCTION EMISSIONS AND INITIATIVES IMPACT

All of the above results are before consideration of the initiatives by the fossil fuel industry to reduce emissions. Based on an analysis of the VCR submissions of the industry and related evidence, a methodology has been developed that suggests that significant reductions, particularly for fugitive methane emissions, are likely. For carbon dioxide, these initiatives, principally related to improved practice and new technologies employed by oil sands operations, are sufficient to hold levels of emissions to about 75 Mt per year after 2010, despite considerable increases in production. For methane, the expected actions of producers and transporters are sufficient to reduce and then stabilize emissions from 1995 onward. This occurs despite an increase in natural gas production of some 30% over the same period.

Non-Energy Emissions

Non-energy emissions (about 12% of total emissions) include a variety of industrial, agricultural, and waste management processes in which greenhouse gases are a direct by-product. Overall, non-energy emissions in 2000 are projected to be 4% lower than 1990 levels before increasing to 39% above 1990 levels by 2020. The main source of the decline is the major change in Dupont's adipic acid manufacturing process, to be phased in between 1997 and 2000, which will reduce nitrous oxide emissions by approximately 10 Mt of carbon dioxide equivalent. Emissions from cement and lime production experience only modest growth owing to the greater use of fly-ash and further efficiencies in the processing of clinker. All other non-energy sources experience growth in emissions more or less in line with economic and population trends.

Results for Total Greenhouse Gas Emissions

The impact of the NAPCC is accounted for in Table 4.3. The "gap" — the difference between the level of emissions in 1990 and 2000 — reported in the 1995 NAPCC document was 73 Mt, or 13% above 1990 levels. The current projection has the difference declining to 46 Mt, or 8.2% above 1990 levels. (Note: Emissions for the base year 1990 in this projection are 564 Mt, not 567 Mt as given in Chapter 3, due to the fact that Canada's Energy Outlook was developed prior to confirmation of revisions to the inventory data. The next projection will reflect changes in the base year figure.)

The review of actions to date, entitled 1996 Review of Canada's National Action Program on Climate Change, concluded that progress is being made. Actions taken by governments and the private sector are estimated to reduce greenhouse gas emissions from what they would otherwise be, resulting in the projected "gap" between emissions at the 1990 stabilization level and the year 2000 now being 8% rather than 13%. It identified areas of opportunity for progress in greenhouse gas mitigation, adaptation, and science.

The NAPCC is a dynamic and evolving program. New policies and programs will be developed by governments and the private sector in the ongoing attempt to promote the abatement of greenhouse gas emissions in Canada.

References

National Air Issues Coordinating Committee (1995). Canada's National Action Program on Climate Change.

National Air Issues Coordinating Committee (1996). 1996 Review of Canada's National Action Program on Climate Change.

NRCan (Natural Resources Canada) (1997). Canada's Energy Outlook: 1996–2020.

Voluntary Challenge and Registry Office (1996). Canada's Climate Change Voluntary Challenge and Registry: December 1996 Progress Report.

TABLE 4.3 THE GAP — GREENHOUSE GAS EMISSIONS IN 2000 VS. 1990

	Emissions (Mt of CO_2 equivalent)			
	1990	*2000*	*Difference*	*% Increase*
1994 Projection in NAPCC	564	637	73	13.0
Current Projection	564	610	46	8.2

CHAPTER 5: The Emission Projection to 2020

Introduction

This chapter offers a reference projection for Canada's greenhouse gas (GHG) emissions over the next 25 years. The projection covers emissions both from energy use, about 90% of the total, and from non-energy sources. Estimates for the former were developed by Natural Resources Canada (NRCan)[1] and for the latter by Environment Canada.

The projection provided in this chapter is not the only possible outcome. It is, however, a considered view, based on a set of reasonable assumptions concerning factors that influence future emission trends. This said, the use of any alternative subset of assumptions concerning the future will yield a different result. Obviously, also, the estimates are more reliable in the shorter to mid-term given the difficulty of envisioning specific changes in technology over a long span of time.

It should also be stressed that this emission projection is not, in the strict sense of the term, a forecast. This is because one important set of variables — namely, federal and provincial energy, environment, and related policies — is held constant over the projection period.

Maintenance of current policy is not an assumption. Rather, it is a deliberately imposed constraint employed both to examine the implications of the current policy mix and to provide a reference to evaluate the need for, and, if warranted, the impact of, new policies.

The remainder of the chapter is organized as follows:

- ***Modelling Structure*** describes the modelling framework employed to develop the projection.
- ***Major Assumptions*** briefly reviews the major framework assumptions underlying the projection.
- ***Results for Total Greenhouse Gas Emissions*** provides the short- and long-term trends for total greenhouse gas emissions from various perspectives.
- ***Sensitivity Analysis*** explores the sensitivity of the results to changes in major assumptions.
- The final section, ***Summary and Conclusions***, summarizes the major conclusions of the projection and suggests its implications for policy.

[1] The energy-related estimates are included in Canada's Energy Outlook: 1996–2020, published by NRCan (1997).

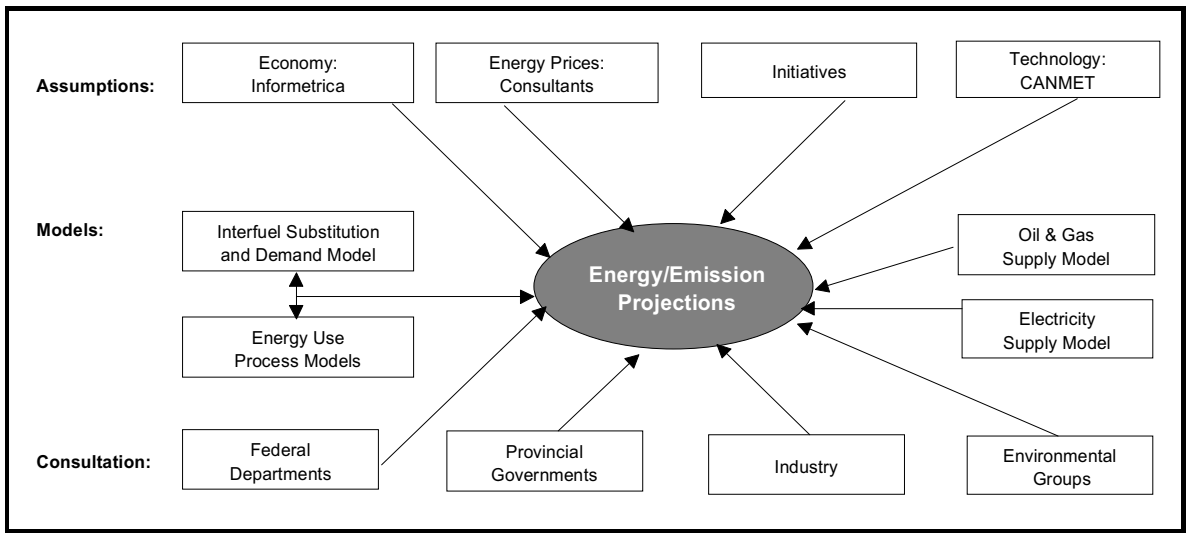

FIGURE 5.1 NRCAN'S FORECASTING PROCESS

Modelling Structure

This section describes the modelling structure underlying Canada's Energy Outlook. The main elements of this structure are portrayed in Figure 5.1 (framework assumptions are discussed in the next section).

In developing the emissions outlook, NRCan uses a modelling structure that combines econometric, end-use, and process techniques.

For energy demand, primary reliance is placed on the Interfuel Substitution and Demand model, which is a highly disaggregated econometric model covering all major fuel types and four end-use sectors (residential, commercial, industrial, and transportation), specified for each of Canada's 10 provinces. Each of the direct energy-consuming sectors is, in turn, further disaggregated. The industrial sector, for example, is divided into 10 industries, whereas transportation separately identifies automobiles, light- and heavy-duty trucks, and the air, rail, and marine subsectors.

Econometric models are extremely powerful in addressing the behavioural aspects of energy demand. They are less successful, however, in reflecting the technological and regulatory reality underlying energy consumption. To capture both aspects, the econometric projections are calibrated, using the same assumptions, with the results of end-use models maintained by NRCan. These end-use models are particularly useful in estimating the effects of initiatives.

Given the projection of electricity demand, the fuel distribution of electricity generation is determined using an optimizing process model known as CANPLAN. This model contains information — capacity, service life, unit cost, etc. — on each existing and hypothetical generating facility in Canada. New capacity is added, usually on a least-cost basis, to satisfy demand, although the generating plans of the utilities are also taken into account. Non-utility generation and cogeneration are also treated as options.

Crude oil, natural gas, and coal supply are projected using a more eclectic modelling structure. First, major oil and natural gas projects are considered, based on their economics and industry announcements. Conventional oil and gas supply is then determined by relating exploration and development costs and the industry's reinvestment behaviour to its cash flow position. Coal supply projections are developed from projected industry requirements. In all three cases, export levels are established by an in-depth examination of domestic and foreign assessments of potential.

For the most part, calculation of greenhouse gas emissions related to fossil fuel consumption is straightforward. Emission factors for each fuel type have been developed by NRCan and Environment Canada based on internationally accepted conventions. For some sources, however, such as fugitive methane emissions from oil and gas production and nitrous oxide (N_2O) emissions from industrial processes, specific assumptions are made, based on studies of technological potential, of the future trend in emissions per unit of output.

A crucial aspect of the outlook process is consultation with experts from the federal and provincial governments, industry associations, and other stakeholders. This involves both informal discussions on the framework assumptions and a more extensive review of the initial results with a wide range of groups. For Canada's Energy Outlook, consultations have been held with all provincial energy departments; with regulatory bodies; with industry organizations representing oil and gas producers, natural gas distributors, electricity generators, major industrial energy users, and automotive manufacturers; and with environmental groups. These consultations do not imply full endorsement of the Outlook by each organization. We believe, however, that they have produced a broad consensus concerning the reasonableness of the results.

Major Assumptions

This section summarizes the major assumptions — energy prices, macroeconomic and demographic factors, and the characterization of current policy — that frame the projection. It concludes with a brief discussion of the approach to measuring the impact of initiatives developed under the National Action Program on Climate Change (NAPCC).

Energy Prices

The Outlook is predicated on continued low energy prices over the next decades. For crude oil, the price of which is determined internationally, and for natural gas, whose price reflects the North American market, the low prices reflect significant resource availability and improved economics as a result of attractive fiscal terms and the continuing application of technology. As shown in Table 5.1, the specific assumptions are for constant real oil prices, at US$20.00 per barrel, and for slightly rising real natural gas prices (from US$1.90/mcf [thousand cubic feet] in 2000 to US$2.05/mcf in 2020). The upward trend in the latter reflects increased North American natural gas demand for electricity generation.

TABLE 5.1 ENERGY PRICING ASSUMPTIONS

	Energy Prices ($1995)			
	1995	2000	2010	2020
Crude Oil ($US/bbl) — WTI at Cushing	18.40	20.00	20.00	20.00
Natural Gas ($US/mcf) — at Henry Hub	1.70	1.90	2.05	2.05
Electricity (¢Cdn/kWh) — Residential Sector				
Ontario	10.1	9.1	8.4	8.4
Canada	8.3	8.0	7.7	7.7
Coal ($Cdn/t)				
Alberta (Domestic Production)	10	10	10	10
Ontario (Imported Coal)	55	55	55	55

Electricity prices will continue to be determined largely at the provincial level. The electricity industry will, however, be increasingly subject to competitive pressures and the consequent need to restructure.[2]

Despite the introduction of competitive wholesale pricing, it is assumed, probably conservatively, that electricity prices for all consumers will remain constant, in real terms, over the projection period. The one exception is in Ontario, where Ontario Hydro has committed to maintain current rates, in nominal terms, until 2005 (Ontario Hydro, 1996) and will reduce its industrial prices, by about 20%, to respond to competitive pressures.

Coal prices are also projected to remain constant in real terms over the projection period. This assumption likely understates the downward pressure on prices from increasing international competition. The large differential between Alberta domestic and Ontario imported coal largely reflects transportation costs.

Macroeconomic and Demographic Assumptions

Macroeconomic and demographic trends are powerful determinants of energy consumption.[3] As shown in Table 5.2, Canada's gross domestic product (GDP) is expected to grow, on average, by 2.2% per year, a rate slightly below that of the U.S. economy. Until the end of the century, growth in the industrial sector is assumed to be strong relative to that in services. This differential reflects both an export-led recovery and the fiscal restraint imposed upon the public administration, education, and health segments of the service sector (which collectively account for 50% of services). Thereafter, industrial growth slows to about 2% per year while the service sector expands slightly more rapidly (albeit from a much reduced base).

It is important not to underestimate the cumulative effect of these small growth rates. By 2000, for example, the Canadian economy is projected to be 12% larger than it was in 1995; by 2020, it is projected to be 70% larger.

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2 The views concerning electricity expressed in this chapter were developed from a consultant's report commissioned by NRCan (Snelson, 1996).

3 The macroeconomic and demographic assumptions are from the Informetrica Winter 1996 forecast. Some elements of the forecast, in particular relating to the growth prospects of specific industries, have been modified following discussions with industry associations.

TABLE 5.2 MACROECONOMIC ASSUMPTIONS

	Average Annual Growth Rates (%)		
	1995–2000	2000–2010	2010–2020
U.S. GDP	2.2	2.5	2.3
Canada GDP	2.2	2.2	2.1
– Industry	3.1	2.0	1.9
– Services	1.7	2.3	2.3
	In Millions		
	1995	2000	2010	2020
Population	29.6	31.0	33.8	36.8
Households	10.6	11.2	12.7	14.5
Vehicles (Cars and Light-Duty Trucks)	15.6	16.2	18.4	21.7
Disposable Income/ Household ($1995)	50 300	49 500	52 200	56 400

Canada's population is assumed to grow from 29.6 million in 1995 to 36.8 million in 2020 (Table 5.2), a rate of increase of approximately 0.9% per year. More than 60% of this increase is related to immigration. The number of households, an important determinant of energy consumption, grows more rapidly (1.2% per year), reflecting complex demographic changes related to the aging of the population. The light vehicle stock (passenger cars, vans, light-duty trucks) increases slightly to 16.2 million by 2000 but grows to almost 21.7 million vehicles by 2020. Also noteworthy are the initial decline in real disposable income per household and its subsequent sluggish recovery. These trends have important implications for the capacity of households to purchase new, more energy-efficient durable goods and housing.

The Policy Setting

As noted in the Introduction, the outlook for greenhouse gases in this chapter is predicated on the maintenance of current federal and provincial energy and related policy over the projection period. Some aspects of current policy are relatively straightforward to identify. Thus, for example, it is assumed that, consistent with the federal–provincial accords reached in the mid-1980s, Canadian oil and natural gas prices and markets will remain deregulated. Similarly, the elements of the tax system that affect energy — royalties, corporate income tax, excise taxes on motive fuels, the Goods and Services Tax (GST), and provincial sales taxes — are assumed to remain in place and in their current form. Table 5.3 identifies the major elements of current policy incorporated in the projections.

TABLE 5.3 CURRENT POLICY — SOME IMPORTANT ELEMENTS

Included

- Continued market orientation (NAFTA) [a]
- Attainment of federal and provincial deficit targets
- Current fiscal (tax, royalty) regimes
- Evolving competition/privatization of electricity markets
- Federal, provincial, and municipal energy efficiency and alternative energy initiatives (including VCR) [b]
- Canada–U.S. Air Quality Agreement
- Additional regulations on fuel quality and refinery operators
- No megaproject support

Not Included

- Further measures to attain GHG stabilization commitment
- Tightened CAFE [c] standards in U.S. or Canada
- Next Steps Smog Strategy
- "Energy Chapter" of the Internal Trade Agreement

[a] NAFTA = North American Free Trade Agreement
[b] VCR = Voluntary Challenge and Registry Program
[c] CAFE = corporate average fuel economy

There are, however, several recent but, at time of writing, evolving policy initiatives, particularly in the environmental area, for which a decision is required concerning their incorporation. These include the Next Steps Smog Strategy, the Canada–U.S. Air Quality Agreement, the "Energy Chapter" of the Internal Trade Agreement for Canadian provinces, and, most obviously, Canada's commitment to limit greenhouse gas emissions. The process to develop the policy, legislation, regulations, and programs for such initiatives is typically protracted, involving lengthy consultations with provincial governments and stakeholders. In some cases, such as the greenhouse gas stabilization commitment, the appropriate mix of policy initiatives has yet to be developed. It is the ongoing role of the NAPCC to develop such initiatives in partnership with stakeholders.

The decision on whether to include such policies in the reference projection is a question of judgement. The "rule of thumb" in reaching this decision is to include a particular policy only if the process of giving it legislative or regulatory expression is sufficiently advanced that an informed public observer could discern the direction and implications of the policy. Table 5.3 summarizes the results of this decision process for major policy elements. The methodology to develop the initiatives has been discussed in Chapter 4.

Results for Total Greenhouse Gas Emissions

This section provides several perspectives on the total greenhouse gas results. Given the policy focus on the stabilization commitment, the examination begins with the "gap" — the difference between levels of emissions in 1990 and 2000.

The gap reported in the 1995 NAPCC document was 73 Mt, or 13% above 1990 levels. The current projection has the difference declining to 46 Mt, or 8.2% above 1990 levels (see Table 4.3). (Note: Emissions for the base year 1990 in this projection are 564 Mt, not 567 Mt as given in Chapter 3, due to the fact that the Outlook was developed prior to confirmation of revisions to the inventory data. The next projection will reflect changes in the base year figure.)

Figure 5.2 provides various perspectives on the gap — pre- and post-initiatives, by emission type, fuel, and sector. Several points are worth noting:

- In the NAPCC projection, the impact of initiatives known at that time, in 2000, was approximately 16 Mt. The current estimate, reflecting both increasing effort and the role of the Voluntary Challenge and Registry (VCR) program, is 38 Mt. Thus, progress in addressing the stabilization commitment has been on the order of 22 Mt.

- By emission, carbon dioxide (CO_2) is the largest contributor to the gap. Reflecting their small absolute contribution, methane (CH_4) and nitrous oxide account for smaller components of the increase.

- By fuel, the important role of natural gas, from production for export and additional domestic demand, is evident. Oil's contribution is small, whereas those for coal and from non-energy sources are slightly negative. The latter reflects the significant reduction in nitrous oxide emissions due to the change in the process for adipic acid production at the Dupont plant in Maitland, Ontario.

- By sector, both end-use and fossil fuel production contribute significantly to the gap. The latter is due to increased natural gas production for export. Electricity generation and non-energy sources record negligible contributions (see discussion on coal and adipic acid above).

Figure 5.3 provides a view of the long-term trend in greenhouse gas emissions by type of emission. Following a slight decline in 2000, largely as a result of lower coal use in Ontario and the process change for adipic acid production, the growth in emissions is inexorably upward. By 2010, emissions are 105 Mt (19%) higher than in 1990. By 2020, they are 203 Mt (36%) higher. The primary sources of these increases are population and economic growth, coupled with low energy prices and a shift to fossil fuels, particularly natural gas, for electricity generation.

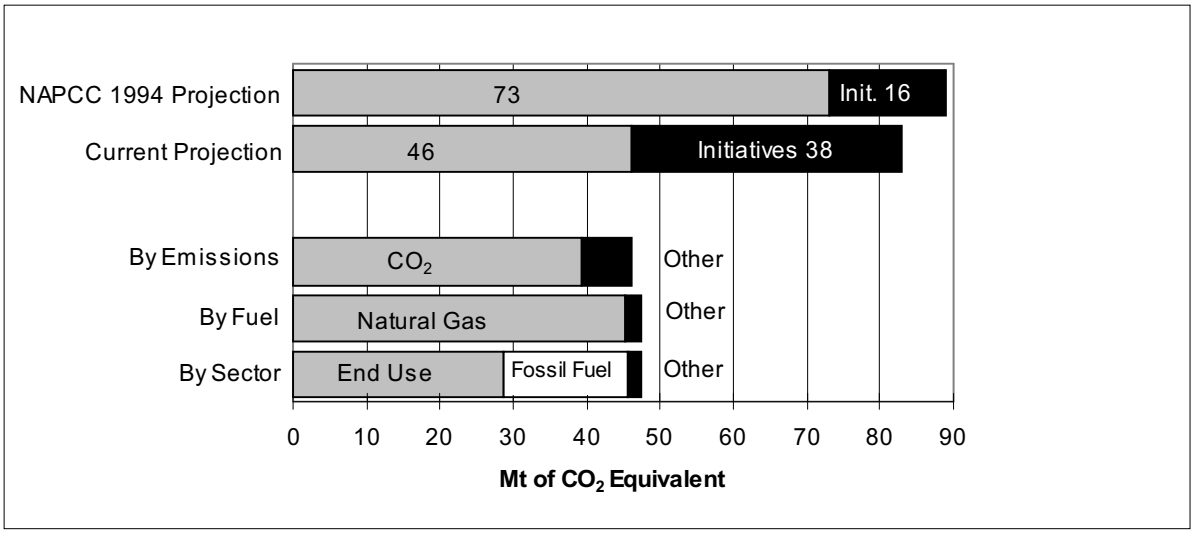

FIGURE 5.2 THE GAP: 1990–2000

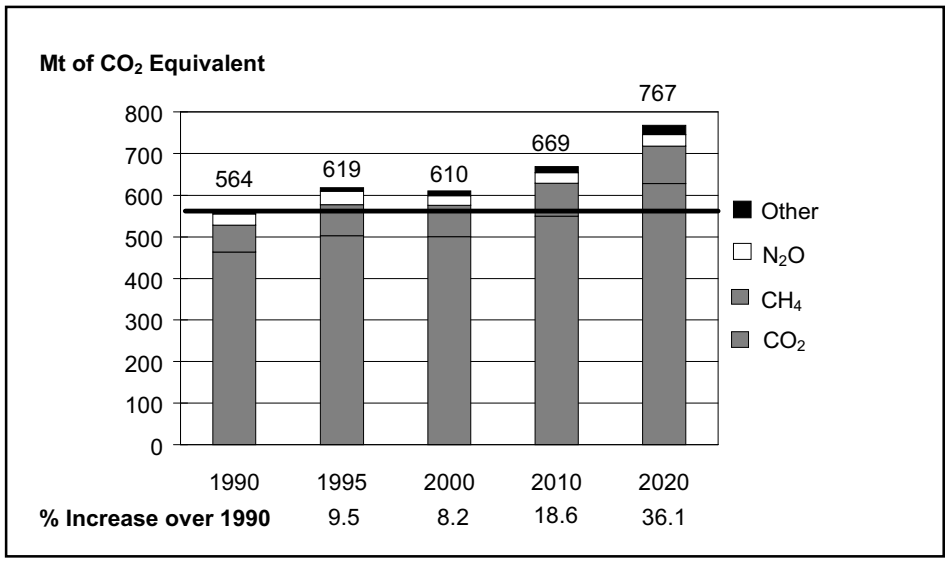

FIGURE 5.3 GREENHOUSE GAS EMISSIONS, 1990–2020

Methane emissions generally follow the overall upward trend. Nitrous oxide emissions, however, decline as a result of the change in the adipic acid process before growing again owing to increased emissions from catalytic converters in automobiles and other vehicles. Other sources, principally chlorofluorocarbon (CFC) substitutes, also grow appreciably from a small base.

Figure 5.4 examines long-term growth in emissions by sector. Transportation is the largest contributor to emissions both in absolute and in growth terms. The increase in emissions from the industrial sector is also significant, but the pace is somewhat slower. The commercial sector generates a modest increase and the residential sector an absolute decrease in emissions. These latter results are closely linked to the impact of energy efficiency regulations on buildings, heating systems, and other energy-using equipment.

For electricity generation, emissions initially decrease but then climb significantly as natural gas and, to a lesser extent, coal become the preferred fuel sources. In the fossil fuel production sector, emissions grow rapidly from 1990 to 2000 but level off thereafter. This trend is related to the increasing effectiveness of initiatives to constrain carbon dioxide emissions and methane leakage by the oil and gas industry, which take place against a backdrop of significantly increased production. Non-energy emissions initially decline, largely as a result of the new process for adipic acid production, but then grow appreciably. The major driver of this growth is the increasing use of hydrofluorocarbon (HFC) substitutes for CFCs.

Figure 5.5 portrays the impact of all initiatives on the growth in greenhouse gas emissions since 1990. In the absence of initiatives, emissions in 2000 would have been 38 Mt higher than the reference case, or about 45% of the gap.[4] Over the longer

[4] It is important to recognize that the initiatives impact portrayed above understates the effect of government action. The initiatives impact covers actions taken from 1995 only. The effect of earlier measures is already incorporated in the historical data and the reference projections. The underestimate is likely most pronounced for the end-use sector, for which a number of programs and other measures have been in effect for several years.

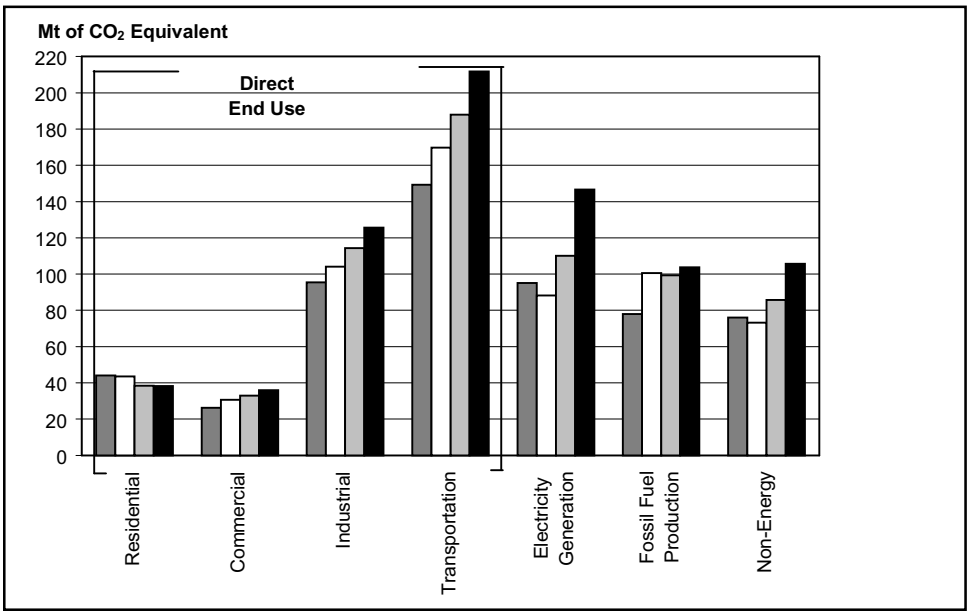

FIGURE 5.4 GREENHOUSE GAS EMISSIONS BY SECTOR, 1990–2020

term, the initiatives are increasingly effective in constraining growth in emissions (reflecting in part the working through of improved standards and practices as energy-using and energy-producing capital stock turns over). By 2020, for example, initiatives are responsible for reducing emissions by 108 Mt, or about 35% of the growth of emissions since 1990 that would have otherwise taken place.

In terms of the various categories of initiatives, those related to end-use energy consumption are increasingly effective over time. Fossil fuel production initiatives make a large difference early in the period, but, thereafter, the impact stabilizes as economic limits for methane capture are exhausted. The electricity generation initiatives remain constant at 3.3 Mt throughout, a possibly conservative assumption. In the non-energy category, the main element is the change in the process for adipic acid production.

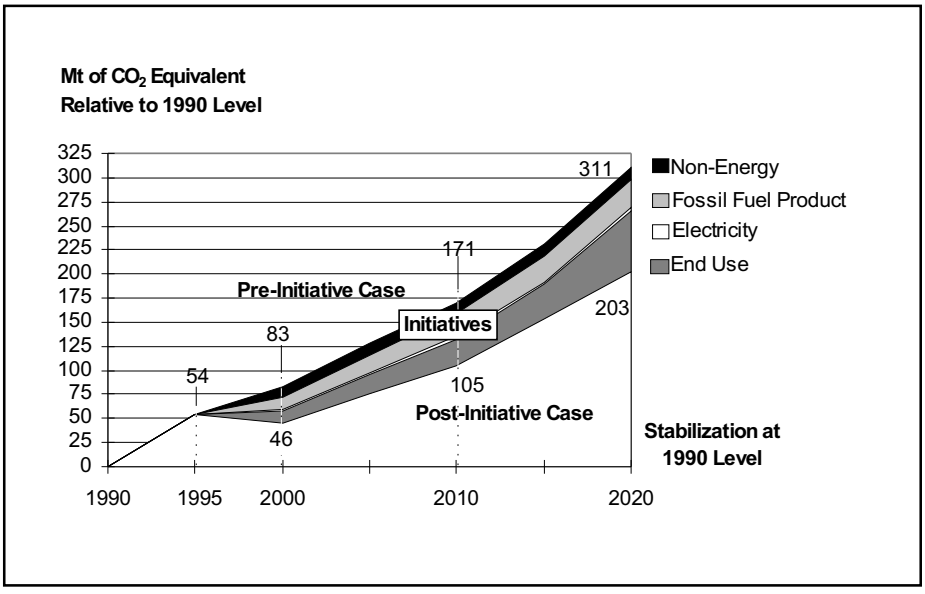

FIGURE 5.5 IMPACT OF INITIATIVES ON GREENHOUSE GAS EMISSIONS, 1990–2020

Figure 5.6 portrays long-term growth in emissions on a provincial basis. The information is organized so as to indicate, for each province, the percent growth in emissions in 2000, 2010, and 2020, relative to the 1990 level. Several points are worth noting:

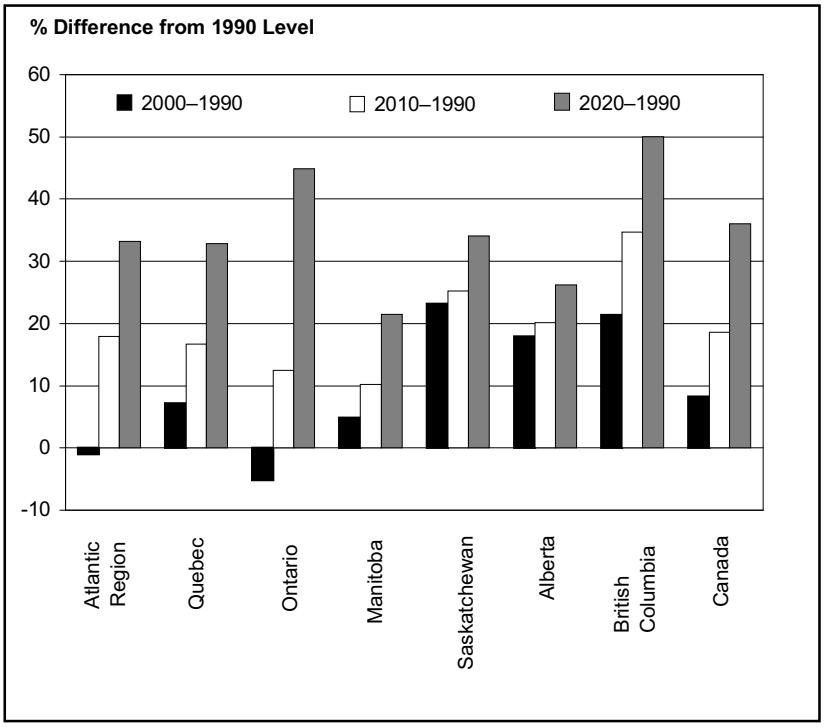

FIGURE 5.6 GREENHOUSE GAS EMISSIONS BY PROVINCE, 1990–2020

- In the short term, to 2000, growth in emissions is greater than the national average in Saskatchewan, Alberta, and British Columbia.
- In the longer term, however, growth in emissions is more evenly distributed across provinces, with Ontario and British Columbia recording above-average increases. For the former, the chief reasons for the increase are the retirement of some nuclear plants and the greater use of natural gas and coal for electricity generation.
- The results for Alberta and, to a lesser extent, Saskatchewan suggest a deceleration in the growth of emissions after 2000. This is largely the result of the increasing effectiveness of the oil and gas industry initiatives to constrain emissions.
- Although Quebec and the Atlantic region have minimal growth in emissions to 2000, thereafter their results are more in line with national trends.

Sensitivity Analysis

Given the many assumptions required for its construction, it is almost inevitable that the reference projection will not accurately reflect the future. To provide a sense of the range of outcomes, Table 5.4 examines the impact of a number of changes in assumptions.[5] Some of these changes — different economic growth prospects, higher world oil prices — reflect plausible alternative external developments. The others are highly stylized representations of possible policy directions.

[5] It is important to emphasize that these sensitivities are rough approximations. In each case, only one assumption is changed — everything else is held constant. Obviously, cases such as a one percentage point change in economic growth or a doubling of energy intensity decline imply associated significant changes in Canada's economic structure.

TABLE 5.4 SENSITIVITY ANALYSIS: PROJECTED CHANGE IN GREENHOUSE GAS EMISSIONS RELATIVE TO 1990

	% Increase over 1990	
	2000	2020
Reference Projection	**8**	**36**
Increase GDP by 1 percentage point/year	11	58
Decrease GDP by 1 percentage point/year	6	20
Increase oil price by US $5 per barrel	7	34
Decrease energy intensity by further 1 percentage point/year	5	13
Increase auto fuel standards by 3%/year (2000–2010)	–	32
Retain nuclear capacity	–	32

Table 5.4 is organized with reference to the differences in emissions, in various years, from 1990. Thus, for the reference projection, greenhouse gas emissions are projected to be 8% higher in 2000 and 36% higher in 2020.

Were Canada's annual economic growth to be one percentage point higher than in the reference case (i.e., 3.2% per year vs. 2.2%), the gap in 2000 would be about three percentage points larger (i.e., from 8% to 11%). By 2020, the difference from the 1990 level would be 22 percentage points higher than in the current outlook. By contrast, if economic growth were one percentage point lower throughout the projection period, emission levels would also be appreciably lower. A US$5 increase in the world oil price would, other things being constant, modestly reduce the gap in both the short and the long term. This smaller decline is due to the fact that the resulting energy price increases would be concentrated in the transportation sector, where fuels are already subject to considerable levels of taxation. Thus, the relative price increases on gasoline and diesel would be muted.

Among the three "stylized" policy scenarios, it is clear that a generalized improvement in energy intensity of one percentage point (i.e., a decline of 2.2% per year instead of 1.2%) would result in a considerably more favourable emission outlook. Emissions in 2020 would be only about 13% above the 1990 level compared with 36% above in the reference case. How such a general result could be achieved is not clear.

Of the two more focused scenarios, a 3% annual improvement in automobile fuel efficiency standards (2000–2010) — about one-half that achieved by the U.S. corporate average fuel economy (CAFE) standards in the early 1980s — would have a modest impact. By 2020, when the full impact of this policy had worked its way through the vehicle stock, emissions would be only about four percentage points lower than in the reference case. Retention of Ontario's nuclear capacity, via replacement of or life extensions to existing facilities, would reduce emissions in 2020 by about four percentage points.

Summary and Conclusions

This chapter traces an outlook for greenhouse gas emissions in Canada over the next 25 years. It is, we believe, a reasonable view, informed by discussion with provincial officials and stakeholder groups. It is not, however, the only possible future, and some of its assumptions, notably those concerning future technological developments, may be too conservative. It should also be stressed that the outlook is not a forecast.

Rather, it is a scenario in which current policy is deliberately held constant. This constraint permits the examination of emission trends in the absence of new policy initiatives.

There are a number of implications for policy that flow from the analysis in this chapter:

- Current actions are not sufficient to meet Canada's goal of stabilizing emissions at 1990 levels by the year 2000.
- The above conclusion appears to hold even if, from an emission perspective, more optimistic assumptions — lower economic growth, higher oil prices — are employed. The greater risk is that the assumptions concerning economic growth and electricity prices are too conservative, with the result that the gap will be larger.
- Although the policy response, to date, has had an impact, a considerably greater effort would seem to be required, within a very short time frame, to achieve the stabilization objective. It is very unlikely that further large opportunities, such as the change in the process for producing adipic acid, exist.
- Of particular note is the transportation sector, a major and growing source of emissions. There may be considerable potential in this sector, but it is very difficult to access by policy means. A somewhat similar conclusion applies to the industrial sector. Electricity generation may provide considerable opportunities, but they are not achievable in the short term.

The long term may provide greater scope for technological innovations to reduce greenhouse gas emissions. The outlook, however, suggests that one should not be too sanguine about this prospect. The combined effects of population and economic growth, coupled with low energy prices, produce an inexorable growth in emissions. Without significant technological breakthroughs, even achievement of long-term stabilization would require major structural and lifestyle changes.

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CHAPTER 6: Possible Impacts of Climate Change on Canada

Canada strongly supports the United Nations Framework Convention on Climate Change (FCCC). Several studies have been undertaken to assess the possible impact of climate change on Canada. They represent only the beginning of work in this area, but they clearly demonstrate that Canadians should be concerned about climate change.

Climate Model Predictions

Recent simulations of climates using atmospheric general circulation models (GCMs) coupled to ocean circulation models have become increasingly realistic and hence have significantly increased scientific confidence in their use for projecting future climates. Several of these have now also been used to address the role of increased regional emissions of sulphate aerosols in partially masking the warming effects of greenhouse gases and modifying the global response of atmospheric circulation to such warming.

Results from these advanced, more realistic experiments are in broad agreement with those from previous climate change projections obtained from equilibrium models. They continue to show greater average warming over land than over oceans, in high latitudes than in low latitudes, and in winters than in summers. The projected rate of warming for anticipated increases in greenhouse gases alone continues to be in the range of 0.1–0.45°C per decade. However, adding the masking effects of further increases in aerosol concentrations, for example, could reduce the net rate of average global warming to 0.1–0.35°C, with greater reductions in heavily polluted regions. Related estimates for the average rate of global sea level rise are between 1.5 and 9.5 cm per decade. In addition, a generally slower ocean circulation system in response to warmer climates is likely to reduce net warming over ocean regions such as the North Atlantic, the North Pacific, and parts of the southern ocean. Confidence in these predictions on a regional scale continues to be low, with significant differences apparent between the different model projections. Modellers also note that global temperatures and sea levels would continue to rise long after greenhouse gas concentrations are stabilized.

For Canada, projections continue to suggest greater warming in interior regions than for the offshore and greater winter warming in the Arctic than in the south. New results from the coupled Canadian model, for example, suggest that increased greenhouse gas and aerosol concentrations are likely to cause a net average warming for central and northern Canada of 4–6°C by 2050 AD, decreasing to 3–4°C along its eastern and western coastlines. Most, although not all, models continue to project increased average winter precipitation across Canada and decreased net soil moisture and water resources in interior Canada in summer. Projections further suggest that the frequency and intensity of both heat spells and convective storms in summer will increase, but that the number of dry days and hence potential for drought periods may also rise. In winter, cold spells will be less intense, but the frequency of intense snowstorms may increase. Such changes in extreme events are likely to be significantly more dangerous to ecosystems and Canadian society than the changes in mean climate conditions that cause them.

One of the reasons that Canada is interested in assessing the impacts of climate change is related to the possibility of positive impacts (e.g., a longer growing season) to various sectors and/or regions; unless they and the means of taking advantage of them are identified, the positive return may be diminished through a lost opportunity or maladaptation. Canada is also interested because of the potential international impacts (i.e., as a member of the global community).

Integrated Studies of Possible Impacts of Climate Change

Impacts of climate change have been studied at the regional and national levels for a number of years, with a move to more integrated assessments. At the regional level, this move to integrated assessments is obvious in the approaches used in conducting the Mackenzie Basin Impact Study (MBIS) and the Great Lakes–St. Lawrence Basin (GLSLB) Project.

The Mackenzie Basin extends across parts of British Columbia, Alberta, Saskatchewan, Yukon, and the Northwest Territories. The MBIS was initiated in 1990 by Environment Canada to produce an integrated assessment of climate change scenarios for the entire watershed. Results of this study indicate that this basin has already experienced a warming trend of 1.5°C this century and that there is evidence that this has led to permafrost thaw and lower lake levels in some areas. Climate projections suggest that this region could experience a warming of 4–5°C by the middle of the 21st century.

The Great Lakes–St. Lawrence Basin is an important regional focal point, as it contains 20% of the world's fresh water, is home to over 42.5 million people, and is a region rich in human and natural resources, with diverse economic activities and complex infrastructures. The GLSLB Project was initiated by Environment Canada as a second-generation integrated climate impact assessment and built upon earlier work by the International Joint Commission. The first progress report of the GLSLB Project was recently released and particularly recognized the need to focus on economic shifts and dislocations caused by potential climate change within a region.

The recent move to integrated assessments of climate change impacts and vulnerability is also taking place at the national level, with two complementary national studies. The first is a broad-based integrated assessment of the impacts of climate change on Canadian environmental, economic, and social systems: The Canada Country Study: Climate Impacts and Adaptation (CCS-CIA). This two-phased study will provide Canadians with a better understanding of their vulnerabilities to climate change and identify adaptation options. The concept for the Canada-wide study emerged from the growing recognition that the existing body of climate impacts and adaptation research is deficient in several respects. It is believed that these deficiencies perpetuate the lack of awareness of Canadians as to the associated risks and vulnerabilities and the need to identify and implement appropriate adaptive measures. Phase I of the CCS-CIA will integrate existing research for particular regions and climate-sensitive sectors into a national synthesis. Phase II will address knowledge gaps and establish new directions for climate impacts and adaptation research.

The second national study, complementing the CCS-CIA, is the Regional Ecosystem Effects of Atmospheric Change (REEAC) Study. This study is a national initiative aimed at the coordination of research into the ecosystem effects of atmospheric change and the integration of related regional studies. It is currently in its initial stages. Using regional scenarios of climate

change and UV-B irradiation over the coming years, a detailed assessment of the effects on hydrology and water quality will be developed, as well as an understanding of probable impacts on natural and managed ecosystems. Evaluation of the environmental, social, and economic effects, as well as identification of actions or policies to minimize or adapt to impacts, will follow.

Implications for Canadian Ecosystems

The results of these integrated regional studies and from various specific sectoral/ecosystem assessments indicate that Canada's ecological and socioeconomic systems are vulnerable and therefore at risk as a result of projected changes in the climate. These vulnerabilities and associated risks can be categorized according to the affected systems: hydrology and water supply, human health, ecology, infrastructure/activities/settlements, coastal zones/margins, agriculture, and forestry. The rate of change and regional impacts, however, remain uncertain.

Hydrology and Water Supply[1]

In many regions, according to climate modelling, summer lake levels and river flows are expected to decline or fluctuate more widely owing to changes in precipitation and/or increases in evapotranspiration. In the Western Cordillera region of British Columbia and Alberta, an acceleration of glacier retreat would eventually result in diminished late-season runoff.

These projected changes in water supply would threaten:

- water availability for agriculture, livestock, industry (e.g., dilution of effluents and cooling), human consumption, and the health of littoral and wetland habitat for fish and waterfowl;
- spring flows and related recharge of soil moisture, wetlands, and impoundments;
- channel and harbour water levels (i.e., increasing requirements for dredging);
- shoreline property values (values may plummet along with retreating shorelines); and
- hydroelectricity generation.

An increased possibility of periods of abrupt high flows is associated with projected increases in the frequency and severity of summer storms, which would threaten to overtop dams, impoundments, and flood control structures, to exceed the capacity of culverts, and to increase the occurrence of spills from urban sewage systems.

Specific examples of the socioeconomic impacts of water supply changes include the following:

- In 1964, low water levels resulted in a $35-million loss for Great Lakes shipping and hydroelectric power. One-third of municipalities along the lakes had water supply problems.
- In the Atlantic provinces and other regions susceptible to spring flooding, changes in late-winter or early-spring precipitation patterns may result in

[1] Ecological impacts dependent on hydrological responses to climate change are still relatively uncertain.

increased frequency of ice jams and flooding. Damages caused by these events are currently estimated to cost Canadians $60 million annually.

- The surface area of Lake St. Clair under typical scenarios for future climates decreases by as much as 15%, and the volume of the lake is reduced by up to 35% or more relative to the present climate. These water level declines may displace the shoreline up to 6 km from its present location, exposing expansive areas of lake bottom.

Human Health

According to climate change projections, the health of Canadians would be affected by more frequent heat waves (or hot spells), especially in cities (heat stress and mortality). People with respiratory problems and older people who are less able to cope with the heat are most susceptible. Cities that experience smog episodes along with the heat are likely to see the greatest increases in hospital admissions and mortality.

Ecology

Changes in Canadian terrestrial, agricultural, forest, and marine ecosystems that are projected to occur in response to current climate change projections over the next century include the following:

- A 100- to 500-km northward shift in major ecosystem boundaries (vegetative, wildlife, insect, and marine) is predicted. For example, the boreal and tundra ecoclimatic zones are expected to be reduced in size, whereas the grassland and temperate ecoclimatic zones are expected to expand. The climate suitability for agriculture is expected to expand northward, particularly in the Clay Belt of central Ontario, the Peace River region of Alberta, and several areas north of 60°N latitude (e.g., the Mackenzie Valley). Soil capability, however, will limit this expansion.

- Changes in ocean circulation and temperature will significantly affect fish stocks, migration patterns, and spawning. Scientists suggest that ocean temperature may be an important factor in the current disappearance of the Atlantic cod stocks and may have implications for Pacific salmon as well. The development and persistence of coastal aquaculture will be affected.

- The rate of climate change is expected to be faster than the rate at which most species can adapt, resulting in considerable disruption in ecosystem functioning. For example, current migration rates for forest tree species range from 4 to 200 km per century, whereas climate projections suggest that a migration rate of 100–500 km would be required over the next century.

Changes in climate system characteristics that are projected to contribute to the shifting of ecosystem boundaries and disruption of ecosystem functioning include:

- decreases in ocean and lake ice cover and duration;

- decreases in permafrost area and glacier retreat in northern and northwestern Canada. The boundary between discontinuous and continuous permafrost is projected to slowly shift northward, resulting in greater infiltration of surface water into the ground. Current observations suggest that, over the last century, the permafrost boundary has retreated nearly 140 km in the central boreal and Mackenzie District;

- changes in vegetative growth rates, increasing in some areas and decreasing in others as the climate becomes more or less suitable;

- increased severity and frequency of drought: agricultural yield will become more variable, and forest losses to fire are projected to increase owing to a greater frequency and severity of droughts. The 1988 drought on the Prairies, for example, resulted in a 31% reduction in grain production. The return period for this magnitude of drought is 35 years. With current climate projections, the return period for this severity of drought is about 17.5 years, or half the current value. Changes in drought may lead to increased fire frequency and severity in major forest areas;

- increased severity and frequency of storms: examples of current weather activity that may provide an indication of possible things to come in the way of storms are numerous. These storms can range in severity. An example of an extreme weather event occurred in July 1996 in the Saguenay region of Quebec, which was hit with record rainfalls. As much as 280 mm of rain fell over a 72-hour period, resulting in severe flooding, soil and stream bank erosion, property damage in excess of $1 billion, and the loss of 10 lives;

- changes in disturbances and increased susceptibility to pests and disease; expansion in the range of current pests and diseases; the introduction of new wildlife, vegetative, and insect species; and increased competition with unwanted species. As an example, spruce budworm, a major forest insect pest, has been observed in northern forest areas during the 1990s in areas where it has never been seen before; and

- changes in Arctic and sub-Arctic peatlands, as warmer temperatures lead to melting of the permafrost layer, thereby affecting their hydrology — lowered water tables in some areas, flooded thaw lakes in others, as well as permafrost erosion — and delivering increased sediment loads to rivers.

Projected implications for biodiversity include the following:

- Loss of habitats and migration opportunities are expected to occur, particularly in some populated mountainous regions, which could result in a loss of biodiversity (e.g., loss of breeding areas for waterfowl in the Great Plains) and therefore have implications for waterfowl, tourism, and subsistence lifestyles.

- Local extinctions and extirpations of northern species of fish and invertebrates may occur as a result of warming in the temperate zone (more pronounced in shallow waters).

Climate change can also exacerbate other environmental impacts (e.g., pollution, human stresses, etc.) on ecosystems. For instance, it has been found that the warming and drying in the Experimental Lakes Area of Ontario have led to increased acidity of the lakes and declining levels of dissolved organic carbon. This, in turn, has led to increased clarity of the water, which allows damaging UV-B rays to penetrate deeper into the lake.

Infrastructure/Activities/Settlements

Water transport changes are projected as a result of climate change — longer season for Great Lakes–St. Lawrence waterway and Arctic shipping, greater number of ice-free days, and reduced ice breaking costs, but lower water levels in the Great Lakes–St. Lawrence Seaway system, with increased transportation costs.

Projected changes in permafrost could impact on northern transportation systems and communities and may require changes in the design of roadways, structures, and pipelines in order to avoid impacts of

landslides, slumping, breaks, and leaks. As well, winter roads could face reduced season and/or carrying capacity.

Warmer summer temperatures could provide conditions for more severe thunderstorms and an increased frequency of tornadoes, with the attendant risk to life and property. The insurance and reinsurance industries are likely to be burdened with greater risks associated with investment in property, infrastructure, and resource-based industry should climate change projections materialize.

Climate change could also cause changes in seasonal patterns of energy demand for heating/cooling.

Coastal Zones/Margins

Projected sea level rise would increase coastal erosion and damage from storm surges, particularly in low-lying coastal regions like the coast of Prince Edward Island and other sensitive areas such as river deltas.

The projected change in sea levels would present problems for some coastal infrastructure, such as harbours and sewage disposal systems. The current sea level rise of 3.5 mm per year is already causing erosion problems in some areas, with an average rate of shoreline retreat in such places currently at 0.3 m per year.

Agriculture

Temperature changes may shift much of the wheat–maize–soybean-producing capacity northward, suggesting an increase in production in those areas where shallow, infertile soils are not a limiting factor.

Agricultural yields may increase in some areas; however, losses may be experienced because of the projected increase in frequency and severity of droughts and severe storms.

Changes in food production in Canada along with other food-producing regions of the globe not only will have potential implications for food producers, but will affect Canadian consumers and exporters.

Forestry

The implications of climate change for Canadian forests and sustainable forest management are considerable. Some of the projections include the following:

- Growth rates, which depend on a number of factors, including climate, are expected to be impacted. In some cases they may increase and in others they may decrease, depending on whether or not the current climate is a limiting factor.
- There may be problems with existing species regeneration.
- Overwinter dormancy may be affected, and cold damage may increase.
- The natural disturbance regime involving fire may change. Wildfires are expected to increase, with larger and more intense fires. Most existing forests trace their origins to wildfires, and fire is the primary natural agent that maintains many forest types over successive generations. Fire, in addition to causing forest losses and affecting human safety and health, will be an important catalyst in speeding ecosystem migration and change.
- Changes in insect species (i.e., their population dynamics and ranges) as well as disease are likely to increase forest damage and losses.

The impacts described are projections based on current information from climate modelling. They will be subject to further refinement and modification as confidence in climate change modelling increases.

CHAPTER 7: Adaptation

Introduction

The United Nations Framework Convention on Climate Change (FCCC) calls on all Parties to "formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to … facilitate adequate adaptation to climate change." This chapter examines adaptation and activities under way in Canada to meet this FCCC commitment.

The Nature of Adaptation

Adaptation refers to adjustments in practices, processes, and structures in systems in response to projected or actual changes in attributes of climate. Important attributes include changes to climate variability and extreme events, as well as an increase in mean conditions such as temperature. Impacts of these climate attributes can be offset by a variety of adaptive responses, including a wide array of measures designed to reduce the vulnerability of systems to climate change and variability, to enhance the capacity of systems to respond in a resilient manner, and to allow people to take advantage of the opportunities that their climatic environment provides.

Adaptive measures can be broadly categorized at three different levels — tactical, strategic, and policy/foundation:

- Tactical — actions/decisions taken by those immediately affected (i.e., at the level closest to exposure); these are more often, but not necessarily limited to, reactions to external changes. Examples include farmers choosing to grow different crops or choosing to use different practices (tillage, fertilizer, irrigation, timing, etc.).

- Strategic — actions/decisions, including government interventions (changes in regulations or policy), taken at the system or sector level (e.g., farming system, fishery, or forest products industry). Examples include actions/decisions taken at the industry level by associations of producers, suppliers, and equipment manufacturers.

- Policy/foundation — fundamental (broader, multi-sectoral) changes in socioeconomic systems, lifestyles, behaviour, social values, and ethics (consistent with the concept of sustainable development).

It is also useful to classify adaptive measures using the following overall framework:

- Bear losses — where there is no capacity to respond in any other way or where the costs of adaptive measures are considered to be high in relation to the risks or the expected damages.

- Share losses — involves sharing the losses among a wider community and includes actions adopted by traditional societies and by larger-scale societies (e.g., public relief, rehabilitation, and reconstruction paid from the public funds). It can also include sharing of losses through private insurance.

- Prevent effects — reducing vulnerabilities through increasing the resilience of the affected systems (e.g., resource management and technological solutions).

- Change use — where the threat makes the continuation of an economic or social activity impossible or extremely risky (e.g., more drought-tolerant crop, withdraw development from exposed coastal areas, etc.).

- Change location — includes relocation of economic or social activities and providing opportunities for relocation of natural ecosystems.

- Education/awareness.

- Research.

Adaptation is not seen as an alternative to the required mitigation. Adaptive measures will be required, even if global mitigation is successful, because of the long lag times in the response of the atmosphere and oceans to the accumulation of greenhouse gases (GHGs) to date. It should also be recognized that if emissions go unchecked in the long run, the impacts will become far greater and put more demands on adaptation. Furthermore, unless the projected pace of climate change can be slowed down (e.g., through mitigation), adaptation may be more difficult, or there may not be enough time to adapt.

It is essential, when developing and implementing a range or portfolio of response options, to recognize that adaptation takes time and is not cost free. In addition, in developing this response portfolio, one should consider the applicability of a particular adaptive measure to the environmental, social, and economic situation of the nation/region. The fact that this measure has been successfully implemented across a wide range of climate conditions does not mean that the same adaptive measures can be transferred rapidly from region to region.

Canada's Response

Within Canada, the following areas have been identified for action, including research, to identify adaptation potential and/or implementation strategies/ measures:

- agriculture, specifically including technological development;

- water resources;

- forestry and forest management;

- hazard and coastal zones;

- urban infrastructure and construction industry; and

- economics.

The Environmental Adaptation Research Group within Environment Canada was established specifically to provide a federal focus for atmospheric change research related to generating knowledge that will help to improve decision making and facilitate the development and implementation of adaptive responses. Included within this aspect of the Group's research agenda are:

- the identification and social and economic assessment of adaptive measures that can reduce damage from atmospheric change, increase resilience or adaptive capacity, and identify potential social and economic opportunities;

- research on the risks of extreme atmospheric events and changing social vulnerabilities; and

- research on the processes of socioeconomic adaptation to atmospheric change and the decision-making processes under uncertainty.

A focal point for much of this research is being provided through the Canada Country Study: Climate Impacts and Adaptation (CCS-CIA). This study is a federal initiative, led by Environment Canada's Environmental Adaptation Research Group, which engages a wide range of collaborators in federal and provincial levels of government, the university community, non-governmental organizations, and the private sector. The objective of the CCS-CIA is to evaluate the impacts of climate variability and climate change on Canada as a whole and to identify and evaluate adaptive responses.

A two-phased approach has been adopted for the CCS-CIA, the first being an evaluation of existing research and information and identification of research gaps, which is to be completed by the fall of 1997. The second phase, beginning in the winter of 1997/98 and extending over the next 4–5 years, will address priority research needs identified in the first phase.

Other regional research initiatives being conducted by the Environmental Adaptation Research Group also have a significant adaptation component. The Great Lakes–St. Lawrence Basin (GLSLB) Project was initiated in 1992 to improve our understanding of the complex interactions between climate, environment, and society, so that regional adaptive strategies could be developed in response to potential climate change and variability. A symposium and report entitled "Adapting to Climate Change and Variability in the Great Lakes–St. Lawrence Basin," scheduled for 1997, will report on research results regarding assessing the risks of climate change and variability in the basin and identifying sustainable adaptive responses through integration of science, governance, industry, and non-governmental perspectives.

Adaptation research was incorporated into the GLSLB Project to begin addressing such questions as: What is adaptation? Why should society adapt? How does society adapt? How can adaptive responses be developed and assessed? and What are the barriers to implementing adaptive strategies?

As a result of this research, factors have been identified that should be considered in the assessment criteria, including:

- Economic feasibility — what are the costs/benefits, and who pays?
- Technical feasibility — is the technology available, and how much time is required to implement the adaptation?
- Social acceptability — does society want it?
- Legal acceptability — are there any laws, agreements, or policies preventing or that can facilitate adaptation?
- Political and institutional acceptability — do political representatives want to adapt, and can existing institutions implement the measures?
- Environmental sustainability — will the environment be enhanced for future generations?
- Flexibility — do the proposed adaptive options prevent or enhance adoption of other corrective measures in the future?

The Mackenzie Basin Impact Study (MBIS) was initiated in 1990 and required the cooperation and collaboration of scientists from many disciplines and stakeholders from the region located in Canada's far north (representatives of Aboriginal groups, industry, colleges, and institutes), as well as representatives from municipal, territorial, provincial, and federal

governments. The purpose of the study was to produce an integrated regional assessment of climate change scenarios for the entire watershed.

At the MBIS Final Workshop, held in Yellowknife, Northwest Territories, from May 5 to 8, 1996, the results of research on "what if" scenarios were presented in paper and poster sessions. Reactions from stakeholders to "so what" and "what should be done" questions were solicited during a series of round-table sessions. Comments by participants at the round-table discussions can be characterized by a few observations:

- When asked if the scenarios of what would happen if the climate changed made a difference to their vision of the future, most round-table participants said "yes" or "yes, in the long term."
- Some participants said the scenario results were new to them and raised new questions to be addressed — especially for people in the forest industry or involved in fisheries management and engineering in permafrost environments.
- Some stakeholders suggested that perhaps the only response was to wait and see what happened, but others encouraged the development of more proactive responses.

In general, members of northern communities said that they could adapt as long as the climate did not change too rapidly.

A number of natural resource departments/faculties within Canadian universities have researchers that have included consideration of adaptive options as part of their research agenda. For example, researchers within the Department of Geography at the University of Montreal have focused their research on evaluating crop yield changes deriving from a greenhouse gas climate change and on assessment of adaptive strategies to such a climate change. Insofar as the studies of adaptation are concerned, researchers conducted farmer reconnaissance surveys and focus group meetings with samples of farmers. The results of these studies show that, based on climate change and crop yield information presented, although climate change and variability do not rank high in terms of adaptation at the farm level, farmers would modify their strategies if certain agroclimatic indicators in addition to the commonly used ones (e.g., variability measures) were available to them.

The agricultural community within Canada is focusing its attentions on technological developments including bio-engineering to increase the resilience of crops and farming practices to address concerns with respect to climate variability and changes. The history of farming adaptation to climatic variations has been documented, and those adaptive strategies may shed some light on likely future options given specified climatic and external conditions. Among the common farm-level adaptive measures identified are:

- abandonment of crops in risky areas;
- reductions in farming intensity;
- diversification of products and inputs;
- spatial diversification;
- using new technology; and
- buying private insurance.

Risk management associated with climate change is expected to become an increasingly important issue for this sector.

The Canadian forest research community is analyzing the possible impacts of climate change and variability on Canadian

forests. The intent of much of this research is to provide an improved understanding of the processes at work and the resulting vulnerabilities and risks and to obtain information required to formulate appropriate adaptive and mitigative policy and management decisions.

Researchers at the Faculty of Forestry at the University of Toronto are studying forest management planning under uncertainty and have developed mathematical models that can be used to develop strategies that account for fire losses and other disturbances. Their models suggest that, when potentially significant fire losses occur, short-term harvest levels should be reduced. The result will be an increase in expected long-term harvest levels and harvest flow stability at the expense of some reductions in profits. Such models can be used to support adaptive forest management strategies.

Within the Canadian Climate Program Board, the Socio-Economic Impacts Committee is addressing aspects of the adaptation to global climate change, including human health, environment, security, and long-term ecosystem research and monitoring.

In addition, the Canadian National Committees for the International Geosphere-Biosphere Programme and the International Human Dimensions of Global Environmental Change Program and the Scientific Committee on Problems of the Environment have met in conjunction with the Canadian Global Change Program (CGCP) Board of Directors. This level of integration has afforded opportunities to link efforts of common interest where there is mutual benefit to be achieved through cooperation. Examples include activities related to human health, environment, and security and concerns regarding land use and change in rural and urban areas.

CHAPTER 8: Financial Assistance and Technology Transfer

The global nature of climate change underlines the need for the development and implementation of international, cooperative solutions.

The United Nations Framework Convention on Climate Change (FCCC) recognizes that developed country (Annex I) Parties have traditionally been the major source of the build-up of greenhouse gas (GHG) concentrations. As a result, and given their greater financial and technical resources to deal with the problem, Annex I Parties have shouldered the initial responsibility for finding solutions to the problem of climate change.

However, forecasts indicate that the future trend in emissions may be significantly altered by the expanding economies of developing country (non-Annex I) Parties and the attendant emissions that accompany this development. There is growing concern that non-Annex I country emissions may soon be of a magnitude to outweigh mitigative measures adopted by Annex I Parties. As a result, engagement of non-Annex I Parties is critical.

Canada's FCCC Commitments

The FCCC provides the framework through which an international, cooperative, long-term effort to address climate change can be established. To this end, Article 4 , and in particular paragraphs 3,4 and 5, commit developed country Parties to:

- provide new and additional financial resources to meet the agreed full incremental costs incurred by developing country Parties in complying with their obligations under Article 12 of the FCCC;
- promote, facilitate, and finance as appropriate the transfer of, or access to, innovative, efficient, and state-of-the-art environmentally sound technologies and know-how to other Parties, particularly developing country Parties, while simultaneously supporting the development and enhancement of their endogenous capacities and technologies, in order to enable them to implement the provisions of the FCCC; and

In addition, developed country Parties are encouraged to provide financial resources to developing country Parties through the negotiation and development of bilateral, regional, and other multilateral agreements.

Canada contributes to the United Nations (UN) development agencies and other international financial institutions and is involved in bilateral projects in developing countries that work towards the implementation of the Convention. A summary of the Canadian contributions to multilateral institutions and programmes from 1994 to 1996 is presented in Appendix I, Table 9. Appendix I, Table 10 outlines a list of climate change related bilateral projects undertaken in developing countries. The details of two projects with China and India are outlined in Appendix I, Tables 11a and b.

Canada contributes to the annual budget of the permanent Secretariat of the FCCC. The purpose of the Canadian contribution is to support the costs associated with the functioning of the FCCC Secretariat, as they are specified in Article 8 of the FCCC. In 1996, the Canadian contribution totalled Cdn $315 000.

Activities Implemented Jointly (AIJ): the Canadian Joint Implementation Initiative (CJII)

On July 3, 1996, the Canadian Joint Implementation Initiative (CJII) was launched as part of Canada's National Action Program on Climate Change (NAPCC).

The CJII Office, which aims to encourage the broad participation of Canadian industries in voluntary international actions to limit greenhouse gas emissions as a complement to their domestic actions, is housed at Natural Resources Canada (NRCan). It is supervised by an interdepartmental steering committee that includes representatives from NRCan, Environment Canada, Foreign Affairs and International Trade Canada, and the Canadian International Development Agency (CIDA).

The CJII Office acts as a clearinghouse for project and funding advice on potential pilot-phase "activities implemented jointly" (AIJ) opportunities for Canadian industry. It provides assistance to sponsors in such areas as the establishment of greenhouse gas emission baselines, the identification of potential sources of funding, as well as the securing of host country approval.

Since the opening of the CJII Office, CJII officials have worked with 10 Canadian companies on 15 potential projects in eight different host countries. All of these projects are in the energy sector, and most of them are in power generation (e.g., energy efficiency, renewable energy, micro-hydro development, cogeneration — see the project proposal abstracts below). The main host countries are Poland, Jordan, Zimbabwe, Indonesia, India, and China.

In addition, the Government of Canada has concluded and continues to pursue a number of bilateral and multilateral cooperation agreements on AIJ to facilitate the development of AIJ projects between Canadian companies and foreign entities.

To date, Canada has concluded four statements of intent to cooperate on AIJ. The first statement of intent was signed at the end of 1995 with Mexico and the United States. Under this three-party statement, the feasibility study of four potential AIJ projects in Mexico is currently being financed (two in the energy sector and two in the forestry sector). The second statement was signed with China (the Ministry of Water Resources) on August 1996 and covers cooperation on energy efficiency, renewable energy — mainly small and medium-sized hydroelectric power projects — and AIJ. The third statement, signed with Korea on January 1997, covers cooperation in the same areas, in addition to calling for joint Korean–Canadian cooperation on AIJ with a third country. The fourth was concluded with the Republic of Latvia. It includes cooperation on energy efficiency, alternative transportation fuel, renewable energy and AIJ. Other cooperation agreements on AIJ are currently being pursued with Poland, Georgia Costa Rica, and Ukraine.

Some current project proposals are as follows:

Atlantic Orient Canada has submitted one project proposal to the CJII Office. The project involves the installation of wind turbines to existing diesel generator facilities on a remote island. The project will reduce greenhouse gas emissions by increasing the use of wind power for electricity generation.

Canadian Hydro Components has submitted one project proposal to the CJII Office. The project involves the development of ultra low head hydro sites on existing dams. The project will avoid carbon dioxide (CO_2) emissions by displacing the need for new coal-fired energy generation.

Environmental Technologies China Ltd. has submitted two project proposals to the CJII Office. Both projects will recover methane (CH_4) from municipal landfills and utilize the landfill gas to generate a total of 2.7 MW of power, increasing to 8.4 MW in future years. The projects are expected to reduce carbon dioxide emissions by 120 000 t per year, eventually increasing to 500 000 t per year.

Merol Power Corporation has submitted one project proposal to the CJII Office. The project involves replacing and upgrading a small hydro facility to provide electrical power to an industrial operation. The project will displace new coal-fired generation.

Ontario Hydro and Hydro-Québec are involved in three joint implementation projects through the E-7, an international organization of eight major electrical utilities from G-7 countries. Each of these projects is officially recognized by the host country government. The first project, led by Ontario Hydro, involves the improvement of the energy efficiency of selected oil-fired units in Jordan. The second project involves the development of a renewable energy system in Indonesia based on photovoltaic solar home systems, a 20-kW photovoltaic–wind hybrid system, and a 200-kW micro-hydro system. The third project involves the construction of a 400-kW micro-hydro power station on an existing dam in a remote area of Zimbabwe.

Ontario Hydro Technologies has submitted one project proposal to the CJII Office and is considering others. The first proposal involves the development of small hydroelectric resources in remote villages to reduce carbon dioxide emissions and deforestation. A second project involves developing mini-hydro sites attached to particular agricultural or industrial developments, thereby replacing diesel generation.

TransAlta Corporation has submitted one project proposal to the CJII Office. The project involves the enhancement of milk production from dairy cattle. This project will reduce methane emissions by 450 kt of carbon dioxide equivalent by the year 2000.

Woodrising Consulting Inc. has submitted one project proposal to the CJII Office. The project includes carbon sequestration through planted and natural afforestation of marginal lands currently under corn production and carbon storage through continuous selective harvests and the generation of wood products. This money-making afforestation project will sequester 49 kt of carbon over its 18-year life.

Technology Transfer and Capacity-Building Initiatives

Technology is expected to play a critical role in reducing greenhouse gas emissions and in helping to increase greenhouse gas sinks. The wider adoption of existing

climate-friendly technologies and the development and deployment of new and improved technologies will be important aspects of a market-based response to climate change concerns.

Climate Technology Initiative (CTI)

The Climate Technology Initiative (CTI) was established during the first CoP to the United Nations FCCC in April 1995. Managed by the OECD and the International Energy Agency (IEA), the CTI has received endorsement from 23 OECD member states, Canada included.

The CTI acts as a clearinghouse to promote and accelerate the development, application, and diffusion of "climate-friendly" technologies. In specific regard to private sector activities, the CTI's mandate includes providing improved market access for emerging technologies in order to ensure that required technologies are available and are being efficiently deployed.

Canadian Consultant Trust Fund for the Global Environment (CCTF-GE)

The Canadian Consultant Trust Fund for the Global Environment (CCTF-GE), a $2-million fund announced in March 1996, aims to enhance global market opportunities for Canadian environmental technologies in all fields. The World Bank uses the CCTF-GE to support preparatory work related to projects that are financed by the Global Environment Facility.

The CCTF-GE is funded jointly by Environment Canada and CIDA. Canadian government officials work in partnership with Canadian industry association representatives and World Bank officials to:

- identify qualified Canadian consulting expertise and suppliers; and
- develop mechanisms to strategically disseminate intelligence arising from project preparation work.

Canadian Environmental Solutions (CES)

Industry Canada has produced an innovative multi-media information product called the Canadian Environmental Solutions (CES) database, which is available on CD-ROM and the Internet (http://strategis.ic.gc.ca/sc_indps/canenvir/engdoc/openscrn.html). The CES identifies technological solutions to a wide range of environmental problems and directs the user to companies in Canada that develop technologies capable of providing the required solutions.

Included in the CES is information on energy efficiency and renewable energy options for reducing the environmental impacts (including climate change) of energy use. The CES also provides information on research and development (R&D) related to energy use and the full range of air quality issues, climate change included.

International Model Forest Program

Canada has long been cognizant of the value of global cooperation in implementing sustainable development practices as they apply to forest resources. In this context, Canada's domestic Model Forest Program has been expanded into a global network of model forests. The resultant International Model Forest Program is designed to promote international partnerships in the sustainable development and management of forest resources. The program encompasses a number of sustainable forest management and development objectives; with regard to climate change, it fosters international cooperation and exchange of ideas on forest offsets and their use as carbon dioxide sinks.

To date, Mexico, Russia, and Malaysia have joined in this international partnership led by Canada.

Energy Efficiency and Renewable Energy Joint Ventures

The Canadian government is assisting in deploying renewable energy and energy efficiency technologies by providing technical support to Canadian companies. Recently, the federal government led a seven-company small hydro technology and industry mission team to Poland. Joint ventures for the manufacturing and commercialization of Canadian technologies will be established that can address some of Poland's key environmental issues. The federal government, in partnership with the Canadian Manufactured Housing Association and key Japanese departments, is assisting in exporting high-quality, energy-efficient manufactured houses to Japan.

Changes to Canadian Export Financing

New equity financing has been earmarked by the Canadian Export Development Corporation to support the development of new export sales financing mechanisms and new partnerships with exporters through the commercial banks. Such financing is critical to ensure that Canadian companies can fully realize the opportunities before them in international markets. This support will be available to all sectors, including Canadian companies dealing with the export of environmental technologies, ensuring that high-quality Canadian technologies are available to developing nations.

Clean Coal Technologies

In the area of clean coal technologies, Canada continues to work with key industry players to develop leading-edge technologies to reduce the levels of pollutant emissions such as organics and trace elements from combustion processes.

As part of Canada's international efforts aimed at reducing greenhouse gas emissions, the Advanced Combustion Research group within NRCan has recently transferred its furnace modelling expertise to the Thermal Power Research Institute in China. In China, the need to improve the performance of existing coal-fired power plants has never been greater. The demand for electrical power is expected to grow at a rate of 6–8% annually over the next decade. Pilot-scale research and furnace modelling are recognized as very cost-effective tools to troubleshoot, optimize, and increase the energy efficiency of existing facilities as well as provide a sound foundation to introduce new designs or design changes to existing facilities. This initiative took place under a British Columbia Hydro contract as part of CIDA's bilateral agreement with China.

Canadian International Business Strategy (CIBS)

The environmental industry is one of 23 key industry sectors contributing to the Canadian International Business Strategy (CIBS). Through the involvement of National Sector Teams consisting of government and private sector representatives, CIBS gives Canadian industry an opportunity to influence government's international business priorities. Each sector-specific strategy identifies Canada's priorities for capturing emerging global trade, technology, and investment business. Alternative fuels and natural-gas-fuelled vehicles represent two examples of CIBS strategies with climate change implications.

Canadian Environmental Industry Strategy (CEIS)

The Canadian Environmental Industry Strategy (CEIS) is designed to assist the "green" industry in three main areas: improving the delivery of government services to the industry; helping to develop and commercialize environmental technologies; and, in particular, expanding markets for this industry here in Canada and around the world. Under the auspices of the CEIS, Environment Canada and Industry Canada administer a number of bilateral environmental cooperation agreements aimed at implementing joint projects in the areas of capacity building and clean environmental technologies and processes. With respect to climate change, Canadian firms are, for example, working on a small-scale hydroelectric project in Poland, developing an emission testing facility in Mexico, and updating Russia's building code to foster energy-efficient housing construction. A study has also been prepared documenting opportunities for Canadian energy and energy conservation technologies.

Canadian Environmental Technology Advancement Centres (CETACs)

The federal government, in partnership with provincial governments, environmental industry associations, and the private sector, has established three Canadian Environmental Technology Advancement Centres (CETACs) in response to findings contained in Building a Stronger Environmental Technology Exploitation Capability in Canada, a study of the Canadian environmental industry conducted by Environment Canada in 1992. CETAC organizations are private sector, not-for-profit corporations that are committed to helping small and medium-sized enterprises (SMEs) overcome the barriers involved in the commercialization of new environmental technologies. They also offer comprehensive technical and business services to help SMEs capture domestic and international markets.

There are currently three CETAC organizations running in Canada: the Ontario Centre for Environmental Technology Advancement, CETAC-WEST, located in Calgary, Alberta, and Enviro-Access Inc., the Quebec and Maritime arm of the CETAC organization.

Other Multilateral and Bilateral Initiatives

Commission for Environmental Cooperation (CEC)

The Commission for Environmental Cooperation (CEC), with support from the Canadian government, is undertaking four pre-feasibility studies for greenhouse gas mitigation projects in Mexico — two emission reduction projects and two carbon sequestration projects. These studies are being carried out in order to determine the environmental, economic, and operational feasibility of the projects, as well as to facilitate the implementation of AIJ projects in the North American Free Trade Agreement (NAFTA) region. The results of these pre-feasibility studies are expected in late 1997.

Canada–Costa Rica Study on the Advantages of Joint Implementation

CIDA and Environment Canada are funding a study that will assess the developmental and environmental advantages of joint implementation for Costa Rica. The study will identify opportunities for Canadian investment, both financial and technology based, in greenhouse gas limitation projects that have developmental benefits for Costa Rica and that contribute to the overall abatement of global greenhouse gas emissions.

Asia-Pacific Economic Cooperation (APEC) Committee on Harmonization of Equipment Standards

In recognition of its expertise in developing, implementing, and enforcing equipment energy efficiency standards, Canada will chair the new Asia-Pacific Economic Cooperation (APEC) Committee on Harmonization of Equipment Standards. The committee will seek to harmonize test methods and assessment systems. Harmonization among APEC nations could reduce the costs of trade in energy-efficient products, which in turn would mean lower prices for consumers and increased use of these products.

Hemispheric Project on Building and Equipment Efficiency

Canada is taking the lead in a Hemispheric Energy Initiative project on building and equipment efficiency, one of seven areas that have been identified for potential action to reduce trade barriers in the western hemisphere. To launch this project, Canada issued a discussion paper and hosted a workshop on building and equipment efficiency for all western hemisphere nations and four multilateral development banks in the spring of 1997.

Canada–Mexico Memorandum of Understanding (MOU) on Energy Efficiency and Alternative Energy

In June 1996, Canada and Mexico signed a Memorandum of Understanding (MOU) on Energy Efficiency and Alternative Energy. The MOU commits NRCan to share information with Mexico on Canada's energy efficiency and alternative energy programs and to examine ways to increase trade and investment with Mexico in these areas. Government officials from both countries are now developing initiatives to carry out these undertakings.

Canada–Mexico–U.S. Statement of Intent to Cooperate on Climate Change and Joint Implementation

In October 1995, Canada, Mexico, and the United States signed a statement of intent to cooperate on climate change and joint implementation (JI). In signing the statement of intent, the Parties agreed to facilitate cooperation on issues of mutual interest in the area of climate change, including JI, the transfer of greenhouse gas mitigation technologies, and education, training, and information exchange.

Conferences and Workshops

GLOBE '96 — March/April 1996

The governments of Canada and the Province of British Columbia, along with the United Nations Development Program and a number of private sector partners, sponsored the Globe '96 Trade Fair and Conference on Business and the Environment in Vancouver, British Columbia. During Globe '96, environmental technologies were showcased alongside corporate and public policy sessions on global and regional sustainable development issues. Renewable energy and sustainable transportation systems were featured. In addition, there was a session devoted exclusively to climate change innovations. The event was attended by over 7 000 international business leaders from the Pacific Rim, Asia, the Americas, and Europe.

OECD Sustainable Transportation Conference — March/April 1996

Over the past half century, our ability to move individuals and goods long distances at relatively low costs has made remarkable progress. However, this advancement has its associated costs. The

growth in demand for transport services is rapidly outpacing the ability of governments to provide infrastructure, as well as posing significant risks to public health and the environment at local, regional, national, and global scales.

In response to these concerns, Canada hosted, in conjunction with the Globe '96 Trade Fair and Conference on Business and the Environment (see above), an OECD Sustainable Transportation Conference.

IEA International Conference: "Technologies for Activities Implemented Jointly (AIJ)"

The IEA Greenhouse Gas R&D Programme, established in 1991 to evaluate technologies that can be used to mitigate greenhouse gas emissions from the use of fossil fuels and identify targets for useful R&D, hosted a "Technologies for Activities Implemented Jointly (AIJ)" Conference in Vancouver, British Columbia, in May 1997. The main aim of the conference was to provide the audience with examples of practical AIJ experiences that highlight the innovative use of climate change technologies.

Workshops

In 1996, Canada contributed US$9 000 towards the organization of an informal FCCC workshop on the development of guidelines for national communications (i.e., national reports) from non-Annex 1 Parties to the FCCC.

Canada contributed both financially (Cdn $50 000) and substantively to the development and organization of a Caribbean Basin–Canada Workshop on Adaptation to Climate Change, which was held in Port of Spain, Trinidad, from October 21 to 23, 1996.

Canada also participated, and contributed US$20 000, to the organization of the International Workshop on Greenhouse Gas Mitigation Technologies and Measures organized by the U.S. Country Studies Program, which was held in Beijing, China, on November 12–15, 1996. The Canadian contribution provided funding for the participation of representatives from developing countries and countries with economies in transition.

Canada co-sponsored the organization of a series of three regional workshops on technology transfer, held in the fall of 1997 in Bangladesh, Brazil and Senegal. Financial contribution amounted Cdn $60 000. The purpose of these events was to increase knowledge about the experience with, and the needs for technology transfer from the recipient's point of view and to acknowledge the climate change actions already in place in developing countries. Results will be reported to the Third Conference of the Parties in Kyoto in December 1997.

CHAPTER 9: Research and Systematic Observations

Canada recognizes that the best available scientific knowledge already provides a sound basis for initiating domestic and international action to mitigate the risks of climate change. Even so, it also recognizes that many areas of scientific uncertainty still remain, that these uncertainties must be addressed in order to make informed decisions on future policy response, and that it has a commitment under the United Nations Framework Convention on Climate Change (FCCC) to promote and cooperate in relevant research and systematic observation. Equally important, such improvements in scientific understanding will also better enable Canadians to utilize their current climate resources effectively and adjust to a changing environment with minimum disruption to the national economy. In Canada's National Action Program on Climate Change (NAPCC), four related strategic "thrusts" for such work have been identified, as follows:

- improve research networks within Canada;
- improve evaluation and coordination of systematic observations;
- enhance statistical and analytical tools to better understand the causes of fluctuations and changes in Canada's climate; and
- develop appropriate tools to assess Canadian options and opportunities for measures aimed at reducing the risks of climate change.

In a time of fiscal restraint and program review, achieving the above objectives has been a significant challenge. However, substantial progress has been made in each of the four major thrusts, with consequent benefits in incremental knowledge of climate processes and behaviour and of the possible implications of climate change for Canadians. These are summarized in the following sections.

Data Collection and Monitoring

Canada is a vast country involving a large range of climate regimes and ecosystem types, many of which are in inhospitable locations remote from populated areas. Hence, systematic observations and monitoring by traditional means of direct human data collection are increasingly difficult and costly, and the need for effective coordination is ever more important.

Climate Monitoring

Canada continues to maintain a national network of climate observing stations (many of which are operated on a volunteer or cooperative basis) and a comprehensive climate data management system to provide timely access to quality data. A process for rationalizing these monitoring activities in an effort to reduce overall costs is now under way and has raised serious concerns about the potential for deterioration of the quality, quantity, and accessibility of such data. The establishment, in 1996, of the Canadian National Committee for the Global Climate Observing Systems (GCOS) is one new initiative that is expected to help address this and other concerns. This committee, consisting of representatives of the Canadian scientific and data collection communities, provides a national mechanism for coordinating systematic observations and data collection activities

within and adjacent to Canada and for exploring ways in which the critical data needs of Canadian and international researchers can be adequately met.

Ecological Monitoring

Complementing the GCOS initiative are the Acid Rain National Early Warning System (ARNEWS) and the Ecological Monitoring and Assessment Network (EMAN). ARNEWS is a national biomonitoring system designed to detect early signs of the effects of atmospheric change on forests so that action can be taken to forestall anticipated damage. It was established in 1984, with 100 permanent sample plots located across the ecozones of Canada. Since 1992, the network has been expanded to 151 plots. The EMAN, an integrated ecologically based observing system, is currently being established to increase scientific understanding of the ecological impacts of a changing environment. To date, some 72 sites, with at least one in each ecological region of Canada, have been tentatively identified for the network.

Monitoring Atmospheric Composition

Canada now continuously monitors greenhouse gas (GHG) concentrations and air chemistry at three long-term stations along the eastern, northern, and western coastlines. A fourth station has operated in interior regions for several years, but its future is now questionable because of fiscal constraints. Periodic measurements of carbon dioxide (CO_2) in Pacific surface waters are also being continued through a ships-of-opportunity program.

Past Climates

A national effort is under way to obtain adequate data from paleogeological sources to reconstruct the last 20 000 years of Canada's climates at 1 000-year intervals. Particular attention has been given to the most recent 6 000 years to provide a sound basis for verifying the accuracy of general circulation models (GCMs).

National Energy Use Database

Canada has had in place, since 1991, a National Energy Use Database (NEUD) with the objective of improving knowledge about energy consumption at the end-use level. NEUD is a partnership among the federal department Natural Resources Canada (NRCan), other governments, and the academic community. NEUD encourages the regular collection of data on energy consumption at the end-use level, the characteristics of energy-using equipment and buildings, the attitudes and behaviour of Canadian consumers towards energy use, and the adoption of energy-efficient technologies. This data collection is important, as the data can be used to assess progress in energy efficiency improvements and to identify areas of opportunity for further action. The data are also relevant for developing indicators of changes in energy-related greenhouse gas emissions and opportunities for mitigative actions. NEUD is helping Canada to become a world leader in this type of information collection and analysis.

Canadian Research on Climate Change

Improved Research Networks

The Canadian Climate Program Board and its subsidiary committees continue to play important roles in coordinating research within Canada into climate change and its impacts. Important progress has also been made in formalizing the networking between scientists in academic and government institutions involved in climate-change-related research in Canada. The most visible aspect of this progress has been the development and implementation

of a formal Climate Research Network, which links research efforts within Environment Canada with those in almost all of the major Canadian universities in order to better understand key chemical, physical, and biological processes important to the climate system and to parameterize these for inclusion in the Canadian GCM. Other government departments have also adopted similar, although less formal, cooperative efforts with academic institutions. In addition, the Natural Sciences and Engineering Research Council (the primary source of research grants to the university-based scientific community) has identified several key climate change research priorities, including studies in ocean circulation, the carbon cycle, paleoclimates, and water cycle processes. Finally, the national Program on Energy Research and Development (PERD) has established a new Energy and Climate Change Task to coordinate and provide a significant increment in funding to climate change research projects within federal government agencies that are particularly relevant to policies with respect to energy supply and demand in Canada.

New Developments in Climate Process Research

Greenhouse Gas Fluxes

Results from the Boreal Ecosystem Atmosphere Study (BOREAS, a cooperative Canada–U.S. project into the role of central Canada's boreal forest in the climate system), together with those from other studies into carbon and methane (CH_4) fluxes from Canada's boreal forests, wetlands, and agricultural regions, have helped clarify the role of Canada's natural ecosystems in global cycles of greenhouse gases. Canadian forests, for example, were a significant sink for atmospheric carbon until the 1970s, consistent with evidence from global carbon cycle models of a major mid-northern hemisphere terrestrial carbon sink. However, this regional boreal forest sink has become a net source for atmospheric carbon dioxide during the past decade owing to a significant increase in biomass loss from wildfires and insects. Models predict that this trend will continue for at least the next few decades. Efforts are currently under way to determine the effects of climate change on the carbon cycle of Canadian forests.

Studies into methane fluxes from Canadian northern wetlands have shown net emissions well below previous estimates based on lower-latitude wetlands and have thus helped to revise estimates for global emissions from high-latitude wetlands. Studies are also under way to assess the extent of gas hydrates in sediments of Canada's north and their potential for releasing large volumes of methane as a result of regional warming. Finally, carbon flux studies over the Pacific Ocean have indicated a large regional sink in the northern Pacific, similar to that of the North Atlantic and counter to past conclusions. Meanwhile, two global carbon cycle modelling groups are using these results in developing simulations of the behaviour of the global carbon budget and its response to change.

Climate Processes

Canada's participation in the World Ocean Circulation Experiment and the Joint Global Ocean Flux Study has helped improve international understanding of both physical and biological ocean processes and contributed to the development of the ocean component of Canada's atmosphere–ocean GCM. Plans are also under way for Canada's participation in international studies of the Arctic Ocean system, although funding approval has not yet been achieved. Meanwhile, Canadian research into hydrological processes in the permafrost-saturated and largely snow-covered lands of the Mackenzie River Basin, a unique

contribution to the international Global Energy and Water Cycle Experiment, has helped to specifically address Canadian priority interests in the region and to better define the role of northern hydrological processes, including related cloud formations, in the global climate system.

Climate Modelling

The Canadian general circulation modelling group is currently completing a multi-century experimental transient run with the Canadian Climate Change General Circulation Model (CCCGCM II) atmospheric model coupled to an ocean model. Estimated trends in radiative forcing due to increased concentrations in both greenhouse gases and sulphate aerosols are included. Results to date show excellent agreement between model projections for the past century and observed climate trends and predict a continued increase in global temperatures at rates of about 0.2°C per decade to the year 2040. Analyses of model results relative to future trends in frequency and severity of extreme weather events are now in progress. The development of the third generation of the Canadian GCM, incorporating many aspects of the results of climate process research noted above, is near completion, with assessment of model performance and subsequent climate change experiments planned for early 1997. Meanwhile, models to incorporate local-scale surface interactions for high-resolution simulations of regional climates, for simulating chemical and dynamic processes in the middle atmosphere, and for studying paleoclimates are under development at three different university centres. Studies are also continuing on the measurements of surface and atmospheric radiation budgets and on the effect of clouds and aerosols on radiative forcing, using satellite data.

Climate Change Detection

Analyses of observed climate conditions in Canada indicate an average increase in annual temperatures of 1°C during the past century, with greatest warming in winter and spring seasons. Some regions have warmed by almost 2°C, while others have cooled. There appears to be an increase in the frequency of tornadoes in western Canada in recent years, but there is no conclusive evidence to suggest that extreme wind and rainfall events have changed significantly or that snowlines in central Canada have retreated. Analyses of synoptic patterns in the northern hemisphere show indications of a significant increase in intense winter storms during the past two decades. Meanwhile, there is further evidence of glacier retreat in the Canadian Rockies and of permafrost retreat in Canada's north. A network for detectors for monitoring yearly thaw has recently been established throughout the Mackenzie Valley.

Efforts to better understand the natural behaviour of extreme weather events and how such may respond to climate change are being enhanced. New analytical techniques developed for the analysis of temperature extremes from climate data records are now also being applied to precipitation. Studies in paleoclimates of regions such as the drought-prone southern Prairies are providing additional information on these variables for previous decades, centuries, and millennia.

Impacts of Climate Change

Canadian studies into how climate change may affect ecosystems and society have progressed to a second generation of analysis focused on integrated regional studies, rather than simpler single-sector analysis. The first such study (the Mackenzie Basin Impact Study, or MBIS), focused on the Mackenzie Basin in Canada's north, is near completion. Results

suggest a net decline in basin runoff and lake levels, earlier snowmelt and ice break-up, and receding permafrost. These primary effects would collectively cause increased land instability and major ecological changes to peatlands, forests, wildlife, and communities in the region. A similar integrated study is now under way in the Great Lakes–St. Lawrence Basin (the GLSLB Project), in cooperation with U.S. researchers, and a third for the Canadian Prairies is under development. The ambitious Canada Country Study: Climate Impacts and Adaptation (CCS-CIA), which will consider the integrated effects of climate change for all of Canada, is now in the planning stage.

Other studies into the impacts on specific communities and economic sectors also continue. These include efforts to better understand the effects of climate change on natural hazards (e.g., landslides and coastal erosion) and the insurance industry, the implications for human health in Canada, and the vulnerability of resources such as renewable energy, forests, ocean fisheries, and agriculture.

Since 1993, Canada has made substantial progress in the development of satellite, aircraft, and ground-based tools for the assessment of terrestrial ecosystems and the interactions of ecosystems with climate on a seasonal and interannual basis. Satellite, aircraft, and ground-based data products are being developed and validated as a key feature of the BOREAS study and in other parts of Canada. The resulting data products will serve in modelling studies and for the detection of ecosystem changes at various spatial scales, from the landscape to national level. Results to date indicate large spatial and interannual variability in ecosystem characteristics, necessitating dense and location-specific monitoring approaches.

Energy Technology Research and Development

The federal department NRCan provides national leadership in energy technology research and development (R&D) through the following approaches:

- Through its laboratories, the department works in close cooperation with industrial, provincial, and international partners to develop and transfer scientific knowledge and technologies in energy efficiency, renewable energy, and alternative transportation fuels.

- Through the federal PERD, the department supports some of the above research in its laboratories as well as research in other participating departments (including agriculture, fisheries) on hydrocarbons, climate change, transportation, and energy efficiency, recognizing that energy cuts across the mandates of many federal departments.

- Through the International Energy Agency's (IEA) Greenhouse Gas Research and Development program, which Canada is currently chairing, NRCan works to evaluate technologies for the mitigation of greenhouse gas emissions from the use of fossil fuels. In addition to holding a successful conference on mitigative options in London, England, in 1995, the program undertook a series of studies in the areas of power generation technologies, advanced capture techniques, ocean storage of carbon dioxide, chemical utilization of carbon dioxide, and full fuel cycle studies. Future work of the program will expand on the above topics and will also look at additional issues such as monitoring and controlling methane emissions, forestry for carbon storage, and practical R&D

in the area of carbon dioxide recycle combustion. Provinces such as Alberta also provide funding support for the program.

NRCan currently manages a balanced portfolio to accelerate the market introduction of proven technologies while at the same time investing with partners in new technologies that will significantly contribute to reduced greenhouse gas emissions in the future.

What follows is an overview of NRCan's technology transfer and R&D activities.

Industrial Sector

The industrial sector is one of the areas where research and technology transfer efforts will yield the largest impact on carbon dioxide reduction. It is a large energy-consuming sector in Canada and accounts for 23% of Canada's total carbon dioxide emissions.

Even though the potential for reduction is significant, diversity in industrial energy use and the fact that energy is a relatively small portion of production costs make it difficult to fully tap this potential.

Canada focuses its industrial energy efficiency activities on key industrial processes such as combustion, drying, and dewatering, in addition to process analysis and optimization.

The industry R&D consists of a targeted cost-shared program supporting the development and use of new energy-efficient processes, products, systems, and equipment proposed by industry. The program forges links between technology developers and end users to encourage the widest possible application of technologies.

The in-house activities of NRCan's industrial research efforts focus on advanced combustion work, thereby helping industrial and energy utility companies reduce their energy use by optimizing combustion processes. Work is also undertaken in developing advanced natural gas technologies.

In the area of clean coal technologies, the federal government is continuing to work with key industry players to develop leading-edge technologies to reduce the levels of pollutant emissions such as organics and trace elements from combustion processes. A vertical combustor was built in 1995 and forms an integral part of NRCan's research activities. This facility will be used in studying the effects of chemical additives and particulate capture devices on the distribution of trace elements, as well as modifying the production process to produce concentrated carbon dioxide for sequestration and enhanced oil recovery.

Canada has also established a National Combustion Network on the Internet (http://www.combustion-net.com) to assist in creating linkages among key players interested in the development and deployment of high-efficiency, low-emission combustion processes. This network will, for example, assist in creating strategic alliances to undertake new research or to enhance public–private sector partnerships in seeking new national and international opportunities.

An example of international collaboration is the assistance that NRCan, together with B.C. Hydro and CIDA, is providing to China in conducting R&D to increase coal-fired plant performance. By transferring know-how on modelling and pilot plant operation, China will improve the performance of its boilers in terms of both increased energy efficiency and reduced emissions.

Buildings Sector

There are still many issues to be addressed and many opportunities to be explored in

both the residential and commercial areas. Energy efficiency and cost-effectiveness improvements are still needed for heating, ventilation, air conditioning, insulation, windows, lighting, and building assemblies, as well as heat management and life-cycle performance of buildings and their components.

Research efforts focus on residential and commercial buildings by developing and deploying technologies, providing support for standards, and providing analytical and simulation capabilities.

Canada will continue to emphasize the key sustainable housing elements that have existed in the past. The "building as a system" approach will focus on producing heat efficiently, minimizing thermal losses, efficiently distributing energy, and increasing the comfort and health of the occupants. This approach will improve the sustainability of buildings over time, by improving the lifetime of the stock while minimizing waste production. All of these objectives will help maximize the reduction of carbon dioxide from both residential and commercial buildings.

Efforts are being made to make communities more energy efficient by applying technologies such as district heating and cooling and the combined production of heat and power.

Renewables

Canada's strategy in the development of renewable energy technologies is to assist industry in improving the cost/ performance and reliability of existing and emerging renewable energy technologies and in commercializing them in Canada and international markets. The government is assisting in deploying renewable and energy efficiency technologies by providing technical support to Canadian companies.

Research efforts of the past have resulted in reliable technologies that are cost-effective in niche markets. Canada has been successful in applying leading-edge technologies in world markets. We are also taking advantage of increased demand for photovoltaics, wind, and small hydro in remote communities and in newly emerging economies. R&D investments are being made to further reduce the cost or increase the reliability of existing technologies and to develop new competitive products such as wind energy equipment for cold climates or micro-hydro. This will ensure that renewables play a prominent role in reducing future greenhouse gas emissions, both nationally and internationally.

To encourage renewable energy investments, Canadian tax rules have been changed to create an essentially level playing field for all energy investments in Canada. Changes improve tax rules for the financing of some renewable energy and conservation projects, including the extension of flow-through share provisions, originally available to oil, gas, and mining investments.

Recently, Canada's Minister of Natural Resources and Minister of Environment announced the Green Power Procurement Initiative, a program to promote the use of renewable energy in Canadian government buildings. This program will help test and deploy leading-edge renewable energy technologies in photovoltaics, wind, small hydro, and bioenergy.

In Alberta, the electricity generation sector has been restructured, allowing for cost-effective renewable electricity sources to compete against conventional sources. Other provinces are also reviewing the structure of their electricity generation sectors.

Transportation Sector

Within the transportation field, there are several mechanisms for reducing climate change effects. These include improved efficiency of vehicles, substitution of alternative fuels, and development of zero-emission vehicles (ZEVs).

The Motor Vehicles Manufacturers' Association signed a Memorandum of Understanding with NRCan in November 1995 to improve fuel efficiency through a balanced approach aimed at vehicle owners and operators as well as vehicle technology. The aim is to contribute to greenhouse gas emission limitation by helping drivers realize the benefits of fuel savings, influencing on-road energy efficiency through vehicle inspection and maintenance programs and on-board diagnostic equipment on new vehicles, and promoting technological progress in the fuel efficiency of new vehicles.

Efforts in the alternative fuel area are focused on electronic controls, light-weight natural gas cylinders, heavy-duty vehicle applications, cost reduction, performance, standards, and infrastructure development. These are contributing to removing technical and institutional barriers to applications of alternative fuels.

The strategic thrust of Canada's efforts will build on existing Canadian technologies and expertise and will centre around the ZEV technologies, focusing on the development of components rather than vehicles. This will include efforts in advanced energy storage systems (flywheels, batteries, light-weight cylinders), hybrid vehicles, advanced materials, and advanced power systems. Focus will be on developing and taking these technologies to the marketplace. In the short term, technology development will be focused on those fuels that will result in ultra-low-emission vehicles.

PERD's Energy and Climate Change Task

The new Energy and Climate Change Task of PERD will target its activities to niche areas where it can build on Canadian expertise and strengths previously developed. The Task has identified four main areas of study. Common to them all is the principle, driven by limited resources, that the Task will not fund widespread baseline data collection work.

Greenhouse Gas Cycles and Storage

Greenhouse gas cycles and storage that are affected by the energy production and use sectors need to be better understood. Methodologies and tools for the measurement and assessment of the effects of anthropogenic greenhouse gas emissions on these cycles will be developed. Carbon dioxide and methane will be emphasized, as these are most closely associated with the energy sector and are the major greenhouse radiative forcing gases.

Climate Change Prediction and Detection

The systematic observation of Canada's climate and the investigation of climate processes particularly relevant to Canada's territory (such as those related to snow and ice, boreal forests, permafrost, and adjacent oceans) are important contributions to international efforts. This work will continue. Work will also be initiated on the recent and increasing importance of the cooling effects of aerosols that mask the radiative forcing effect of increased concentrations of greenhouse gases. The Task will also support specific studies on techniques for understanding historical records, for present-day detection, and for prediction of climate change in the areas of land cover, water, biota, and the atmosphere. Studies will be carefully

chosen to complement the greater body of climate work organized within Canada and internationally by groups such as the Climate Change Program Board and the Intergovernmental Panel on Climate Change (IPCC).

Capture of Greenhouse Gases and Their Disposal

The Task will address the development of technologies for the capture of greenhouse gases (after their formation) and their disposal. There are two broad means of capturing greenhouse gases: (1) from the greenhouse-gas-forming process, usually combustion, before they are released, and (2) from the atmosphere, after they are released. The work in both areas is in the early stages, and large resources cannot yet be assigned to them. Capture before release is most advantageous from large stationary sources, such as electric power stations; it is also expensive. Thus, work is necessary to reduce the cost of capture and to modify processes so that the exhaust stream has as high a concentration of carbon dioxide as possible. The subsequent sale of carbon dioxide, potentially for improved oil recovery, provides a partial incentive for the development and deployment of capture technologies. The concentration of carbon dioxide in the atmosphere is very low. Stimulating natural uptakes, in either land- or ocean-based processes, is seen as a more viable means of taking carbon dioxide directly from the atmosphere. As a step in this direction, the Task will first focus its attention on the forests, as they represent an established source for land-based uptake.

Impact of Climate Change on the Canadian Energy Sector

Finally, the Task will study the possible impact of climate change on the Canadian energy sector and identify appropriate adaptive strategies. Although some studies have been done, they are few and scattered. An initiative for a more comprehensive attack has been launched as the CCS-CIA, which could help the Task focus on areas of greatest need. It is clear that there are many areas of concern, including changes to water availability for hydroelectricity, changes to electricity demand in summer for space cooling and in winter for space heating, and changes to the stability of permafrost, which is important for resource exploration over much of Canada's north.

Over the coming years, greenhouse gas abatement activities and impact studies will become increasingly important, and there should be greater emphasis on these within the PERD Task.

Other Initiatives

Climate Change Voluntary Challenge and Registry (VCR) Program

The Voluntary Challenge and Registry (VCR) program is an integral part of Canada's NAPCC. It challenges organizations, primarily industry, business, government, and public institutions, to take voluntary actions to reduce greenhouse gas emissions. The program calls on participants to confirm their commitment to voluntarily limit greenhouse gas emissions, to develop an action plan, to encourage others to take up the challenge, and to work with an industry association and/or through existing government voluntary programs. The VCR program builds on existing strengths and capacities of Canadian business sectors and governments to develop flexible and cost-effective actions, including the development and use of new technologies to address greenhouse gas emissions. The VCR is evolving, with over 600 registrants as of December 1996, representing over half of Canada's greenhouse gas emissions.

Pollution Prevention

The Canadian federal Pollution Prevention Strategy is an economic and environmental initiative that shifts the focus of environmental protection from reacting to pollution towards preventing pollution at the source. One element of the strategy focuses on participation in international pollution prevention strategies by stimulating the shift to pollution prevention through technology transfer, voluntary agreements, and energy conservation; incorporating pollution prevention into international standards; and advancing pollution prevention through international protocols and agreements. The Canadian Council of Ministers of the Environment has adopted pollution prevention planning as a guiding principle.

Canadian Directory of Energy Efficiency and Renewable Energy Programs in Canada

This computerized database, assembled by NRCan with provincial cooperation, covers all Canadian federal, provincial, and territorial programs and initiatives in the energy efficiency and renewable energy area. The computerized database (DOS, PC and Macintosh) of the 1994–1996 Canadian Directory of Energy Efficiency and Alternative Energy Technologies is available upon request. It also includes similar programs delivered by Canadian natural gas companies. Hard copies of the Directory are available through NRCan and Trade Officers of Foreign Affairs and International Trade Canada.

Summary

Canada has made good progress in developing its programs for monitoring climate and ecosystems, in improving knowledge of the scientific information base required for informed policy response to the risks of climate change, and in technology R&D. This progress is broadly consistent with that proposed in its NAPCC. Several key concerns include the maintenance of an effective monitoring program while addressing the need for fiscal restraint; the enhanced participation of the private sector in research networks; inadequate levels of research related to the Arctic climate, particularly in oceanography, and into the socioeconomic consequences of actions to reduce risks of climate change; full multi-sector/multi-government participation in the CCS-CIA; and more effective communication of relevant science to policy-makers and the general public.

CHAPTER 10: Education, Training, and Public Awareness

Introduction

The United Nations Framework Convention on Climate Change (FCCC) recognizes the important role of education in the international response to global warming. The FCCC refers explicitly to education, training, and public awareness. Article 4(1)(a) indicates that all Parties should "promote and cooperate in education, training, and public awareness related to climate change and encourage the widest participation in this process, including that of non-governmental organizations."

Article 6 of the FCCC expands on Article 4(1)(a), indicating that Parties must promote:

- the development and implementation of educational and public awareness programs on climate change and its effects;
- public access to information on climate change and its effects;
- public participation in addressing climate change and its effects and in developing adequate responses; and
- the training of scientific, technical, and managerial personnel.

In keeping with Canada's commitment to develop a national communication program on climate change, all levels of government and a number of non-governmental organizations have undertaken a range of initiatives to further public awareness and understanding on this urgent issue.

Federal Government Actions

Canadians' level of concern about climate change has grown in the past few years. However, surveys consistently show that a lack of awareness exists in terms of what individuals can do to help reduce the levels of greenhouse gas (GHG) emissions produced by our country. In recognition of this problem, a number of initiatives have been undertaken by the federal government.

The federal government has also initiated an alliance-building approach to work with partners in key sectors to reach their constituents with messages on the need for action on climate change. Work will take place with these sectors to develop outreach materials and messages for their target audiences. A strategy to move this outreach initiative forward and to liaise with potential partners is being developed and will be implemented shortly.

Actions that are part of Canada's national outreach program on climate change are briefly described below.

Environment Canada: Action 21

In 1995, Environment Canada launched Action 21. This national program has both public awareness and funding components to encourage local action in support of national environmental priorities. In 1995 and 1996, the public awareness component was designed to support Environment Canada's climate change program areas.

Market research found the public's understanding of climate change to be limited. Although many individuals had certainly heard of the term "global

warming" and were very concerned with air issues, few were able to explain the issue in any detail. Sustainable transportation was chosen as the focus of the climate change public awareness activities.

Using the creative platform "Canada's Healthy Neighbourhoods," this national, bilingual awareness campaign relies on donated air time and print space. The strategic approach is to encourage individual action in support of a healthier environment by highlighting success stories of real people taking action in their day-to-day lives or taking the lead in their community to reduce car use. The link between the automobile, climate change, and smog is very prominent in the awareness campaign.

In addition to this national campaign, several complementary social marketing activities are being implemented by Action 21 to increase awareness and understanding of climate change and the actions individuals can take to reduce their dependence on the automobile. For example, in partnership with Health Canada, Action 21 also launched "Healthy Environment" spots on the national television weather network and funded a series of active transportation workshops, delivered by a non-governmental organization.

In 1995 and 1996, the funding component of Action 21 also provided financial assistance to a number of organizations addressing air issues in their communities. The majority of projects funded in this area focused on encouraging alternative transportation modes, reducing vehicle emissions through responsible vehicle care, and energy conservation. For example, with financial assistance from Action 21, the Alberta Lung Association is coordinating vehicle emission tests at automotive service centres in Edmonton, and Pollution Probe has involved organizations in Ottawa, Toronto, and Edmonton in a clean air challenge ("Clean Air Commute") and vehicle emission testing clinics.

The focus in 1997 will be on sustaining the message on climate change and sustainable transportation through producing a second batch of air segments and print space; developing or maintaining media, corporate, interdepartmental, and non-governmental organization partnerships to implement complementary awareness activities; and continuing with the weather network programs. The major new addition to the campaign will be the introduction of a radio programming component, using national network radio to reach listeners across the country.

Environment Canada: Atmospheric Environment Service

In June 1995, as an element of activities aimed at raising Canadians' awareness of climate change, Environment Canada's Atmospheric Environment Service developed the concept of releasing to the media seasonal summaries of temperature trends and extreme weather events. The intent of these summaries was to provide more information on the extreme weather that Canadians have recently experienced. The summaries to date have generated extensive media coverage, and a recent survey indicates that many Canadians are now more aware of climate change.

Natural Resources Canada (NRCan)

One of Natural Resources Canada's (NRCan) key responsibilities is helping Canadians become more energy efficient. NRCan has several public awareness programs aimed at improving energy efficiency and expanding use of renewable energy and thereby limiting greenhouse gas emissions across the country. NRCan produces and markets numerous publications aimed at the general public as well as more specific audiences. These

publications offer information on a wide range of topics, including alternative transportation fuels, home energy efficiency, and energy-efficient office equipment, heating systems, appliances, lighting products, and vehicles.

Each year, NRCan distributes about 1.5 million copies of more than 300 energy efficiency and alternative energy publications to individuals and program allies. Recently, the department produced a series of seven award-winning animated public service announcements featuring the Enercat cartoon character. These messages, broadcast by television stations across the country, remind Canadians to use energy efficiently.

With help from Canada Mortgage and Housing Corporation, NRCan produced articles on energy efficiency for newspaper supplements. These articles discussed home energy renovations, renewable energy technologies, and other topics. These supplements were distributed to almost 2.5 million households.

NRCan has also developed programs such as Auto$mart, to provide Canadian motorists with helpful tips on buying, driving, and maintaining their vehicles in ways that will reduce fuel consumption, save money, and protect the environment.

The FleetWise and FleetSmart programs have also been developed to encourage managers of vehicle fleets both within the federal government and outside government to reduce their environmental impacts and operating costs through energy-efficient practices and the use of alternative fuels.

Provincial/Territorial Activities

Provincial and territorial governments continue to work to increase public awareness of climate change and to encourage action by individuals to reduce greenhouse gas emissions. For example, the province of British Columbia has a Fuel Smart program in place to raise awareness about transportation energy efficiency and will work with utilities and other partners to expand the government's energy education and consumer information programs. The Alberta Clean Air Strategic Alliance has introduced a Clean Air Week and is encouraging reduction of public and private sector greenhouse gas emissions, through initiatives such as Eco-Efficient Communities.

A "Green Communities" program initiated by the Ontario government helps communities to increase energy and water efficiency. A total of 15 Ontario communities are currently participating in this initiative, with substantial energy and water savings being realized.

A number of provinces also have plans to develop new educational material to broaden the general public's understanding of the climate change issue.

Other provincial and territorial programs can be found in Appendix I, Table 1.

Municipal Governments

The federal government has worked closely with the Federation of Canadian Municipalities (FCM) to assist in the development of the Federation's "20% Club," and Environment Canada has provided funding for the 20% Club Secretariat. The Club's primary objective is to encourage municipalities to reduce their greenhouse gas emissions that contribute to climate change by 20% of 1990 levels by the year 2005. The 20% Club currently has 30 members, including municipal and regional governments from across Canada, representing 32% of the population. One of the objectives of the 20% Club is to highlight municipal government leadership and initiatives. Over a dozen case studies profiling municipal initiatives can be

viewed on the FCM web site, www.fcm.ca. The Secretariat for the 20% Club has set a target of 50 new members by the end of 1997.

NRCan is collaborating with FCM to develop and implement an energy efficiency building retrofit program that will replicate the Federal Building Initiative, which has been very successful in supporting energy efficiency projects in federal facilities.

Non-Governmental Organizations

Environmental Groups

Environmental groups continue to play a vital role in informing the public about climate change and building the capacity of local communities to address the issue. A number of national and regional Canadian environmental groups were actively promoting public awareness of the climate change issue in 1995 and 1996. Many of these groups received funding from Environment Canada for their climate change activities.

For example, the Sierra Club of Canada undertook a national capacity-building tour, meeting with local environmental groups to update them on the issue. The goal was to enable them to take action to build awareness and action in their communities. Pollution Probe implemented a "Clean Air Commute" challenge during the month of June in Toronto in 1995, and in 1996 the challenge was expanded to Edmonton and Ottawa. The Union québécoise pour la conservation de la nature (UQCN), a Quebec-based environmental group, has held several climate change and transportation workshops. The Pembina Institute has developed an education kit for climate change, including a Web site that will assist their future work with students and educators.

Canadian Global Change Program (CGCP)

The Canadian Global Change Program (CGCP) of the Royal Society of Canada has been an active player in communicating relevant information on climate change to the Canadian public. The CGCP produces a bulletin entitled *Changes*, which provides concise information on key global environmental issues. Two issues published recently — Canada and Climate Change: What Is It and What Can We Do About It? and Reducing Greenhouse Gas Emissions: The Additional Benefits — have focused on climate change. Workshops and conferences are also organized periodically to create venues where information can be presented and discussed. Important events have included a symposium for parliamentarians and their advisors at which both the Canadian Environment Minister and the U.S. Under-Secretary for Global Affairs spoke about climate change. The CGCP has also developed specific material and services for the educational community, including a book entitled Global Change and Canadians and an accompanying teachers' guide.

Private Sector Associations and Companies

A number of private sector associations and companies in the energy production, transmission, and distribution sectors have education programs for employees and their customers that promote the efficient use of energy. Examples are educational and information material produced by electrical and natural gas utilities and by associations such as the Canadian Association of Petroleum Producers (CAPP) and the Canadian Energy Pipeline Association (CEPA). For example, the gas and the electricity distribution utilities provide information to over four million homes each month, and all sectors (production, transmission, and distribution) of both the gas and electricity industries have information and training programs for their employees.

APPENDIX I

Appendix I, Table 1 Summary of policies and measures affecting emissions of CO_2 and other GHGs

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
GOVERNMENT OF CANADA							
Federal Building Initiative	Awareness Information Education Demonstration	A program designed to assist federal government departments in implementing energy efficiency improvements. Energy retrofits are financed from energy savings.	Instit.	Full-scale status. Started in 1991.	NA		Private sector commitments have been made to invest $120 million, which will yield $17 million in annual energy savings. By 2000, estimated energy intensity savings of 146 MJ/m^2 from 1990 levels, and 265 MJ/m^2 by 2005.
Federal Industrial Boiler Program	Awareness Information Education R&D and Demonstration	Assists federal departments, agencies, and Crown corporations in reducing GHG emissions, increasing energy efficiency, and reducing operating costs.	Comm. Instit. Indust.	Full-scale status. Start 04/01/91. 1995 Expend. $526 000.	NA		Specific services include efficiency audits, non-destructive metallurgical examinations, and life-cycle costing studies. CO_2 emissions were reduced by 15 kt in 1995/96.
Industrial Energy Innovators Initiative	Awareness Information Education	Emphasizes a voluntary challenge approach whereby organizations commit to upgrade the efficiency of their buildings and report on the energy savings achieved. Many of the retrofits are implemented by energy service companies and financed using third-party funds, which are repaid from energy savings.	Comm. Indust. Munic.	Full-scale status. Implemented in 1991.	NA		Since 1991, the Industrial Energy Innovators Initiative has enrolled more than 300 organizations, which have committed to the implementation of sustained economic projects to reduce energy waste.
Industrial Energy Efficiency Technology Program	Awareness Information Education R&D	Program capitalizes on federal expertise in heat management and process analysis and optimization to reduce energy use and increase product quality and productivity.	Indust.	Full-scale status.	NA		Benefits ongoing.

* (planned, implemented; legislation passed or not; status of funding)

** (Note: in order to avoid double counting, in most cases the effects of individual measures are not quantified due to their inter-relationship and combined impact with similar or other complementary measures. The combined effects of most of the measures are accounted for in the emissions outlook to 2000 and beyond - see Appendix 1, Tables 1(a), (b), (c).)

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
GOVERNMENT OF CANADA (cont.)							
Mobile Foundry Laboratory	Awareness Information Education R&D	Laboratory to conduct energy audits at 20 foundaries a year for the next 3 years.	Indust. Manuf.	Full-scale status.	NA		Benefits ongoing.
"Green" Power Purchase	Demonstration	Two federal departments, Environment Canada and NRCan, have contracted to purchase electricity produced from renewable energy for their buildings in two provinces in order to promote renewable energy contracting.	Instit.	Pilot project. Start 1997.	NA		This is a pilot project, which will be monitored to assess its wider application within the federal government.
Energy from the Forest (ENFOR)	R&D and Demonstration	Research on biomass supply for energy.	Forest.	Full-scale status. Start 04/78. End 03/97. 1995 Expend. $1 077 000.	NA		Primary focus is on biomass production from forest residues.
National Energy Codes for Buildings and Houses	Standards and Regulations	Develop national model energy codes that specify minimum levels of thermal performance for commercial and residential buildings. Help provinces and municipalities put them into operation.	Resid. Comm.	The codes, under development since 1990, were recently completed.	NA		The codes will be published early in 1997 and considered by provinces and municipalities for adoption.
Industrial Energy Efficiency	Awareness Information Education	The Minister of NRCan, working with a council of industry Chief Executive Officers (CEOs), challenged industry to set energy efficiency targets for the major energy-using industrial sectors. NRCan works with members of the Canadian Industry Program on Energy Conservation (CIPEC) in developing the sector targets and in obtaining company-level commitments through the Industrial Energy Innovators Initiative.	Indust.	Full-scale status. Started in 1992.	NA		Thirteen industrial task forces have committed to energy efficiency improvement targets, ranging from 0.7% to 3.0% per annum between 1995 and 2000. More than 200 companies, representing 65% of energy use in the manufacturing and mining sectors, are participating in the initiative.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
GOVERNMENT OF CANADA (cont.)							
FleetWise	Awareness Information Education	Helps federal government institutions become more energy efficient and use ATFs.	Transp.	Full-scale status. Started in late 1995.	NA		Projected 21% reduction of CO_2 from 1990 levels by 2000 and 33% by 2005.
Auto$mart	Awareness Information Education	Provides motorists with energy efficiency information on the purchase, maintenance, and operation of vehicles.	Transp. (private)	Full-scale status. Started in 1994.	NA		In the first year of the initiative's operation, interested parties made almost 4 000 telephone enquiries to the toll-free number.
Industrial Benchmarking Reports	Awareness Information	Industrial establishments will be provided with a confidential benchmarking report on their energy efficiency progress, including how they compare to national and international averages for their sector. Information will also be provided on best practices in energy management for their industries.	Indust.	To be implemented in 1997.	NA		Initiative being designed.
Sustainable Transportation	Awareness Information Education	Develop policies, priniciples, and programs that lead to sustainable transportation and reduced GHG emissions.	Transp.	Full-scale status.	NA		Benefits ongoing.
Tree Plan Canada	Awareness Information Education	The strategy calls for the planting of trees by companies and organizations to sequester CO_2 and other radiatively active gases.	All	57 million trees planted since 1992.	NA		At maturity, will have sequestered and reduced CO_2 emissions by 6.2 Mt.
Action 21	Awareness Information Education	Public awareness program focusing on the automobile and its contribution to air pollution. Program encourages Canadians to use alternative modes of transportation.	Transp.	Full-scale status.	NA		Government is providing workshops on alternative modes of transportation.
FleetSmart	Awareness Information Education	Will encourage commercial fleet operators to reduce operating costs through energy-efficient practices and the use of ATFs. Will provide information, workshops, technical demonstrations, and training.	Transp.	Launched in late 1996.	NA		Premature, since program quite new.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
GOVERNMENT OF CANADA (cont.)							
Buy$mart	Awareness Information Education	Will provide consumers with fuel efficiency information on individual vehicle models through a vehicle label. Vehicle manufacturers will promote vehicle efficiency and provide information and training to their dealers.	Transp.	Under development.	NA		Premature, since program not fully designed.
Energy Efficiency Regulations	Standards and Regulations	Regulations under the *Energy Efficiency Act* establish minimum energy performance levels for prescribed products. To date, regulations have been established for 20 residential energy-using products, electric motors, and lighting products. These will be expanded in the near future to include five additional residential products and six additional products in the commercial sector.	Resid. Comm. Indust. Institut.	Full-scale status. First regulations came into effect in 1995.	NA		Regulations apply to products that account for 65% of residential energy demand. The lighting regulations are estimated to reduce CO_2 emissions in the year 2000 by an amount equivalent to the annual CO_2 emissions of more than 1 million cars, 5.3 Mt annually by 2000.
Canadian Joint Implementation Initiative (CJII)	Awareness Information Education	The program will encourage and support Canadian parties to implement projects internationally to reduce GHG emissions.	Comm. Indust.	Start 01/10/96.	NA		The CJII office is anticipating 15 fully developed JI proposals for 1997.
EnerGuide	Awareness Information Education Standards and Regulations	Regulations under the *Energy Efficiency Act* require manufacturers to affix EnerGuide labels to equipment to inform consumers of the product's relative energy consumption. This is supported through directories for consumers, information and education campaigns, and training for retail sales staff.	Resid.	Full-scale status.	NA		In 1994, NRCan introduced a new label for six residential appliances that was easier to understand and provided comparative energy consumption information. In 1995, the program was expanded to include room air conditioners.
Hydrogen Fuel-Cell Bus	R&D	Government helped Ballard Power Systems in building world's first hydrogen fuel-cell bus. The bus does not emit any GHGs.	Transp.	Pilot testing of bus began 1993.	NA		New prototype being tested.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
GOVERNMENT OF CANADA (cont.)							
Building Energy Technology Advancement Program	Awareness Information Education	The program emphasizes ways to produce heat efficiently, minimize thermal loss, and distribute energy. Projects include R&D and field trials of new technologies.	Comm. Instit. Resid.	NA	NA		Benefits ongoing.
National Communication Program on Climate Change	Awareness Information Education	An action-oriented public education campaign on climate change and other air issues coordinated among governments and other organizations.	NA	Planned for 1997.	NA		
Renewable Energy Strategy	Awareness Information Education Research	Government will increase its initiatives re: information, training and education, and supporting renewable energy technology research, conferences, workshops, publications, and market research and access.	All	Announced Oct. 1996.	NA		In 1995/96, NRCan spent $9 million on renewable activities. Government also changed investment tax rules in 1996 to promote investments in renewable energy.
APEC Harmonization of Equipment Standards	Standards	Will seek to harmonize test methods and assessment systems for equipment standards among member countries of the Asia-Pacific Economic Cooperation (APEC) organization.	Resid. Comm.	APEC Committee will begin deliberations in 1997.	NA		Premature, since initiative just beginning.
National Biomass Ethanol Program	Financial Incentive	The program, administered by the Farm Credit Corp., offers a guaranteed repayable line of credit for firms to build or expand ethanol plants in Canada. The line of credit is available if the government reduces or eliminates the excise tax exemption for ethanol in the future.	Indust.	Announced Dec. 1994. $65 million in credit can be accessed 1999–2005.	NA		
Community-Based Energy Planning	Awareness Information Education	Federal government works with municipalities, utilities, and urban planners to explore more integrated approach to community-based energy planning. Expanding the use of district heating and cooling systems based on waste heat, cogeneration, or renewable fuels.	Munic. Utilities	Ongoing.	NA		NA

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
GOVERNMENT OF CANADA (cont.)							
Alternative Transportation Fuels Research & Development	Awareness Information Education R&D	Promote R&D for the commercialization of ATFs such as natural gas, propane, alcohol fuels, and electric vehicles.	Transp.	Full-scale status. 1995 Expend. $2.3 million.	NA		NA
Transportation Efficiency — Research and Development Program	Awareness Information Education R&D	Objective is to reduce vehicle fuel consumption and emissions through the development of energy-efficient technologies.	Transp.	Full-scale status. Start 08/01/92. 1995 Expend. $930 000.	NA		NA
Advanced House Program	Awareness Information Education R&D	Provides cost-shared support to industry for the construction of technologically advanced homes that consume 25% of the energy of conventional housing.	Resid.	Pilot Demonstration	NA		Technologies proven through this program will be considered for incorporation into the R-2000 Program.
Memoranda of Understanding with Energy Associations	Awareness Information Education R&D	Energy associations agree to encourage strong voluntary actions by member companies to address climate change issues.	Indust.	Full-scale status as of 1995	NA		NA
C-2000 Program	Awareness Information Education R&D	Promotes the adoption of energy-efficient advanced technologies and innovative management in commercial buildings through support for the construction of a small number of pilot projects, monitoring, and technology transfer.	Comm. Instit.	Pilot Demonstration	NA		NA
R-2000 Program	Awareness Information Education Standards (voluntary)	Improves the level of energy efficiency in housing by developing and marketing the energy-efficient R-2000 voluntary standard. Teaches house builders the standard, and tests and certifies houses. Encourages buyers to purchase houses that meet the standard.	Resid. (New)	Full-scale status. Started in 1980; ongoing and cumulative.	NA		More than 9 000 house builders trained to the R-2000 standard, and more than 7 000 certified R-2000 homes have been built.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
GOVERNMENT OF CANADA (cont.)							
Home Energy Retrofit Initiative	Awareness Information Education Demonstration	Encourages homeowners to improve the energy efficiency of their houses when they renovate and maintain them. Achieved through information media, the development of a Home Energy Rating System (HERS), and demonstration projects.	Resid.	Full-scale status. Start 1995.	NA		NRCan is developing the *Canadian Voluntary Home Energy Rating System Guidelines*, undertaking marketing and promotion, and helping design the Renovation Demonstration and Training and Certification initiatives.
Program of Energy Research and Development (PERD)	Awareness Information Education R&D	Study the linkage between energy and climate and the implications for Canada's energy sector. The second part of the PERD Task will develop techniques to capture and dispose of GHGs after they have been formed during energy-related activities.	Energy	Full-scale status. Start 04/96. Annual budget of $70 million.	NA		NA
Voluntary Challenge and Registry (VCR) Program	Awareness Information Education	The VCR invites Canadian businesses and organizations to express their intention to participate, on a voluntary basis, and develop action plans to limit or reduce their net GHG emissions. VCR office supported by federal and provincial governments and the private sector.	All sectors	Full-scale status. Start 01/08/94.	NA		Benefits ongoing. Over 600 participants as of Nov. 1996. Registrants represent sources of over 50% of Canada's GHG emissions.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
BRITISH COLUMBIA							
BC21 Power Smart	R&D	An energy efficiency and water conservation program for existing homes.	Resid.	Start 94/12. End 96/03. Expend. for most recent year: $17.1 million.	NA		Program has been phased out. Measures include the direct installation of water-saving products in 75 000 homes, retrofit advice, preferred financing and a $4.7 million fund for special innovative projects. Savings ongoing.
BC's Equipment Energy Efficiency Standards	Standards and Regulations	Regulations under the act require a wide range of appliances and equipment to meet minimum energy performance standards.	Comm. Instit. Resid. Indust.	Full-scale status. Implemented 08/01/90.	600 kt GHGs per year.		Regulations periodically updated.
Clean Vehicles and Fuels Program	Vehicle Emissions Testing & Maintenance Financial Incentive Program	The program provides support for all kinds of clean transportation fuels. Reduces air emissions from vehicles through actions such as emissions testing and maintenance. Reductions of approx. 20% in fleet emissions based on AirCare.	Transp.	Full-scale status.	Reductions of 24% CO, 20% hydro-carbons, 3% NOx, 0.5% CO_2 in fleet emissions.		Benefits ongoing.

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					2000	2005	
BRITISH COLUMBIA (cont.)							
Forest Sustainability Initiatives	Voluntary or Regulated Standards	Phasing out of "Beehive Burners" and encouraging other value-added use for wood residue (5 Mt no longer incinerated).	Forest.	Full-scale status.	NA		NA
Landfill Criteria	Voluntary or Regulated Standards	Attempting to reduce amount of waste going to landfills or incinerators by 50% per capita by the year 2000. Also regulating methane and other GHGs that are escaping from landfills.	Munic.	Full-scale status.	NA		NA
Transportation Demand Management (TDM)	Awareness Information Education	Develop TDM strategies for the province's major urban areas. Provided funding for a new cycling infrastructure.	Transp.	Full-scale status.	NA		TDM for government and Crown employees is under expansion.
AirCare	Voluntary or Regulated Standards	Test the exhaust systems of 1 million light-duty vehicles per year.	Transp.	Full-scale status. Start 1992.	Reduced GHG by 113 kt annually since 1992.		A voluntary vehicle scrapping program is to be pilot tested in the Lower Fraser Valley.
B.C. Energy Code for Buildings and Houses	Voluntary or Regulated Standards	Program supports the introduction of new energy efficiency requirements for buildings and homes into the B.C. Building Code.	Comm. Resid.	Start 1997.	NA		NA
Energy Efficient Public Buildings Program	Voluntary or Regulated Standards	Encourages energy retrofits in existing public facilities.	Comm. Instit..	NA	NA		The 3-year program should produce energy savings of $11–20 million per year.
Environmental Awareness Program	Awareness Information Education	Information packages for government employees.	Govt.	NA	NA		NA
Going Places	Regulated and Voluntary Standards	The construction of an HOV network in Lower Mainland, B.C.	Transp.	NA	NA		NA
Destination Conservation	Awareness Information Education	Jointly funded program for education and energy retrofit for B.C. schools.	Instit.	Full-scale status.	NA		Ongoing benefits.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
ALBERTA							
Clean Air Strategic Alliance	Awareness Information Education Standards and Regulations	Develop consensus on recommendations of private and public sectors for reduction of GHG emissions.	All sectors	NA	NA		Alliance recommends initiatives that have the potential to reduce GHG emissions — e.g., for vehicles, energy efficiency in manufacturing standards, and energy codes.
Energy Efficiency Audits	Energy Performance Contracts	Government of Alberta is assessing energy efficiency of its own buildings. Audits are reviewed to identify candidates for cost-effective energy retrofits.	Govt.	Being implemented.	NA		Government buildings use a computerized database that keeps track of energy consumption to make energy conservation decisions.
Small Power Research and Development (SPR&D) Program	R&D	Independent developers of approved small hydro, wind, and biomass projects can sell power to electrical utilities at a levelled price or escalated price indexed to inflation. This program is also aimed at technology transfer.	All	Full-scale status. Start 06/01/88.	Total offsets of 4.0 Mt of CO_2 possible over next 20 years.		The total production of electricity from SPR&D projects will be 581 GWh per year when all projects are commissioned. In 1995, 397 GWh of electricity were generated under the program.
Alberta Forest Conservation Strategy	Standards and Regulations	Forests are managed for sustained yields. This is to ensure that the volume of timber harvested does not exceed the volume grown.	Forest.	NA	NA		NA

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ALBERTA (cont.)							
Canada–Alberta Environmentally Sustainable Agriculture Agreement	Awareness Information Education R&D	Program encourages tillage practices that reduce GHG emissions.	Agric.	5-year cost-shared agreement.	NA		Program executed in conjunction with the Alberta Reduced Tillage Initiative. Establishes a framework for addressing environmental concerns within the agricultural sector.
Forestry Education Programs	Awareness Information Education	Forever-A-Tree is a forest conservational program for children in Grades 5 and 6. Arbour Day program gives seedlings to schools for planting. Trees are also provided to other interest groups for demonstration purposes.	Educ.	NA	NA		NA
Land Purchase Program	Standards and Regulations	The province buys land to retain wetlands and tree cover, thereby reducing GHG emissions.	NA	NA	NA		Benefits will be ongoing.
Action on Waste Program	Standards	A comprehensive waste management strategy to reduce the levels of municipal solid waste.	Munic.	NA	NA		Measures include recycling, 50% reduction of 1990 waste levels by 2000.
Cost-Effective Use of CO_2 Emissions	R&D	The Alberta Chamber of Resources is leading an initiative to find a cost-effective use for Alberta's CO_2 emissions.	Comm.	NA	NA		NA
Energy Efficiency Standards	Awareness Information Education	The government of Alberta has been encouraging the Canadian Gas Association and the Canadian Standards Association to include energy efficiency requirements with manufacturing standards.	Indust.	NA	NA		NA
Jasper Energy Efficiency Project	Awareness Information Education Financial Incentive	A community-wide effort to reduce electricity demand and defer construction of a transmission line or expansion of the electricity generating plant.	Resid. Comm.	Complete.	Reduction in emissions of 6.6 t NOx and 6 020 t CO_2.		Total annual energy savings of 6 320 328 kWh.

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ALBERTA (cont.)							
Drumheller Power Smart Partnership Program	Awareness Information Education	Program aims to reduce water, gas, and electricity use in city facilities and customers in the city.	Resid.	NA	NA		Annual savings of $40 000 in five municipal facilities.
Destination Conservation	Awareness Information Education	A student-driven program that increases personal awareness and encourages participation by all members of school communities to conserve energy.	Instit.	NA	NA		Accrued savings of $1.5 million over the last 7 years. Over 300 schools participating.
Power Smart	Awareness Information Education R&D	Energy utilities deliver such programs as information and education, training, and endorsement and labelling of energy-efficient products and technologies.	NA	NA	NA		Power Smart is a national and international brand to foster energy efficiency actions by consumers.
Sustainable Communities Initiative	Awareness Information Education	Attempts to influence Albertan communities to reduce their waste stream by approximately 5% as a result of composting. Involves communities in activities that demonstrate an adoption of, and commitment to working towards, a shared vision of sustainable development.	Munic.	NA	NA		NA
Smog Free	Awareness Information Education Financial Incentive	An educational program that makes it easy and convenient for motorists to reduce their vehicle emissions. There are financial discounts for work that reduces emissions. Increasing public awareness by publicizing program through mass media and the participating service centres.	Transp.	3 years in Calgary. 1st year in Edmonton.	NA		NA
Greenhouse Gas Curriculum	Awareness Information Education	Topics of GHGs and global warming are addressed in the curriculum for the compulsory courses of social sciences, natural sciences, and natural resources for junior and high school students. The program is creating greater awareness today for solutions in the future.	NA	NA	NA		NA

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					2000	2005	
ALBERTA (cont.)							
Drilling Waste Management	Standards and Regulations	Implement procedures for petroleum drilling waste management and disposal requirements, in an attempt to reduce waste generated from drilling activities. Encourages the reuse of drilling materials and the use of more environmentally benign drilling systems, muds, and additives.	Oil and Gas	Full-scale status. Start 1993.	NA		NA
Timber Harvest Planning	Standards and Regulations	Operating ground rules, which outline the practices that must be followed when harvesting timber.	Forest.	NA	NA		NA
Leasehold Agreements	Maintenance	Owners of government-leased buildings are encouraged to implement cost-effective energy efficiency measures.	Comm.	NA	NA		Benefits ongoing.
Beverage Container Recycling	Awareness Information Education	Objective is to educate consumers and promote a higher rate of return of containers. Effort is under way to develop an industry-run recovery program.	Resid. Comm.	NA	NA		Will reduce waste and energy use.
Eco-efficient Communities	Awareness Information Education	Provides municipalities with success stories, a "How to Guide," and workshops on potential actions.	Munic.	Information developed. Some municipalities approached.	NA		NA
Farm Energy Management	Awareness Information Education	Assists primary producers in the areas of energy use, energy efficiency, and alternative and renewable energy.	Agric.	Full-scale status.	NA		NA
Waste Management Actions	Awareness Information Education	A user-friendly information and resource kit will be assembled and shared with all government departments to encourage them to undertake voluntary waste management measures.	Govt.	NA	NA		Advisory support for starting the program will be provided.

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					2000	2005	
SASKATCHEWAN							
R-2000 Initiative	Awareness Information Education	A leading-edge standard for energy efficiency, high-quality new residential housing is being actively promoted through a joint venture.	Resid.	NA	NA		Benefits will be ongoing.
1-800 Energy Conservation Line	Awareness Information Education	Phone line provides energy conservation/efficiency information to residents of the province. The objective of the phone line is to provide residents with one-stop shopping for information and to promote the wise use of energy. The line provides information and brochures from NRCan and other sources.	Resid. Transp.	Full-scale status. Start 02/02/91.	NA		NA
Energy Efficiency Plan	Standards and Regulations	Plan calls for improved energy efficiency in government buildings and also examines opportunities for alternative fuels in its vehicle fleet.	Govt.	NA	NA		NA
Energy Efficiency Commitment	Awareness Information Education R&D	Government supports the vigorous analysis of methods to reduce GHG emissions, including the analysis of voluntary measures and measures previously evaluated at the national level. Energy use audits are offered to a broad range of government, institutional, and commercial energy users in the province.	Govt.	NA	Estimated 1 kt/year saved to date.		Program expanding.

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SASKATCHEWAN (cont.)							
Agricultural Energy Use Database	Awareness Information Education	An Agricultural Energy Use Database has been established at the University of Saskatchewan in cooperation with the federal government to assess energy use in the agricultural sector. Provincial farms have experienced rapid expansion of conservation farming techniques, encouraged by the province.	Agric.	Full-scale status.	26 Mt of CO_2 sequestered over last decade.		Also promoting sustainable forest management.
Gas Ready	Economic Measures	SaskEnergy is promoting the "Gas Ready" home concept, which will enable consumers to take advantage of efficient natural gas technology in new homes.	Resid.	Full-scale status.	NA		Benefits are ongoing.
Supporting Voluntary Challenge and Registry (VCR) Program	Voluntary Measures	The province is encouraging industry to register actions under the nation's Voluntary Challenge and Registry Program.	All sectors	Full-scale status.	NA		The VCR office has received over 20 submissions from Saskatchewan companies.
Air Quality Task Force	R&D	Task force undertook a comprehensive review of air issues. Government will develop a Clean Air Strategy to integrate actions on various air emissions.	All sectors	Full-scale status.	NA		NA
Regina Airport Energy Retrofit	R&D	SaskPower and the federal government are exploring the potential for an energy retrofit of the Regina Airport.	Govt.	Research status.	NA		Benefits to be determined.

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					2000	2005	
MANITOBA							
Energy Advisory Service	Awareness Information Education	Provides information to the public, housing industry, and other agencies through a toll-free telephone line service and publications. Provides information on home improvements, energy-efficient appliances and products, and services.	Comm. Instit. Resid. Agric. Transp.	Full-scale status. Start 06/81.	NA		Ongoing benefits in reducing energy consumption.
Minimum Tillage Practices	Awareness Information Education	Program aims to encourage farmers to use minimum tillage practices to save energy.	Agric.	Full-scale status.	NA		
Agricultural Waste	Standards and Regulations	Development and operation of particleboard manufacturing plants that utilize excess agricultural cereal straw, which is otherwise burned, into base consumer products. Reduction in the burning of the straw also reduces the emissions of CO_2 and other air pollutants into the atmosphere.	Manuf.	NA	NA		NA
Home Energy Savers Workshops	Awareness Information Education	Workshops conducted throughout the province to inform homeowners on how to plan and implement energy-saving measures and purchase energy-efficient appliances and products.	Resid.	Full-scale status. Start 09/85.	NA		As of June 1995, 310 workshops have been delivered to over 5 200 homeowners.
Manitoba Pro-Trucker Program	Awareness Information Education	Pro-Trucker is a program to reduce the fuel utilization of large trucks through driver education and training.	Transp. (Comm.)	Full-scale status. Start 05/91.	NA		An annual fuel economy challenge is a component of the program.

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					2000	2005	
MANITOBA (cont.)							
Energy Efficiency and Renewable Energy Projects	R&D	Government will continue to support programming that contributes towards the adoption of energy efficiency in industry and commerce, government, and the home.	All sectors	NA	NA		Benefits will be ongoing. Continues to promote development in the production, use, and export of renewable energies.

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					2000	2005	
ONTARIO							
Energy Efficiency Act and Regulations	Standards and Regulations	Sets a minimum efficiency level for specified appliances and products sold in Ontario.	Comm. Instit. Resid.	Full-scale status. Start 06/01/88.	Reduce CO_2 levels by over 260 kt.		Benefits are ongoing.
Graduated Tax for Fuel Conservation	Financial Incentive	The tax is based on the fuel economy of new vehicles; it places an extra tax on less fuel-efficient vehicles.	Transp.	Full-scale status.	Reduce annual CO_2 emissions by 200 kt.		NA
Green Communities Initiative	Awareness Information Education	The initiative encourages/supports the greening of communities through multi-sectoral initiatives that integrate local energy and water efficiency and other pollution control activities.	All sectors	Full-scale status. Start 06/01/91.	NA		19 Ontario communities participating in the initiative. Water savings of 20–30% and energy savings of 10–15% to date.
Alternative Fuel Vehicle Program	Financial Incentive	Program offers a retail sales tax refund on vehicles that operate on natural gas, propane, or electricity. Producers of ethanol have been granted a favourable tax agreement until 2010.	Transp.	Full-scale status.	NA		NA
Upgrades in the Ontario Building Code	Standards and Regulations	Energy efficiency provisions for the construction of new buildings have been upgraded in several stages. Amendments to the Plumbing Code will reduce demand for water by setting a maximum flow rate.	Resid. Comm.	Full-scale status.	1 200 kt annually.		NA
Methane Reduction	Standards and Regulations	Government will reduce overall methane emissions from landfills in Ontario.	Munic.	Planned.	NA		NA

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					2000	2005	
ONTARIO (cont.)							
Custom Manure Applications	Awareness Information Education	Program focuses on environmental safety and nutrient efficiency in the context of manure application.	Agric.	NA	NA		Manure applications are being evaluated to determine, among other things, how to reduce methane formation.
Solar Photovoltaic and Thermoelectric Generation	Demonstration	Installation of combined solar photovoltaic and thermoelectric generation to provide the electricity for a remote radio repeater station.	NA	NA	NA		Replaced an existing diesel generation system.
The Green Workplace	Standards	Helps Ontario government implement waste reduction and water and energy conservation.	Comm. Instit.	NA	Reduction of 27 kt of CO_2 annually since 1995.		By 1995, waste reduction efforts had reduced waste going to landfills by approx. 15 kt annually.
Government Energy Management (GEM) Program	Standards and Regulations	Implement action plans to improve energy efficiency in government-owned and -operated buildings. GEM is also offering assistance in auditing and monitoring the implications of energy use patterns; identifying cost savings and retrofitting existing buildings; and providing energy management training.	Govt.	$3 million invested in retrofits with another $6 million to be invested, for a total annual savings of $3.2 million.	NA		NA
Build Green Inc.	Awareness Information Education	A program that facilitates the recycling of building materials.	Resid.	NA	NA		NA
Building Environmental Performance Assessment Criteria	Voluntary Measures	A program that evaluates the environmental merits of office buildings.	Comm.	NA	NA		Program is beginning with pilot projects in provincial buildings.
Environmentally Conscious Design Guidelines	NA	Government has developed guidelines for use in the construction of new government buildings.	Govt.	Full-scale status.	NA		Benefits will be ongoing.

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ONTARIO (cont.)							
Industrial and Commercial Building Conversion	NA	Government is working to generate private funds to convert industrial or commercial buildings to residential use to increase urban densities and reduce vehicle use for commuting. Government is also working to eliminate any impediments in the use of recycled-content materials from the Ontario Building Code.	Resid.	NA	NA		NA
FleetWise	Standards and Regulations	Objective of program is to minimize fuel use and expense of vehicle fleets through such measures as regular maintenance, driver education, and the purchase of smaller cars.	Transp.	NA	NA		NA
Car Pool Program	Awareness Information Education	The active promotion of car and van pools through such programs as Voice Response System, a registration system for matching drivers and passengers, and Share-A-Ride, a computer system that matches people interested in carpooling. Share-A-Ride is available on a province-wide basis through a toll-free number.	Transp.	Full-scale status.	NA		NA
Vehicle Inspection and Maintenance Program	Awareness Information Education	This program is aimed at identifying and reducing the emissions from vehicles in need of repair.	Transp.	Pilot status.	NA		Included in this program is Metro Toronto's high-tech vehicle inspection centre, which is being run as a 1-year pilot project.
Transit Opportunities	Awareness Information Education R&D	The province is committed to working with municipalities and regions to identify opportunities for HOV lanes, ATF, and other transit projects.	Transp.	Full-scale status.	NA		NA
Alternative Fuel Vehicle Program	Financial Incentive	Program offers a retail sales tax refund on vehicles that operate on natural gas, propane, or electricity. Exempts ATFs (except propane) from fuel tax.	Transp.	Full-scale status.	NA		Producers of ethanol have been granted a favourable tax agreement until 2010.

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ONTARIO (cont.)							
Natural Gas Powered Transit Buses	R&D	CNG-powered transit buses are being used in some Ontario cities and on a pilot basis; the monitoring of the fleet continues, and new developments are being evaluated.	Transp.	Pilot.	NA		Pilot project to develop, test, and evaluate the use of liquefied natural gas powered buses.
Bicycle Infrastructure	Awareness Information Education	Municipalities receive provincial funding for bicycle infrastructure on a similar basis as funding for roads and transit.	Transp.	Full-scale status.	NA		NA
Energy Efficiency	Economic Measures	Reduce energy use in government-owned and -operated buildings.	Govt.	Full-scale status.	2.9 PJ reduction between 1990 and 1995.		Benefits ongoing.
Water Efficiency Measures	Economic Measures	Water-efficient showers, self-closing water faucets, and water-efficient laundry equipment installed in correctional facilities.	Instit.	Full-scale status.	NA		NA
Resource Conservation Guide for the Dairy Processing Sector	Awareness Information Education	Government published a guide to resource conservation and cost-saving opportunities in the dairy processing sector.	Agric.	Full-scale status.	NA		Benefits to be ongoing.
Crown Forest Sustainability Act	Awareness Information Education	Purpose of act is to provide for long-term health and sustainability of Crown forests. Forest Renewal Trust Fund was put in place to provide adequate funds for forest renewal.	Forest.	Full-scale status.	NA		NA
Community Transportation Office	Awareness Information Education	Works to address potential policy barriers to local coordination of community transportation. Coordination should reduce emissions by decreasing the number of vehicles used in a community.	Transp.	Full-scale status.	NA		NA

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
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ONTARIO (cont.)							
Transportation Demand Management	Awareness Information Education	A committee formed to develop and implement strategies for a coordinated approach to transportation demand management.	Transp.	Full-scale status.	NA		NA
Ethanol Fuel Use	Voluntary Measures	Government departments have adopted policies supporting the use of ethanol-blend fuels in fleet vehicles.	Transp.	Full-scale status.	NA		NA
Government Actions	Economic Measures	The government has undertaken measures to reduce travel, measures to improve vehicle efficiency, and reductions in government operations.	Govt.	Full-scale status.	NA		Benefits are ongoing. 27% reduction in GHG emissions from 1990 to 1995.

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QUEBEC							
Quebec's Energy Productivity Program	Financial Incentive Programs	Financial support for feasibility studies and demonstration projects, and is geared towards users of energy sources other than electricity.	Agric. Indust.	Full-scale status. Start 01/01/86.	NA		Since 1986, Ministère des Ressources Naturelles has conducted more than 500 feasibility studies for a total in subsidies of approx. $5 million and an energy savings potential of $110 million.
Forest Act	Standards and Regulations	Sets guidelines for maintaining long-term productivity of forests.	Forest.	Full-scale status.	NA		Benefits to be ongoing for CO_2 sequestration.
Institutional Energy Program	Standards and Regulations	Aim of the program is to integrate efficient management mechanisms into government systems.	Govt. Instit.	Full-scale status.	NA		Some areas covered are car parking, day-to-day management, and financing mechanisms for energy efficiency.
Traffic Management Systems	R&D	In the Montreal area, the government has experimented with traffic management systems that include energy efficiency as an objective.	Transp.	Pilot	NA		Benefits being studied. The government will continue to initiate measures encouraging energy efficiency.
Farm Manure Stocking and Spreading Practices	Voluntary or Regulated Measures	A modification in policies by the government resulting in the adjustment of farm manure stocking and spreading methods of producers. The government has also developed and implemented a program for the rehabilitation of active or closed landfills.	Agric.	Full-scale status.	NA		NA

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QUEBEC (cont.)							
Energy Efficiency Project	Awareness Information Education	A joint energy efficiency pilot project with Hydro-Québec to provide municipalities and regional county municipalities with an energy coordinator.	Munic.	Pilot.	NA		Benefits to be determined.
Energy Watch	Awareness Information Education	An energy efficiency information centre for SMEs, municipalities, agriculture, education, transport, and public and parapublic sectors. Centre also provides information to internal and external customers targeted by Quebec's Energy Efficiency Strategy.	All sectors	Full-scale status.	NA		NA
Equipment Efficiency Regulations	Standards and Regulations	Will include new regulations concerning the energy efficiency of existing appliances, and will be applicable to the new equipment and appliances put on the market. Rules on labelling appliances will be simplified. The aim of the new regulations is to enhance the energy efficiency of appliances and reduce consumers' energy bills.	Comm. Resid.	Full-scale status. Start 10/01/92.	NA		Benefits ongoing.
Ministry of Transportation Strategic Plan	Standards and Regulations	Government has drawn up a strategic plan, which covers maintenance of transport infrastructure and equipment, development of intermodal and integrated transport modes.	Transp.	Full-scale status. 1994–1997.	NA		Benefits ongoing.
Agricultural Practices	Awareness Information Education	Agricultural producers will be made aware of and trained in new agricultural practices to promote energy efficiency.	Agric.	Full-scale status.	NA		Benefits to be determined.
Residential Energy Rating System	Awareness Information Education	Objective of the program is to develop a residential energy rating system that would tie a building's market value to its energy rating. This will result in easier access to financing for home purchase or renovations.	Resid.	NA	NA		NA

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
QUEBEC (cont.)							
Building Regulations	Standards and Regulations	An energy efficiency guide that incorporates changes in energy efficiency standards for new builders and will be a reference for housing planners and builders.	Comm. Instit. Resid. (new)	Full-scale status.	NA		Quebec will also be adopting the National Energy Code. Government is also offering an experimental energy management program for schools.
Methane Capture	Regulation	Changes to regulations permit the capture and burning of methane from waste disposal sites.	Munic.	Operational	NA		It is expected that this measure will cover 60–70% of the total volume of municipal waste.
EcoGeste	Voluntary	This voluntary climate change program is similar to the Voluntary Challenge and Registry program in effect elsewhere in the country. It is designed to stimulate voluntary mitigative GHG initiatives among large, medium-sized, and small enterprises, institutions, and other businesses.	Indust. Comm. Instit.	Full-scale since Sept. 1966.	NA		
Increase Spending on Public Transit	Economic Measures	Government will increase spending on public transport infrastructure and will assist in other transportation projects.	Transp.	Full-scale status.	NA		NA

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
NEW BRUNSWICK							
Provincial Building Initiative	Awareness Information Education	Helps departments and hospital corporations to use third-party financing to implement energy improvements in provincially owned buildings.	Comm. Instit.	Full-scale status. Start 06/01/95.	NA		The objective is to retrofit all facilities to improve energy efficiency within a 3-year period.
Water Efficiency Program	Economic Measures	Encourages municipalities to take actions to reduce water consumption through promotion and rate reductions for their customers. Measures undertaken include upgrading of facilities to prevent leakage and infiltration.	Munic.	Full-scale status.	NA		NA
Pollution Prevention	Standards and Regulations	Pollution prevention techniques used in the assessment of facilities required to receive approvals to operate under environmental legislation. Pollution prevention reduces the consumption of raw materials and energy and the production of wastes requiring treatment.	Indust.	Full-scale status.	NA		NA
Provincial Energy Efficiency Regulations	Regulated Standards	Regulate the minimum efficiency levels, based on national standards, in energy-using equipment. Regulation objectives are to eliminate the least efficient equipment.	Comm. Resid.	Full-scale status. Start 06/01/95.	NA		NA
Air Resource Management Area Committees	Awareness Information Education	Local committees examine what contributes to reduced air quality in their communities and develop action plans to reduce that impact.	Munic.	Full-scale status.	NA		NA

* (planned, implemented; legislation passed or not; status of funding)

** (Note: in order to avoid double counting, in most cases the effects of individual measures are not quantified due to their inter-relationship and combined impact with similar or other complementary measures. The combined effects of most of the measures are accounted for in the emissions outlook to 2000 and beyond - see Appendix 1, Tables 1(a), (b), (c).)

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
NEW BRUNSWICK (cont.)							
Pro Trucker	Awareness Information Education	Energy-efficient truck driver training through seminars and one-on-one consultations. Makes recommendations on equipment specifications for drivers and fleet managers.	Transp. (Comm.)	Full-scale status.	NA		NA
Best Available Control Technology Assessment Process	Voluntary or Regulated Standards	Program looks at pollution prevention opportunities, followed by a top-down assessment of applicable control technologies. Process also looks at the impact of pollution controls on other elements of the environment and on energy consumption.	Comm. Instit.	Full-scale status.	NA		NA
Auto Propane Marketing Program	Awareness Information Education	Three programs to engage in marketing activities and to establish an improved fuel supply and maintenance structure throughout New Brunswick.	Transp.	Full-scale status. Amount invested $450 000.	NA		Vehicle conversions, primarily of private fleets, are progressing at a rate of one per week with a target of 200 conversions by 1998.
Expanded Silviculture Program	Awareness Information Education	Plan calls for an increase in productivity of managed timber.	Forest.	Full-scale status.	NA		Faster-growing trees that have the ability to absorb more CO_2 are currently under production in New Brunswick.
Biomass Energy Program	Awareness Information Education	Program improves the potential for expanded biomass use. Program elements include resource inventories, economic evaluations, and technology transfer.	Agric.	Full-scale status.	NA		Benefits to be determined.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
NOVA SCOTIA							
ENERACCOUNT	Awareness Information Education	A database established to record and facilitate analysis of energy performance indicators for all publicly funded facilities.	Comm. Instit.	Full-scale status. Start 1987.	NA		Future efforts will focus on improving ENERACCOUNT.
Energy Performance Contracting	Economic Measures	The undertaking of energy efficiency related capital improvements to public buildings.	Comm. Instit.	Full-scale status.	NA		The province will encourage all government-funded facilities to examine the feasibility of energy performance contracting by 1998.
Nova Scotia Coal Research Agreement	R&D and Demonstration	The program is working to improve the energy efficiency and reduce the environmental impact associated with coal production and use in Nova Scotia.	Electrical Utilities	Full-scale status.	NA		Programs focus on advanced utilization technologies for new thermoelectric facilities.
Non-Utility Generation (NUG)	Awareness Information Education	NUG is encouraged through the supplying of information regarding cogeneration and technical assistance to potential private power suppliers.	Manuf. Indust. Comm. Resid.	Full-scale status.	NA		Benefits ongoing.
Landfill Gas Management Plans	R&D	Government is developing options for managing landfill gases in order to reduce GHG emissions from solid waste.	Munic.	Pilot	NA		Have launched a province-wide plan to halve garbage going to landfills by the year 2000.

* (planned, implemented; legislation passed or not; status of funding)

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Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
NOVA SCOTIA (cont.)							
Residential Energy Programs	Awareness Information Education	Program designed to increase residential energy efficiency through information, training, and advice to homeowners. Program includes a toll-free information number and seminars in housing and heating issues.	Resid.	Full-scale status.	NA		NA
R-2000 National Builders Program	Awareness Information Education	Conferences on energy-efficient healthy housing and funding for technology transfers.	Resid.	Full-scale status.	NA		Benefits ongoing.
Energy Efficient Appliance Act and Regulations	Regulated Standards	Sets minimum efficiency levels for energy-using appliances and equipment sold or leased. Labelling for appliances and equipment also included.	Comm. Instit. Resid.	Full-scale status. Start 01/01/91.	NA		NA
Motor Vehicle Inspection Program	Standards and Regulations	Government operates an annual motor vehicle inspection program, which includes an inspection of a vehicle's pollution control system.	Transp.	Full-scale status.	NA	NA	NA
Supporting Transportation by Rail	Economic Measures Financial Assistance	The province has provided financial assistance to CN Railway for the establishment of an inland double-stacked container service. NS Railway Act also permits the operation of short-line railway operations. Railway transportation is more energy efficient than long-haul trucking.	Transp.	Full-scale status.			NA
Renewable and Alternative Energy Information Transfer	R&D	Information is provided on the cost-effective use of renewable and alternative energy. Technical assistance is provided for a preliminary analysis of specific opportunities.	Indust. Comm. Instit. Resid. Agric.	Full-scale status.	NA		NA

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
PRINCE EDWARD ISLAND							
Energy Efficiency Initiative	Financial Assistance	Provides financial assistance to companies for implementing energy conservation measures.	Indust. Comm.	Full-scale status.	NA		Benefits ongoing.
District Heating System Expansion	Economic Measures	Trigen Energy Canada Inc. is expanding the district heating systems in Charlottetown.	Indust. Comm. Resid.	Full-scale status.	Will eliminate 10 kt of CO_2 annually.		The expansion will displace 3.5 million litres of fuel oil annually.
Methane Recovery Systems	Standards and Regulations	Methane is recovered from the province's two largest food processing plants and from Charlottetown's municipal wastewater treatment plant.	Manuf. Munic.	Full-scale status.	Methane recovered is 7.7 million cubic metres annually.		Benefits ongoing.
Powerwise Opportunities & Thermal Energy Efficiency Workshops	Awareness Information Education	Workshops assist the province's manufacturers and processors in identifying conservation measures that will reduce energy consumption and GHG emissions.	Manuf.	Full-scale status.	NA		Benefits ongoing.
Air Quality and Ozone Depleting Substance Regulations	Standards and Regulations	The province has implemented measures to curb the use of ozone-depleting substances, which include measures to reduce GHG emissions.	All	Full-scale status.	NA		Benefits ongoing.

* (planned, implemented; legislation passed or not; status of funding)

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Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
NEWFOUNDLAND							
Energy Efficiency Measures	Voluntary or Regulated Standards	The Newfoundland and Labrador Housing Corporation has been working to improve the energy efficiency of its stock.	Resid.	Full-scale status.	NA		Benefits ongoing.
Pro Trucker Program	Awareness Information Education	Energy-efficient truck driver training through seminars and one-on-one consultations.	Transp.	Full-scale status.	NA		Activity in program is currently higher than at the beginning.
Institutional Energy Performance Contracting (EPC)	Economic Measures	Initiative is to use EPC to improve energy efficiency in institutions, particularly health and education.	Instit.	Full-scale status.	NA		Approximately one-half of health and one-quarter of educational institutions are at some stage of implementation.
Non-Utility Generation	Economic Measures	To utilize non-utility generation to meet new power requirements. Most projects are renewable energy or high efficiency (e.g., cogeneration).	Utility	Full-scale status.	NA		Four small hydro projects contracted to deliver power in 1998. New request for proposals issued in January 1997 for up to 200 MW.
Auto Propane Market	Awareness Information Education Financial Incentive	Reduction in provincial gasoline taxation from the current level of $0.16/L to $0.07/L for propane. Implemented to encourage propane conversion and reduce emissions. In 1992, a program for light-duty vehicles also implemented to stimulate auto propane market.	Transp.	Full-scale status.	NA		In 1992, a program for light-duty vehicles also implemented to stimulate auto propane market.

* (planned, implemented; legislation passed or not; status of funding)

** (Note: in order to avoid double counting, in most cases the effects of individual measures are not quantified due to their inter-relationship and combined impact with similar or other complementary measures. The combined effects of most of the measures are accounted for in the emissions outlook to 2000 and beyond - see Appendix 1, Tables 1(a), (b), (c).)

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
YUKON							
National Energy Codes for Houses and Buildings	Standards	Adoption of the National Energy Code for Houses and the National Energy Code for Buildings is being considered. These codes will save energy and reduce emissions from the use of heating fuels.	Resid. Comm. Instit.	Adoption to be initiated.	20 kt/year.		Yukon input provided during public review of the draft codes.
Energy Management Plan for Schools Pilot	Economic Measures	The Energy Management Plan for Schools pilot is designed to reduce energy costs. Costs are funded from savings from no- and low-cost measures.	Instit.	Now in third year of program. Start 1994.	2.1 kt/year.		Pilot has been expanded from 6 to 19 schools. GHG emissions down 7.6% in pilot.
Energy Management Plan for Government Facilities	Economic Measures	An initiative to reduce energy cost in government buildings has been proposed. Extending the approach used in the Energy Management Plan for Schools to other government buildings is being considered.	Instit.	In first year of program development. Start 1997.	6.8 kt/year.		Involvement of all government departments requested. Some initial pilot measures are being implemented.
Energy Efficiency Loans	Financial Incentive Programs	Financing mechanisms are being used to leverage investment in energy efficiency retrofits of buildings to reduce heating and electricity costs.	Resid.	Existing loan programs.	23.1 kt/year.		Loan data suggest as many as 20% of all loans are for energy efficiency measures.
Surplus Electricity Utilization Pilot	Economic Measures	Surplus hydroelectricity, when available in off-peak hours, can be used in two Yukon government buildings for space heating and domestic hot water heating. Provision for surplus electricity sales equipment is being considered in the design of all new government buildings. This is done where complete installation of necessary equipment cannot be justified initially.	Instit.	Start 1995 (2 pilot installations completed).	1.3 kt/year.		A report on initial two pilots showed savings. Provision for surplus electricity sales made in one new building. Water flows are below average. Demand is uncertain.

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Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
YUKON (cont.)							
Electrical Infrastructure Loan for Resource Development Program	Financial Incentive Programs	This program provides low-interest loans to help remote resource development industries obtain power. Loans may be used either to connect with the main power grid or to produce power for eligible projects.	Indust.	Full-scale status. Implemented 12/01/93.	NA		Loans may be used either to connect with the main power grid or to produce power for eligible projects.
Energy Management Program for Schools (Pilot)	Awareness Information Education	A collaboration between government departments, to achieve greater energy cost savings within government buildings (reduce emissions from reduced heating fuel use).	Educ.	Pilot, demonstration.	NA		As a first step towards this goal, a comprehensive, 3-year energy conservation program is being piloted in six Yukon schools.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
NORTHWEST TERRITORIES							
Energy Conservation Capital Program	Awareness Information Demonstration	Improve the energy performance of government assets by implementing energy corrective measures.	Govt.	Initiated.	NA		
NWT Project on Community Energy Planning	Awareness Information Demonstration	To reduce energy and utility costs for remote communities. Project team will help communities implement a community energy planning process.	Munic.	Initiated.	NA		Two pilot communities in the Arctic; one in eastern NWT and one in western NWT.
Destination Conservation (School Energy Management Program)	Awareness Information Demonstration	Initiate this student-driven energy management program, which includes establishing utility baselines; energy, water, and waste audits; implementing lifestyle campaigns by students; and implementing technical upgrades.	Govt.	Pilot with one school board.	NA		Plan to offer in other schools in the 1997/98 school year.
Energy Awareness and Communication Strategy	Awareness Information Demonstration	Promote the six regional Energy Management Offices, programs, and services; develop the awareness of energy; provide useful energy supply and management information. Various media: TV, newspaper, print, video, electronic mail.	Resid. Small Business Instit.	Initiated.	NA		
Business and Home Energy Assessments	Awareness Information Demonstration	A one-to-one information session with the client in his/her home, providing customized energy and water management information.	Resid. Small Business	Initiated.	NA		
Energy Management Training for the General Public	Awareness Information Demonstration	Coordinate the delivery of energy management courses through NWT colleges and other adult training organizations.	Resid. Small Business	Pilot.	NA		

* (planned, implemented; legislation passed or not; status of funding)

** (Note: in order to avoid double counting, in most cases the effects of individual measures are not quantified due to their inter-relationship and combined impact with similar or other complementary measures. The combined effects of most of the measures are accounted for in the emissions outlook to 2000 and beyond - see Appendix 1, Tables 1(a), (b), (c).)

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
NORTHWEST TERRITORIES (cont.)							
Hydrogen Study	R&D	Study will determine the feasibility of utilizing excess hydroelectric capacity at the Taltson site to produce hydrogen for industrial applications.	NA	Feasibility stage.	NA		
Igloolik Wind Demonstration Project	R&D	Two 15-kW wind machines were installed in Igloolik in the summer of 1993 to supply electricity to the community grid.	NA	Pilot/ demonstration in operation.	NA		Operations will be monitored, and, if successful, consideration will be given to establishing a larger "wind farm."
PV Demonstration Project	R&D and Demonstration	A 3-kW photovoltaic (PV) system was installed in an institutional building in Iqaluit in the summer of 1995.	NA	Pilot in operation.	NA		If the initial test is successful, a larger hybrid diesel/PV system will be installed in subsequent years.

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation: *	Estimate of mitigation impact**		Monitoring: intermediate indicator of progress
					2000	2005	
MUNICIPALITIES							
The City of Edmonton Revolving Energy Retrofit Fund	Awareness Information Education	Program is helping to fund numerous retrofit projects. Government is encouraging the use of recycled building materials for renovations and saving reusable materials from demolition projects.	Resid. Comm.	Full-scale status. $2.5 million investment in energy efficiency projects.	Annual reduction of 1 040 t of CO_2.		NA
Ottawa & Toronto Municipal Reductions	Voluntary Measures	Toronto and Ottawa have committed to reducing CO_2 emissions from municipal operations.	Munic.	NA	20% reduction from 1988 CO_2 levels.		Metro Toronto has already distributed over 17 000 retrofit kits under Toronto's water efficiency program.
City of Regina Water Utility Efficiency Improvement Program	Efficiency Program	Goal is to identify opportunities for energy efficiency and operational improvements to the city's water supply system.	Munic.	Full-scale 1994. Capital cost $102 000.	Annual reduction of 2 kt of CO_2.		Since 1994, annual energy savings have been $125 000, and CO_2 reduction of 2 kt.
Regional Municipality of Hamilton-Wentworth Transit Fleet Conversion to Natural Gas	Voluntary Measure	Goal for 2000 is for half of the transit fleet to be fully accessible natural gas fuelled buses.	Munic. Transp.	Full-scale.	NA		Currently, 38 buses using cleaner CNG; CO_2 emissions 20% lower than diesel-fuelled buses, in addition to lower life-cycle costs.
Windsor Energy Efficiency Program	Energy efficiency	Goal to retrofit all city-owned buildings for energy and water efficiency.	Munic.	Phase I begun 1993; phase II in Nov. 1995.	Annual reductions of 480 000 kg CO_2.		Cost of projects $2.3 million, with annual energy savings of $470 000.

* (planned, implemented; legislation passed or not; status of funding)

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Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation:	Estimate of mitigation impact		Monitoring: intermediate indicator of progress
					2000	2005	
MUNICIPALITIES (cont.)							
Vancouver Bicycle Network	Voluntary Measure	Objective is for a city-wide bikeway network to encourage cycling. Four priority corridors chosen.	Munic. Transp.	Under development. $2 million spent in past 5 years. $3 million expenditures over next 3 years.	NA		Three of four bikeways in place. Between 1993 and 1995, percentage of cyclists on routes into downtown rose from 1.2 to 2.1%.
International Council for Local Environmental Initiatives (ICLEI)	Standards and Regulations	A cooperative municipal energy improvement program. ICLEI is setting up a pilot facility and will provide brokering and consulting services to municipalities on energy retrofits.	Munic.	Pilot project. $100 million invested in municipal retrofits.	NA		Benefits ongoing.

LEGEND FOR TABLE 1

ATF = Alternative Transportation Fuel
CNG = Compressed Natural Gas
GHG = Greenhouse Gas
HOV = High-Occupancy Vehicle
JI = Joint Implementation
NA = not available or not applicable
NRCan = Natural Resources Canada
R&D = Research and Development
SMEs = Small and Medium-Sized Enterprises

Agric. = Agriculture
Comm. = Commercial
Educ. = Educational
Expend. = Expenditures
Forest. = Forestry
Govt. = Government
Indust. = Industrial
Manuf. = Manufacturing
Munic. = Municipal
Resid. = Residential
Transp. = Transportation

GWh = gigawatt-hour
kg = kilogram
kt = kilotonne
kW = kilowatt
kWh = kilowatt-hour
L = litre
m^2 = square metre
Mt = megatonne
MW = megawatt
PJ = petajoule
t = tonne

Appendix I, Table 1 (a) Summary of policies and measures: effects on CO_2 emissions

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation (planned/ implemented; legislation passed or not; status of funding)	Estimate of mitigation impact (megatonnes of CO_2)				Monitoring: intermediate indicator of progress
					2000	2005	2010	2020	
1. Electricity generation	Voluntary Challenge & Registry (VCR) program				3.3	3.3	3.3	3.3	
2. Upstream oil & natural gas production	VCR				3.3	6.3	8.8	11.8	
3. Residential, commercial, industrial	Regulations, programs, VCR				10.0		22.0	54.0	
4. Transportation	Regulations				2.0		5.0	9.0	

Appendix I, Table 1 (b) Summary of policies and measures: effects on CH_4 emissions

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation (planned/ implemented; legislation passed or not; status of funding)	Estimate of mitigation impact (kilotonnes CH_4)				Monitoring: intermediate indicator of progress
					2000	2005	2010	2020	
1. Oil production	Voluntary Challenge & Registry (VCR) program				194	252	278	265	
2. Natural gas production	VCR				136	233	276	361	
3. Pipelines	VCR				107	133	144	169	

Appendix I, Table 1 (c) Summary of policies and measures: effects on N_2O emissions

Name of policy/measure	Type of instrument	Objective and/or method of achieving reduction (including description of how effects take place)	Sector	Status of implementation (planned/ implemented; legislation passed or not; status of funding)	Estimate of mitigation impact (kilotonnes N_2O)				Monitoring: intermediate indicator of progress
					2000	2005	2010	2020	
1. Adipic acid reduction	Voluntary & Challenge Registry (VCR) program		Chemical		33.8	33.8	33.8	33.8	

Appendix I,Table 2 (a) Summary of projections of anthropogenic greenhouse gas emissions

	Emissions of GHGs in CO_2 Equivalent (teragrams)					
	1990	1995	2000	2005	2010	2020
Fuel combustion: energy and transformation industries	144	162	148	157	170	198
Fuel combustion: industry	73	76	82	87	91	102
Fuel combustion: transport	149	165	170	178	188	212
Fuel combustion: other	71	76	74	73	71	74
Other	130	140	136	141	149	182
Total	567	619	610	636	669	768

Appendix I, Table 2(b) Summary of projections of anthropogenic CO_2 emissions

	Emissions of CO_2 (teragrams)					
	1990	**1995**	**2000**	**2005**	**2010**	**2020**
Fuel combustion: energy and transformation industries	145	161	145.9	154.8	167.6	206.7
Fuel combustion: industry	71.9	75.3	81.5	86.0	90.0	100.4
Fuel combustion: transport	140.0	150.0	155.0	163.0	172.0	194.0
Fuel combustion: other	69.8	74.4	73.2	72.1	70.3	73.2
Other	37.0	39.0	45.0	47.0	50.0	54.0
Total	463.7	499.7	500.6	522.9	549.9	628.3

Appendix I, Table 3 Summary of projections of removals of CO_2 by sinks

	CO_2 removal by sinks (megatonnes)					
	1990	1995	2000	2005	2010	2020
Agricultural soils	-6.986	-2.804	0.728	1.924	1.820	NA
Land-use change and forestry	NA	NA	NA	NA	NA	NA
Other	NA	NA	NA	NA	NA	NA
Total removals	NA	NA	NA	NA	NA	NA

NA = not available

Appendix I, Table 4 Summary of projections of anthropogenic CH_4 emissions

	Emissions of CH_4 (gigagrams)					
	1990	1995	2000	2005	2010	2020
Fuel combustion	47	43	47	48	49	53
Fugitive emissions from fuel production	1,360	1,716	1,516	1,379	1,347	1,323
Industrial processes	0	0	0	0	0	0
Enteric fermentation	650	720	810	910	1,000	1,300
Animal wastes	250	270	300	340	370	500
Rice cultivation	0	0	0	0	0	0
Waste: landfills and wastewater	840	890	870	920	950	1,000
Other: composting and municipal solid waste	1	2	3	3	3	3
Total	3,148	3,641	3,546	3,600	3,719	4,179

Appendix I, Table 5 Summary of projections of anthropogenic N_2O emissions

	Emissions of N_2O (gigagrams)					
	1990	**1995**	**2000**	**2005**	**2010**	**2020**
Transport	29	48	46	48	51	57
Other energy sources	7	7	9	10	11	12
Industrial processes: adipic acid	35	35	1.7	1.7	1.7	1.7
Industrial processes: nitric acid	2.5	2.5	2.6	2.6	2.6	2.6
Agriculture: fertilizer use	11	13	13	13	13	13
Waste: wastewater and municipal solid waste	0.1	0.2	0.2	0.2	0.2	0.2
Other: anaesthetics and propellants	1.4	1.4	1.5	1.6	1.6	1.8
Total	86	107.1	74	77.1	81.1	88.3

Appendix I, Table 6 Summary of projections of anthropogenic emissions of other greenhouse gases

	Emissions of other greenhouse gases (gigagrams)					
	1990	1995	2000	2005	2010	2020
SF_6	0.1	0.08	0.08	0.08	0.08	0.08
HFCs (CO_2 Equivalent)	NA	500	2,000	4,000	7,000	14,000
PFCs						
CF_4	1	1	1	1	1	1
C_2F_6	0.07	0.07	0.1	0.1	0.1	0.1
Other	NA	NA	NA	NA	NA	NA

NA = not available or not applicable

Appendix I, Table 7 Summary of projections of anthropogenic emissions of precursors and SOx

	Emissions of precursors and SOx, (gigagrams)					
	1990	1995	2000	2005	2010	2020
CO	10,612	9,970	10,183	10,924	11,836	13,632
NOx	2,106	1,979	2,015	2,007	2,031	NA
NMVOCs	2,829	2,679	2,682	2,782	2,915	NA
SOx	3,305	2,805	2,802	2,854	2,867	NA

NA = not available or not applicable

Source: Pollution Data Branch, Environment Canada.

Appendix I, Table 8 Summary of key variables and assumptions in the projections analysis

	1990	1995	2000	2005	2010	2020
World coal prices (US$/ton)						
Alberta	7.4	7.4	7.5	7.5	7.5	7.5
Ontario	45	40	40	40	40	40
World oil prices (US$/ton)/95 WTI at Cushing	183	135	155	155	155	155
Domestic energy prices (by fuel type and for electricity)						
Electricity ¢/kWh						
Residential	6.2	8.3	8.8	9.5	10.3	12
Commercial	5.2	6.9	7.3	7.8	8.5	9.9
Industrial	3.9	4.8	4.9	5.1	5.5	6.4
Natural gas $/GJ						
Residential	4.7	5.1	6	6.7	7.3	8.5
Commercial	4	4.6	5.4	6.1	6.7	7.8
Industrial	2.7	2.4	2.9	3.3	3.7	4.2
LFO ¢/L						
Residential	35.8	35.6	41.2	46.6	51.5	60.3
Commercial	35.7	34.1	39.3	43.4	47	55
HFO ¢/L- Industrial	12.9	15.7	18.9	20.5	22	25.6
Gasoline ¢/L - Transportation	58.3	56.7	64.5	71.3	77	89.9
Diesel fuel ¢/L - Transportation	51.5	54	61.2	67	72.1	83.8
GDP (domestic currency) (billions 1986$)	503.1	542.2	605.4	673.6	749.5	926.2
Population (millions)	27.8	29.6	31	32.4	33.8	36.8
New vehicle efficiency (by vehicle type) (L/100 km)	9.8	9.7	9.6	9.4	9	8.3
Average vehicle-km travelled	20,631	21,579	21,721	21,873	21,977	22,509
Primary energy demand (PJ)	9,584	10,932	11,444	11,957	12,399	13,453
Index of manufacturing production (1990+100)	NA	NA	NA	NA	NA	NA
Industrial production (billions 1986$)	148	157	182	203	223	269
Other	NA	NA	NA	NA	NA	NA

NA = not available or not applicable
WTI = West Texas Intermediate
LFO = Light fuel oil
HFO = Heavy fuel oil

Appendix I, Table 9 Financial contributions to the operating entity or entities of the financial mechanism, regional and other multilateral institutions and programs

	Contributions (millions of Cdn dollars)[a]			
	1993-94	**1994-95**	**1995-96**	**1996-97**
Global Environment Facility	NA	111.1 (over 3 years)		
Multilateral institutions				
World Bank (IDA/IBRD) + IMF	397.17	401.14	466.45	NA
International Finance Corporation	8.98	10.02	9.78	NA
African Development Bank	108.78	NA	NA	NA
Asian Development Bank	86.66	88.61	4.63	NA
Caribbean Development Bank	6.98	1.44	6.07	NA
Inter-American Development Bank	11.75	14.05	24.98	NA
United Nations Development Program	38.8	NA	NA	NA
United Nations Environment Program	1.1	0.9	0.8	0.3
United Nations FCCC - Core Budget	NA	NA	0. 317	0.315
United Nations FCCC - Trust Fund for the Negotiating Process	NA	0.125	0.009	NA
United Nations FCCC - Special Voluntary Fund for Participation	NA	0.100	0.025	NA
Multilateral Scientific Programs				
IPCC	0.337	0.482	0.382	0.201
WMO	1.820	1.915	2.163	1.920
IAI	0.010	0.085	0.097	0.03
START	NA	NA	0.025	NA

[a] Amounts in this table represent the overall Canadian contributions to these institutions. Disbursement correspond to financial year, (April 1st – March 31st)

NA = non available or non applicable
IMF - International Monetary Fund
IDA - International Development Association
IBRD - International Bank for Reconstruction and Development
IPCC - Intergovernmental Panel on Climate Change
WMO - World Meteorological Organization
IAI - Inter-American Institute for Global Change Research
START - Global Change System for Analysis, Research and Training

Appendix I, Table 10 Bilateral financial contributions related to the implementation of the Convention, (Canadian dollars)[a]

Recipient country	Category	1994–95	1995–96	1996–97
Energy: SADC	Energy efficiency and energy conservation project	1 608 228	1 113 487	969 314
SADC	Renewable energy resources	1 219 852	1 394 987	986 899
India	Renewable energy resources	1 370 879	504 197	NA
China	Energy efficiency and energy conservation project – Energy efficiency in buildings	NA	NA	1 212 857
China	Energy efficiency and energy conservation project – Electric power research	666 168	1 617 149	1 568 185
Forestry: Honduras	Research, institutional support and development activities	NA	NA	201 435
Cameroon	Forest management and forest industries planning	NA	1 289 336	2 532 279
Agriculture: Haiti	Environmental rehabilitation and conservation activities	NA	NA	499 731
Other: India	Multipurpose waste recycling project	NA	NA	142 870
TOTAL		**4 865 127**	**5 919 156**	**8 113 570**

[a] Amounts in this table represent the disbursement for the corresponding financial year, (April 1st – March 31st)
SADC = Southern Africa Development Community
NA = Not applicable

Appendix I, Table 11 (a) Projects or programs that promote, facilitate and/or finance transfer of or access to "hard" and "soft" technologies

Project / program title: Energy Efficiency in Buildings

Purpose: To assist the Chinese Ministry of Construction to: a) Prepare relevant policies, regulations, standards and design criteria for energy efficiency in buildings; b) Strengthen its organisational capacity by perfecting a Centre for Energy Efficiency in Buildings; c) Establish a comprehensive management system and incentive program to encourage energy conservation; and d) Adapt and demonstrate appropriate energy efficient technologies and products in residential and commercial buildings in major climatic zones.

Recipient country	Sector	Total funding	Years in operation	Duration of project
China	Energy	8 447 885 ($ Cdn.)	1	1996–2001

Description: Since 1979, China has entered a period of rapid economic growth and rising incomes. Domestic energy required for heating, cooling and hot water is expected to increase rapidly as the demand for a more comfortable environment grows with the economy and the rising standard of living. Total energy consumption for buildings is expected to grow at 6 percent per year, far outstripping energy production, planned at 2-4 percent per year. In order to meet its growing energy demand for domestic energy, China wants to improve energy efficiency in buildings without compromising the energy needs of other sectors. The Energy Efficiency in Buildings project is fully consistent with CIDA's ODA priorities on environment and infrastructure services. It clearly aligns with the environmentally sustainable development parameters of the China Country Development Policy Framework. The project will promote environmental sustainability by enhancing the Chinese capacity to manage energy requirement through the use of energy conservation and efficient technologies and products, which would result in a reduction of gas emission from coal burning. The project will promote capacity building and economic linkages and partnership between Canadian private sector and Chinese public and private sector as well as promoting social welfare by providing better living and working conditions.

The goal is to enhance the Government of China's capacity to manage its environment and improve atmospheric quality by reducing air pollution and energy consumption in residential and commercial buildings through energy efficient technologies.

Ministry or company, contact person, address and phone number: Government of Canada through the Canadian International Development Agency (CIDA) 200 Promenade du Portage, Hull, Québec, Canada, K1A 0G4. Contact: Jean Sabourin, CIDA, Telephone: (819) 997-4742

Appendix I, Table 11 (b) Projects or programs that promote, facilitate and/or finance transfer of or access to "hard" and "soft" technologies

Project / program title: BIOGAS II

Purpose: To support and strengthen the network of Indian NGOs in their efforts to introduce and extend biogas technology; to further develop and strengthen partnerships between the governmental and NGO agencies involved in biogas programs.

Recipient country	Sector	Total funding	Years in operation	Duration of project
India	Energy	4 329 252 ($ Cdn.)	6	1990–1996

Description: Canada has been asked to participate in Phase II of a successfully completed and favourably evaluated in Phase I of the project. The government of India strongly supported the project's continuation and enhancement of the CHF/AFPRO partnership and project methodology. The project will improve the lives of Indian women by decreasing their workload as well as improving their health through a smoke-free kitchen environment when cooking is done with gas, to prevent environmental degradation by reducing the demand for fuel wood. Other benefits will be reduced health hazards associated with raw animal wastes, increased home lighting, highly effective fertilizer from slurry and reduced commercial fuel use which should help in reducing greenhouse gas emissions.

The goal is to maximize the benefits and extend the use of biogas technology in rural communities in India.

Ministry or company, contact person, address and phone number: Government of Canada through the Canadian International Development Agency (CIDA), Promenade du Portage, Hull, Québec, Canada, K1A 0G4. Contact: William Anderson, CIDA, Telephone: (819) 994-4104