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CANADA'S FOURTH NATIONAL REPORT ON CLIMATE CHANGE

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

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PREAMBLE

Canada's New Government is taking an integrated approach to the reduction of both greenhouse gas (GHG) and air pollutant emissions. Because air pollutants and GHGs share many common sources, coordinated requirements would allow for capital investment decisions that maximize synergies and cost-efficiencies among options to reduce air pollutants and GHGs. In order to maximize potential health and environmental benefits and minimize the potential for inadvertently increasing some air emissions, the Government's approach will be to take comprehensive action on all air emissions in order to find an optimal solution for mitigation of both issues.

BACKGROUND

On September 28, 2006, the Commissioner of the Environment and Sustainable Development released her 2006 Report on Climate Change. The Report described that even though the federal government had announced billions of dollars in funding since 1992 toward meeting commitments to address GHG emissions, as of 2004 Canada's GHG emissions were 26.6% above 1990 levels. The Commissioner urged Canada's New Government to come up with a credible, realistic and clear plan that should address the long-neglected need to help Canadians cope with the consequences of climate change and to commit to specific actions with timeframes for completing them.

The 2006 Report of the Commissioner of the Environment and Sustainable Development is available on the Office of the Auditor General of Canada web site.

AN INTEGRATED REGULATORY APPROACH

The cornerstone of Canada's new approach is legislation tabled in Parliament on October 19, 2006. *Canada's Clean Air Act* takes a comprehensive approach to the problem of worsening air quality and GHG emissions. Standards on air pollution and GHG emissions will provide certainty to industry to allow the greatest use of technology to make the investments needed to reduce both.

The Act represents a significant shift from a voluntary to a regulatory approach. It will work to improve the air we breathe and protect our environment in a manner that is strict but fair. It will set clear targets and timelines for key economic sectors, from the energy we consume, to the products we use, to the cars we drive.

Over the next three years, new regulations on all major sectors will be implemented. They will lead to significant and long-term reductions in air pollution and GHG emissions from industry, transportation and consumer products, as well as new standards for energy efficiency in a wide range of everyday products and appliances.

Compliance options being examined include an industry-led emissions trading system; a technology investment fund that would support the development of transformative technologies for emissions reductions to which companies, and potentially governments, could contribute; opt-in mechanisms that would enable entities not covered by regulation to voluntarily assume emissions targets; incentives that could see companies receive credit for investments in technology, such as CO_2 capture and storage which will lead to significant reductions in the future; mechanisms to recognize credit for early action; or domestic offsets in which verified emissions reductions outside the regulated system are recognized as eligible for compliance in the regulated system.

TARGETS FOR INDUSTRY

Targets are an important dimension of Canada's new approach. The Act and subsequent Notice of Intent to Regulate demonstrate a clear commitment to the establishment of short-, medium- and long-term industrial air pollution and GHG emission reduction targets. These fixed targets will compel polluters to respect emissions limits and will be at least as stringent as those in other leading environmental countries. These targets will have timelines that encourage emitters to take into account the coordinated requirements in their capital stock investment decisions.

Short-term intensity based GHG reduction targets will be set in consultation with provinces and territories and all affected industry sectors. In the medium-term, the emissions intensity approach will build towards absolute reductions in emissions and thus support the establishment of a fixed cap on emissions. The Government will establish a long-term target to reduce GHG emissions by between 45 and 65% from 2003 levels by 2050. The Government has asked the National Roundtable on the Environment and the Economy (NRTEE) to provide advice on the precise long-term target and scenarios for how this target could be achieved.

ENERGY EFFICIENCY

A substantial part of the reductions Canada can achieve in air pollution and GHGs can and should come from the energy we do not waste in the first place. *Canada's Clean Air Act* gives the Government of Canada expanded authority to regulate products that affect or control energy consumption, such as thermostats, and to help Canadians purchase the most energy efficient products.

TRANSPORTATION

In the medium term, there is a need for regulatory action on GHG emissions from the transport sector. Emissions from cars and trucks account for about 75% of Canada's total transportation GHG emissions, and passenger travel accounts for about half of that. Under *Canada's Clean Air Act,* the Government will issue regulations in order to limit GHG emissions from cars and trucks as soon as a voluntary Memorandum of Understanding with the auto sector expires in 2010.

Once a Memorandum of Understanding that has been negotiated with the Railway Association of Canada expires, in 2011, GHG emissions from the rail sector will also be subject to regulation.

The Government has already announced a number of initiatives that reduce emissions in the transportation sector. Initiatives included significant new investments in public transit infrastructure and a tax credit for public transit users, as well as a commitment to require 5% average renewable content in transportation fuels by 2010.

MONITORING AND ENFORCEMENT

Canada's Clean Air Act also gives the Government enhanced powers to monitor polluters and requires all environmental fines levied for non-compliance go into an environmental damages fund that will be will be applied directly to cleaning up the environment.

CONCLUSION

Canada's Clean Air Act will be accompanied, in the near future, by a slate of programs to support the regulatory agenda. The Act will put in place the fundamentals for the large reductions in emissions that will be necessary now and in the future.

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List of Acronyms, Abbreviations, and Units

4NR	Canada's Fourth National Report on Climate Change
AAFC	Agriculture and Agri-Food Canada
ACIA	Arctic Climate Impact Assessment
ACT	Availability and Choice Today program
AMI	Advanced Manufacturing Initiative
ANCAP	Aboriginal and Northern Community Action Program
AP2000	Action Plan 2000
APEGGA	Association of Professional Engineers, Geologists, & Geophysicist of Alberta
APF	Agricultural Policy Framework
AR4	Fourth Assessment Report (part of IPCC)
ARD	afforestation, reforestation and deforestation
ARPEL	Asociacion Regional de Empresas de Petroleo y Gas Natural en Latinoamerica y el Caribe: the Regional Association of Oil and Natural Gas Companies in Latin America and the Caribbean
ASAP	Accelerated Standards Action Program
ASTAE	Asia Alternative Energy Program
ATFCan	Advanced Technology & Fuels Canada
ATVP	Advanced Technology Vehicles Program
BAU	business as usual
BMPs	beneficial/best management practices
BRICs	Brazil, Russia, India and China
C-CIARN	Canadian Climate Impacts & Adaptation Research Network
C-IBC	Canada-India Business Council
CADDET	Centre for Analysis and Dissemination of Demonstrated Energy Technologies
CANMET	Canada Centre for Mineral and Energy Technology
CanMOST	Canadian Motor Selection Tool
CAPP	Canadian Association of Petroleum Producers
CBIP	Commercial Building Incentive Program
CBM-CFS	Carbon Budget Model of the Canadian Forest Sector
CCA	capital cost allowance
CCAF	Climate Change Action Fund
CCCDF	Canada Climate Change Development Fund
CCCS	Canadian Climate Change Solutions
CCFCC	Canadian Cooperation Fund on Climate Change
CCIAD	Climate Change Impacts and Adaptation Directorate
CCIAP.	Climate Change Impacts and Adaptation Program
CCME	Canadian Council of Ministers of the Environment
CCP	Cities for Climate Protection
CCPE	Canadian Council of Professional Engineers
CCRAEC	Canada - Costa Rica Agreement on Environmental Cooperation
CCTDIIP	Climate Change Technology Development and Innovation Initiative Program
CCTPO	Climate Change Technology Promotion Officers
CCWG	Canada-China Climate Change Working Group
CDM	Clean Development Mechanism
CEAA	Canadian Environmental Assessment Agency
CEPA	Canadian Environmental Protection Act
CER	Certified Emission Reduction
CES	Canadian Environmental Solutions
CETC	CANMET Energy Technology Centre

CEVEQ	Centre d'expérimentation des véhicules électriques du Québec
CFC	chlorofluorocarbon
CFCAS	Canadian Foundation for Climate and Atmospheric Sciences
CFS	Canadian Forest Service, Natural Resources Canada
CGHGI	Canada's Greenhouse Gas Inventory
CH_4	methane
CIDA	Canadian International Development Agency
CIHR	Canadian Institutes of Health Research
CIITT	Canadian Initiative for International Technology Transfer
CIPEC	Canadian Industry Program for Energy Conservation
CITI	Canadian International Technology Initiative
CME	Canadian Manufacturers and Exporters
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2 C&S	CO_2 Capture and Storage
CO_2 eq.	carbon dioxide equivalent
CONRAD	Canadian Oil sands Network for Research and Development
CoP	Conference of the Parties (signatories to the UNFCCC)
CP1	first commitment period
CRCE	Canadian Renewable and Conservation Expenses
CRF	Common Reporting Format
CSA	Canadian Standards Association
CSI	Canadian Solar Inc.
CSIF	Canada Strategic Infrastructure Fund
CTEEFI	Commercial Transportation Energy Efficiency and Fuels Initiative
CTFCA	Canadian Transportation Fuel Cell Alliance
CTI	Climate Technology Initiative
DEP	Decentralized energy production
DFAIT	Department of Foreign Affairs and International Trade
DSM	demand-side management
EBI	Existing Buildings Initiative
ÉcoGESte	Bureau d'enregistrement des mesures volontaires sur les changements climatiques
EE	Energy Efficiency Standards and Regulations
EEB	EnerGuide for Existing Buildings
EEMT	Enhanced Equipment Market Transformation
EEP	Ethanol Expansion Program
EGH	EnerGuide for Houses
EGI	EnerGuide for Industry
EGNH	EnerGuide for New Houses
EGTT	Experts Group on Technology Transfer
EGV	EnerGuide for Vehicles
EMT	Equipment Market Transformation program
ENGO	environmental non-governmental organization
EPA	Environmental Protection Agency, United States
eq.	equivalent
ESAA	Environmental Services Association of Alberta
ESCM	Environmental Supply Chain Management
ESMAP	Energy Sector Management Assistance Program
ESS	Earth Sciences Sector, Natural Resources Canada
ETAA	Environmental Technology Assessment for Agriculture
ETAG	Energy Technology Applications Group
ETWG	Energy Technology Working Group

FAACS	Feasibility Assessment of Afforestation for Carbon Sequestration
FBI	Federal Buildings Initiative
FCM	Federation of Canadian Municipalities
FCRN	Fluxnet Canada Research Network
FEP	Freight Efficiency Program
FETI	Freight Efficiency and Technology Initiative
FFI	Future Fuels Initiative
FHIO	Federal House in Order
FIBP	Federal Industrial Boiler Program
FIP	Freight Incentives Program
FNBP	First National Climate Change Business Plan (part of NIS)
Forest 2020 PDA	Forest 2020 Plantation Demonstration and Assessment Initiative
FSDP	Freight Sustainability Demonstration Program
FVI	Federal Vehicles Initiative
GDP	Gross Domestic Product
GEF	Global Environment Facility
GoC	Government of Canada
GHG	greenhouse gas
GHGMP	Greenhouse Gas Mitigation Program for Canadian Agriculture
GMF	Green Municipal Fund
GVRD	Greater Vancouver Regional District
GWP	global warming potentials
h2EA	Hydrogen Early Adopters Program
H2FCC	Hydrogen and Fuel Cell Committee
HDD	Heating Degree Days
HDDV	Heavy duty diesel vehicle
HDGV	Heavy duty gasoline vehicle
HFC	hydrofluorocarbon
HOV	High Occupancy Vehicle
HPRP	Health Policy Research Program
HVAC	heating, ventilating and air-conditioning
IAWG	Intergovernmental Climate Change Impacts and Adaptation Working Group
IBIP	Industrial Building Incentive Program
ICE	Industrial Consumption of Energy survey
ICP	Infrastructure Canada Program
IDRC	International Development Research Centre
IEA	International Energy Agency
IEI	Industrial Energy Innovators
IISD	International Institute for Sustainable Development
IITD	International Initiative for Technology Development
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPCC-24	24th session of the IPCC
IPHE	International Partnership for the Hydrogen Economy
IPY	International Polar Year
ITS	Intelligent Transportation Systems
JCEC	Canada-China Joint Committee on Environment Cooperation
JI	Joint Implementation
JMM	Joint Ministers Meetings
KMU	Knowledge Management Unit

LAC	Latin American and Caribbean
LDC	Least Developed Countries
LDG	Let's Drive Green
LDGT	Light duty gasoline truck
LDGV	Light duty gasoline vehicle
LFE	large final emitter
LFG	Landfill Gas
LOI	Letters of Intent
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change and Forestry
MAC	Mining Association of Canada
MAPLE-C	Model for Analysis of Policies Linked to Energy-Canada
MEV	Marketing of Efficient Vehicles
MIP	Market Incentive Program
MMS	Minerals and Metals Sector, Natural Resources Canada
MNECB	Model National Energy Code for Buildings
CoP/MoP	Meeting of the Parties (signatories to the Kyoto Protocol – part of the UNFCCC)
MOST	Moving On Sustainable Transportation
MOU	Memorandum of Understanding
MRIF	Municipal Rural Infrastructure Fund
MSC	Meteorological Services of Canada
MSW	municipal solid waste
Mtoe	Million tonnes of oil equivalent
MVFEI	Motor Vehicle Fuel Efficiency Initiative
N_2O	nitrous oxide
NACP	North American Carbon Program
NAFTA	North American Free Trade Agreement
NAI	National Afforestation Inventory
NAPAs	National Adaptation Programmes of Action
NAPCC	National Action Program on Climate Change
NASA	National Aeronautics & Space Administration
NBEP	National Biomass Ethanol Program
NCE	Networks of Centres of Excellence
NCGAVS	National Carbon and Greenhouse Gas Accounting and Verification System
NEI	Northern Ecosystem Initiative
NEMA	National Electrical Manufacturers Association
NEMS	National Energy Modeling System, United States
NFCMARS	National Forest Carbon Monitoring, Accounting and Reporting System
NFI	National Forest Inventory
NIS	National Implementation Strategy on Climate Change
NCCP	National Climate Change Process
NGL	natural gas liquids
NGO	non-governmental organization
NGV	natural-gas vehicle
NOPP	National Office of Pollution Prevention
NRC	National Research Council of Canada
NRCan	Natural Resources Canada
NSERC	Natural Sciences and Engineering Research Council of Canada
NVRS	New Vehicle Ranking System

O_3	ozone
OE	Opportunities Envelope
OECD	Organisation for Economic Co-operation and Development
OERD	Office of Energy Research and Development, Natural Resources Canada
OEE	Office of Energy Efficiency, Natural Resources Canada
OSEC	Oil Sands Environmental Coalition
OTC	One-Tonne Challenge
PARC	Prairie Adaptation Research Collaborative
PCF	Prototype Carbon Fund, World Bank
PCP	Partners for Climate Protection
PEO	public education and outreach
PERRL	Pilot Emission Removals, Reductions and Learnings Initiative
PFC	perfluorocarbon
PV	photovoltaic
R-2000	R2000 Standard
R&D	research and development
RAPB	Refrigeration Action Program for Buildings
RCVCC	Reducing Canada's Vulnerability to Climate Change
REDI	Renewable Energy Deployment Initiative
REEEP	Renewable Energy and Energy Efficiency Partnership
REH	Retrofits of Existing Houses
RER	registered emissions reductions
RMAF	Results-Based Management and Accountability Framework
RPE	Rural Poverty and Environment
S&T	science and technology
SBSTA	Subsidiary Body for Scientific and Technological Advice, UNFCCC
SCI	Sustainable Cities Initiative
SCM	Supplementary Cementing Materials
SEP	Shelterbelt Enhancement Program
SEPA	State Environmental Protection Agency, China
SSHRC	Social Science and Humanities Research Council of Canada
SF_6	sulphur hexafluoride
SIA	science, impacts and adaptation
SMART	System of Measurement and Reporting for Technologies
SME	small and medium-sized enterprise
STDC	Sustainable Technology Development Canada
SUV	sport utility vehicle
T&I	technology and innovation
T&I R&D	Technology and Innovation Research and Development Initiative
T2M	Technology to Market Program
TCHC	Toronto Community Housing Corporation
TEAM	Technology Early Action Measures
TERI	The Energy and Resources Institute
TPC	Technology Partnerships Canada
TTCE	Trade Team Canada Environment

UK United Kingdom
UN United Nations
UNDP United Nations Development Programme
UNEP United Nations Environment Programme
UNFCCC United Nations Framework Convention on Climate Change
UPE Urban Poverty and Environment
U.S. United States of America
UTSP Urban Transportation Showcase Program

VCR Voluntary Challenge and Registry

WCSB Western Canadian Sedimentary Basin
WMO World Meteorological Organization
WPPI Wind Power Production Incentive

Abbreviations of Terms

Abbreviation	Prefix	Multiple
k	kilo-	10^3
M	mega-	10^6
G	giga-	10^9
T	tera-	10^{12}
P	peta-	10^{15}
E	exa-	10^{18}

Abbreviation	Definition	Abbreviation	Definition
MJ	megajoule = 10^6 Joules	km	kilometre
GJ	gigajoule = 10^9 Joules	t	tonne
TJ	terajoule = 10^{12} Joules	Pkm	passenger-kilometre
PJ	petajoule = 10^{15} Joules	Tkm	tonne-kilometre
EJ	exajoule = 10^{18} Joules	tpy	tonnes per year
kW	kilowatt = 10^3 Watts	kt	kilotonne
kWh	kilowatt hour = 10^3 Watts hour	Mt	megatonne
MW	megawatt = 10^3 kW	Gg	gigagrams
MWh	megawatt hour = 10^3 kWh	bbl	barrel
GW	gigawatt = 10^6 kW	C$ or $	Canadian dollars
GWh	gigawatt hour = 10^6 kWh	US$	United States dollars
TW	terawatt = 10^9 kW		
TWh	terawatt hour = 10^9 kWh		

EXECUTIVE SUMMARY

In 1992, Canada joined more than 150 nations in becoming a party to the United Nations Framework Convention on Climate Change (UNFCCC) at the Earth ("Rio") Summit in Brazil. The goal of the UNFCCC was to promote sustainable development and, at that time, set out an objective for developed countries to return net greenhouse gas (GHG) emissions to 1990 levels by the year 2000.

As part of a commitment to measure progress, countries are obligated to undertake an accurate and comprehensive reporting process with the submission of national communications to the UNFCCC Secretariat. Following specific reporting guidelines, these national communications are intended to update a country's climate change status and related mitigation and adaptation responses. Canada's first three national communications were submitted in 1993, 1997 and 2001.

The fourth national communication, entitled Canada's Fourth National Report on Climate Change (4NR), provides an update of Canada's current status and responses to climate change. Some of the highlights in the 4NR are:

- An overview of Canada's key policies and measures;
- A summary of Canada's national GHG inventory and projections of emissions to 2020; and
- An overview of the science, impacts (vulnerability assessment) and adaptation issues facing Canada in the future.

Other areas of interest in the 4NR include a description of Canada's national circumstances, which provides a national context for GHG emissions, financial contributions and technological transfer to developing countries, and public education and outreach programs.

INTRODUCTION

Chapter 1 provides a brief overview of the international consensus on the science of climate change, as articulated by the Intergovernmental Panel on Climate Change (IPCC). The chapter also discusses the nature of commitments under the UNFCCC and presents an historical overview of Canada's development of domestic strategies to address climate change and its progress on those strategies.

NATIONAL CIRCUMSTANCES

As outlined in Chapter 2, Canada's vast geography, natural-resources production, export-oriented economy, northern climate, and high population growth all contribute to increased energy demand – a key determinant of GHG emission levels. Another key determinant is economic growth. Canada experienced significant economic growth since the late 1990s, particularly affecting energy- and carbon-intensive sectors.

Across the economy, energy intensity (e.g., the amount of energy used in the production process) combined with the carbon content of the fuel used significantly influences GHG emissions levels. Energy efficiency helps countries reduce the impact that economic growth and other activities have on GHG emissions. Canada is a global leader in developing energy-efficiency technologies and practices.

Elements of Canada's national circumstances and their influence on GHG emissions and response strategies need to be better understood. This understanding is key to putting in context Canada's progress on climate change and the practical impacts of climate change, and to developing further mitigation and adaptation strategies.

INVENTORY OF GHG EMISSIONS

Chapter 3 summarizes the human-induced emissions by sources, and removals by sinks, of GHGs for Canada in 2004. It also discusses underlying trends in emissions for the period 1990-2004.

According to Canada's *National Inventory Report - Greenhouse Gas Sources and Sinks in Canada, 1990-2004*, Canada's GHG emissions have increased by approximately 27% since 1990. In 2004, Canadians contributed over 758 megatonnes (Mt) of carbon dioxide equivalent (CO_2 eq.) of GHGs to the atmosphere (excluding Land Use, Land Use Change and Forestry estimates). Major factors affecting emissions in recent years include growth in fossil fuel production (mainly for export) and increases in Canadian transportation energy consumption.

About 85% of Canada's total GHG emissions are associated with energy production, distribution and consumption. About 60% of that amount is attributable to the consumption of fossil fuels by the four end-use sectors, while the remaining 40% is associated with the energy production and distribution sectors (electricity, refining, and upstream oil and gas sectors).

POLICIES AND MEASURES

Chapter 4 describes the evolution of domestic climate change policy between 1990 and 2005, and provides an overview of key federal, provincial and territorial policies and measures used to address climate change in Canada since 2001. Specifically, it describes mitigation measures to support Canada's climate change policies across five sectors of the Canadian economy (buildings, transportation, industry, agriculture, and forestry), as well as technology and innovation measures.

A detailed list of policies and measures is provided in Appendix 1, at the end of this report. It contains all major initiatives of the Government of Canada as well as an illustrative sample of initiatives undertaken by other levels of governments and non-governmental organizations.

GHG EMISSION PROJECTIONS

Chapter 5 outlines Canada's emissions projections to 2020, derived from the Canadian Energy Outlook 2006. Total GHG emissions are projected to reach 828 Mt by 2010, and almost 897 Mt by 2020.

Between 2004 and 2010 the emissions from electricity are not expected to increase considerably. However, between 2010 and 2020, the emissions from this sector are likely to decrease due to the expected retirement of some coal-powered electricity generation plants, replaced largely by natural gas.

From 2010 to 2020, emissions from the upstream oil and gas sector are expected to decline somewhat, as conventional oil production declines, while emissions from refining and synthetic crude oil production will continue to increase. Emissions from all other sectors (with the exception of electricity) are expected to increase further, notably in the transportation, industrial, residential and commercial sectors.

PHYSICAL AND SOCIO-ECONOMIC IMPACTS

As outlined in Chapter 6, the magnitude, timing and regional impacts of climate change could have serious repercussions on Canada's natural resources, social and economic systems, and infrastructure, and possibly on the health and general well-being of Canadians.

As a consequence of climate change, weather variability could in turn generate damaging consequences for the health of Canadians. While there may be limited positive impacts associated with global warming, Canada's vulnerability to extreme weather events such as droughts, floods, hurricanes and violent thunderstorms and windstorms could also increase. Impacts of climate change on precipitation and evapo-transpiration could affect soil moisture levels and erosion, water quality and safety, surface and ground water levels, hydrologic cycle variability and predictability, and wetland area extent.

Consequently, these could have serious ramifications for agriculture, tourism, municipal water supplies, water transportation and wildlife habitat. The forestry and fisheries sectors could also be threatened by possible changes in climate.

FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

As described in Chapter 7, as part of its international efforts to develop climate change solutions, Canada provides financial contributions and technology transfers to developing countries to promote information exchange and bilateral co-operation.

A large part of this funding goes to UN programs and to the Global Environment Facility (GEF), but part of this funding also goes to Regional Development Banks and other international institutions. Technology transfers and capacity building programs represent important steps in enabling action on climate change, as well as engendering global sustainable development practices.

SYSTEMATIC OBSERVATION

Understanding the climate system is crucial for addressing climate change. Canada continues to take action to improve our understanding of the science of climate change and to identify and assess appropriate adaptive responses. Chapter 8 demonstrates that Canada is working to improve its research networks, evaluation and co-ordination of systematic observations, statistical and analytical tools to understand changes in climate, and tools to assess Canadian options pertaining to adaptation. Research on climate change related to science, impacts and adaptation, and on modelling future climate scenarios is being done by a number of different agencies within the country, including federal and provincial agencies and universities.

PUBLIC EDUCATION

As outlined in Chapter 9, federal, provincial, territorial and municipal governments, along with environmental organisations, educational institutions and private industries, all play a vital role in informing and training the public on climate change. A range of activities has contributed to building awareness of climate change among Canadians and has encouraged them to take personal action to reduce GHG emissions.

CHAPTER 1 INTRODUCTION

1.1 CLIMATE CHANGE

The Earth's temperature is determined in part by a naturally occurring heat-retaining process known as the "greenhouse effect". Without this natural process, the Earth's average temperature would be -18°C instead of the current +15°C. The greenhouse effect depends on a number of "greenhouse gases" (GHGs) that are present in the atmosphere: water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and chlorofluorocarbons (CFCs). GHGs trap the sun's heat near the Earth's surface, raising the Earth's temperature and making life on Earth possible.

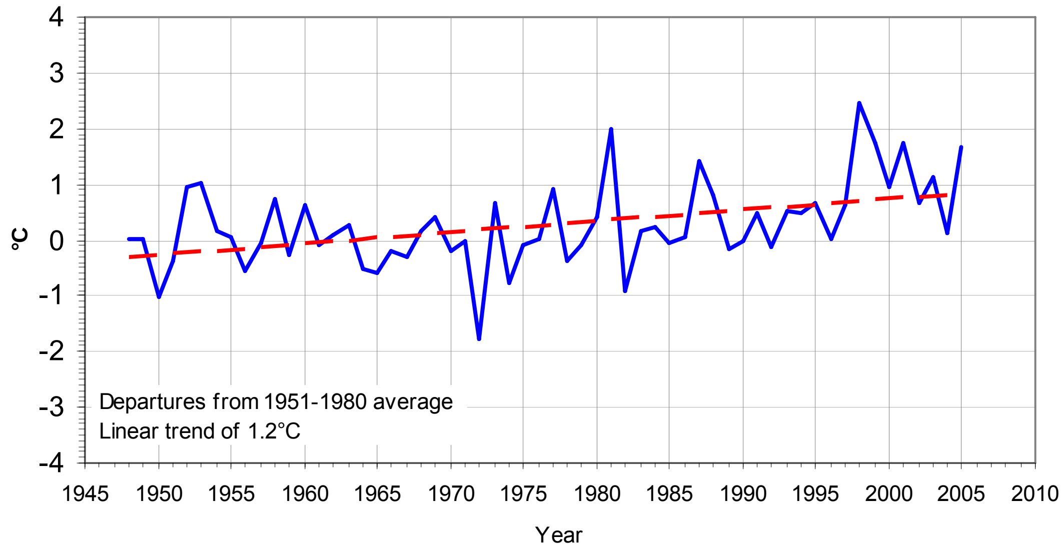
The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." While certain GHGs are naturally occurring, human activities – primarily those that use energy, but also global deforestation and agricultural activities – release additional GHGs into the atmosphere. Of these anthropogenic (human-induced) GHGs, three are of primary concern, as they represent the major human contribution to climate change:

- *Carbon dioxide (CO_2)*: An increasing amount of carbon dioxide is released by the burning of fossil fuels (coal, oil, natural gas) for industrial purposes, transportation, and the heating/cooling of buildings. In addition, deforestation causes less carbon dioxide to be naturally absorbed by foliage.
- *Methane (CH_4)*: An increasing amount of methane is released by landfills, wastewater treatment, solid waste incineration, certain agricultural practices, and grazing cattle.
- *Nitrous oxide (N_2O)*: An increasing amount of nitrous oxide is released into the atmosphere through practices such as the use of chemical fertilizers and the burning of fossil fuels.

The scientific consensus, as reflected by the Intergovernmental Panel on Climate Change (IPCC), is that incremental GHG emissions caused by human activity since the Industrial Revolution are having a discernible impact on the climate. In the IPCC's view, while human activity may cause only about 5% of global GHGs (with natural processes accounting for the remainder), it is enough to upset the delicate balance of GHGs in the atmosphere and, by extension, the climate. The result is the continued warming of the atmosphere and resulting changes in its composition.

Working Group I of the IPCC reports in its *Third Assessment Report on Climate Change* (IPCC, 2001) that the globally averaged temperature is projected to increase by 1.4°C to 5.8°C over the period 1990–2100. In Canada, a warming trend of +1.2°C has been identified over the last 58 years (Figure 1.1.1). The year 2005 had the fifth highest national temperature departure since 1948, and 1998 was the warmest year (+2.5°C) during that period.

Figure 1.1.1: Annual Canadian temperature departures and long-term trend, 1948 – 2005



Source: Environment Canada (2005)

While the earth has gone through warming and cooling cycles in the past, the current rate of climate change is more rapid than what the earth normally experiences. It is expected to have significant effects on plants, animals and entire ecosystems that are unable to adapt quickly enough. Canada's Arctic is believed to be particularly vulnerable. The climate change will not be uniform, and the north's climate may rise by nearly 3°C to 4°C in winter months over the next 50 years. This could lead to melting glaciers and sea ice, rising sea levels, and endangered wildlife. The north provides an early indication of the environmental, social and economic significance of global warming.

1.2 COMMITMENTS UNDER THE UNFCCC

The UNFCCC is the world's foremost international treaty to reduce global warming and to cope with whatever temperature changes are inevitable. To date, 189 countries have become Parties to the treaty, with the goal of stabilizing GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. They have agreed to undertake national programs to meet this goal.

In December 1992, Canada ratified the UNFCCC, which entered into force on March 21, 1994. Under the UNFCCC, Canada is committed to:

- adopt measures to mitigate climate change by addressing anthropogenic emissions by sources, and removals by sinks, of all GHGs;
- regularly publish and update reports on these mitigation measures;
- formulate measures to facilitate adequate adaptation to climate change;
- promote and cooperate in the development and transfer of technologies and practices to control, reduce, or prevent anthropogenic GHG emissions;
- promote sustainable development approaches (e.g. promote the conservation and enhancement of sinks and reservoirs of all GHGs, and take into account climate change in economic and environmental decision making);
- promote and cooperate in the exchange of scientific, technological, and socio-economic information related to climate change, by working nationally on data collection, research, and systematic observation to further understanding of climate change;
- provide new and additional financial resources to help developing countries comply with their obligations under the UNFCCC;

- promote, facilitate, and finance the transfer of environmentally sound technologies to developing countries, enabling them to implement the provisions of the Convention; and,
- collaborate with other countries to ensure that the policy instruments they use to reduce climate change complement, rather than counteract, measures taken elsewhere.

A subset of the Parties to the UNFCCC agreed to a supplementary international treaty, the Kyoto Protocol, which has stricter demands for reducing GHG emissions and more powerful, legally-binding measures for Annex I countries.

The Kyoto Protocol was negotiated at the Third Conference of the Parties to the UNFCCC (CoP3) in December 1997. The Kyoto Protocol was signed by Canada in April 1998, and formally ratified by the Government of Canada (GoC) in December 2002. On February 16, 2005, a sufficient number of countries had ratified the Kyoto Protocol for it to enter into force. The Protocol is based on binding GHG emissions targets for industrialized countries at between -8% and +10% of the countries' individual 1990 emissions levels, "with a view to reducing their overall emissions of such gases by at least 5% below existing 1990 levels in the commitment period 2008 to 2012." Canada committed to reduce GHG emissions to 6% below 1990 levels during the commitment period.[1]

1.3 NATIONAL REPORTING TO THE UNFCCC

Canada's first national communication under the reporting requirements of the UNFCCC, entitled *Canada's National Report on Climate Change*, was submitted in 1994. It describes what had been done at the time by Canadian governments, communities and the private sector in the areas of climate change mitigation, adaptation, research, education, and international cooperation. The second and third National Reports, submitted in 1997 and 2001 respectively, provide an update of Canada's situation and additional responses to climate change.

The guidelines for the publication of these national communications to the UNFCCC are produced by the Subsidiary Body for Scientific and Technological Advice (SBSTA). They are designed to assist Parties in meeting commitments to develop, update, publish, and make available national inventories of emissions by source, and removal by sinks, of all GHGs not controlled by the Montreal Protocol. The guidelines also aim to promote the provision of consistent, transparent, comparable, and accurate information in the development of national communications and to ensure that the CoP has enough information to review the implementation of the Convention.

Canada's *Fourth National Report on Climate Change* provides an update of Canada's current status and responses to climate change, as requested in the SBSTA guidelines. Canada's national strategy to address climate change is elaborated in various sections of this document, which is organized as follows:

- Chapter 2: National Circumstances
- Chapter 3: Greenhouse Gas Inventory Information
- Chapter 4: Policies and Measures
- Chapter 5: Emissions Projections to 2020
- Chapter 6: Vulnerability Assessment, Climate Change Impacts and Adaptation Measures
- Chapter 7: Financial Resources and Transfer of Technology
- Chapter 8: Research and Systematic Observation of Climate Change
- Chapter 9: Education, Training and Public Awareness

This report documents policies and measures to address climate change in Canada as of December 31, 2005. The federal election of January 2006 resulted in a change in government and a decision to fund, on an interim basis, the majority of climate change programming until such time as the specifics of new policies and measures are developed. Budget 2006 provided the first instalment of this new environmental agenda, with $1.3 billion to support public transit capital investments including rapid transit, transit buses, intelligent transportation systems and other investments including high occupancy vehicles and bicycle lanes. Investing in public transit infrastructure

[1] The Kyoto Protocol covers only those GHGs that are not already controlled by the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, which covers chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform. The GHGs covered under Kyoto are carbon dioxide, methane, nitrous oxide, HFCs, PFCs, and sulphur hexafluoride.

will reduce both GHGs and air pollutants. A tax credit for public transit users was also introduced. Also in terms of significant developments in 2006, Canada has committed to a 5% average renewable content in Canadian motor fuels by 2010.

The Government is committed to addressing climate change, and is currently developing policies and measures to address GHG emissions. These policies and measures will focus on achieving sustained reductions in emissions in Canada and transforming our economy for the long term.

In October 2006 the New Government announced the central component of its environmental Agenda with the introduction of *Canada's Clean Air Act*. The Act and subsequent Notice of Intent to regulate demonstrate a clear commitment to the establishment of short-, medium- and long-term industrial air pollution targets. Short-term intensity-based GHG reduction targets would be set in consultation with provinces and territories and all affected industry sectors. Over the longer term, the Government is committed to achieving an absolute reduction in GHG emissions between 45 and 65% from 2003 levels by 2050.

1.4 RELATED DOCUMENTS

Additional documents have been developed in conjunction with *Canada's Fourth National Report on Climate Change*, as part of Canada's commitment to reporting under the UNFCCC and Kyoto Protocol.

The first document is *Canada's Greenhouse Gas Inventory, 1990-2004* (CGHGI), which was submitted to the UNFCCC Secretariat in 2006. The report is produced yearly to respond to a requirement under the Kyoto Protocol to provide an annual National Inventory Report and a set of tables in a common reporting format as outlined by the IPCC. Chapter 3, *Greenhouse Gas Inventory Information*, is a summary of the more comprehensive CGHGI report.

Another report to be submitted to the UNFCCC is the *Demonstrable Progress Report*. The report is produced in line with Article 3.2 of the Kyoto Protocol and Decisions 22/CP.7 and 25/CP.8 of the UNFCCC. The report is designed to demonstrate to the international community the actions Canada is taking to comply with its international commitments on climate change, and to outline Canada's efforts to reduce GHG emissions.

A GHG emissions projections for Canada entitled *Canada's Energy Outlook: The Reference Case 2006* was released in October 2006. This outlook provides greater depth into the material covered in Chapter 5. The forecast relies on a new model developed to improve the projections provided in the 1999 version of the report, entitled *Canada's Emissions Outlook: An Update*.

Finally, a report that provides valuable information on trends in Canada's energy end-use is *Energy Efficiency Trends in Canada, 1990 to 2004*, released in 2006.

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CHAPTER 2 NATIONAL CIRCUMSTANCES AFFECTING CANADA'S GREENHOUSE GAS EMISSIONS

This chapter describes Canada's GHG emissions and emissions intensity relative to the international community, and discusses national circumstances that may explain the differences.

2.1 CANADA IN BRIEF

Canada is a country of great physical extremes and contrasts. Its surface area is 9,984,670 km^2; with land accounting for 9,093,507 km^2 and fresh water for 891,163 km^2. It is the second largest country in the world, after Russia. It is composed mostly of plains and rolling lowland, with the North America cordillera (the Rockies, Columbia, and Coast mountain ranges) passing north-south in the west. Only 5% of the total land area is suitable for agriculture, as much of the country is too cold, mountainous, rocky or permanently frozen. The country extends 5,300 km east to west – the distance between Paris and New York – and 4,600 km north to south. Average and seasonal temperatures vary widely, depending on the region, with most of the country experiencing short hot summers and long, extremely cold winters.

Canada's population in mid-2005 was 32.8 million, with 80% of the population living within 160 km of the United States border in urban centres. This distribution illustrates the very high level of economic integration with the U.S. Over 40% of the output of the Canadian economy is exported, mainly to the U.S. Forty percent of Canada's exports are energy-intensive, resource-based commodities, and more than half of Canada's oil and natural gas production is exported to the U.S. Along with Mexico, Canada and the U.S. are parties to the North American Free Trade Agreement (NAFTA).

Canada's GDP was just over $1 trillion USD (purchasing power parity) in 2004 (derived approximately 71% from services, 26% from industry and 2% from agriculture), with a GDP per capita of $31,500.[2] Canada is developing a high-tech, knowledge-based economy, and services form the largest component of GDP, but the development and export of renewable and non-renewable resources (such as energy, agricultural and fisheries products, forest products, and minerals) continue to play an important role and have a significant impact on regional emissions. Ontario and Québec are the most industrialized and populated provinces; the economies of most of the other regions are characterized by smaller manufacturing and service sectors and a greater emphasis on energy production, resource extraction, agriculture and tourism. Alberta, and to a lesser extent British Columbia and Saskatchewan, are major crude oil and natural gas producers; Alberta is also the location of one of the world's largest potential sources of hydrocarbons—the oil sands. Atlantic Canada produces offshore fossil fuels, and British Columbia has a substantial untapped offshore fossil fuel resource.

Given the diverse nature of the country's regions, knowledge of Canada's governance structure and political tradition is essential to understanding its response to climate change. Governing rights and responsibilities are divided among the national and provincial governments based on the Canadian constitution. The constitution does not assign exclusive responsibility for environmental protection or related public policy to a single level of government. Jurisdiction over the many areas critical to the implementation of climate-change policy is shared among federal and provincial governments. Natural resources are under provincial jurisdiction, while international treaties, issues of general security and most taxation regimes are under federal jurisdiction. While the federal government plays a formative role in national environmental policy, this division of responsibilities calls for a high degree of cooperation among the federal, provincial, municipal and First Nations governments in shaping effective climate policy.

[2] In this chapter, figures may not add up to totals due to rounding.

2.2 CANADA'S EMISSIONS IN PERSPECTIVE

In this section, Canada's GHG emissions and emissions intensity in 1990 and 2002 are compared with those of the other G7 countries and Brazil, Russia, India and China, whose economies are emerging. Even though the quantitative analysis presented later in this chapter focuses solely on the G7 countries, emissions data for Brazil, Russia, India and China is provided for context.[3] The 1990 to 2002 period is used in this chapter because 2002 is the latest date for which reliable international statistics are found. This section begins with a brief discussion of greenhouse-gas and carbon-dioxide accounting issues, which set the context for the analysis.

2.2.1 Greenhouse Gases (GHGs) vs. Carbon Dioxide (CO_2)

In discussions and writings on climate change, the acronyms GHG and CO_2 are often confused and used interchangeably. All the GHGs add to the energy-retaining capacity of the atmosphere. CO_2 is only one of these gases, albeit the most voluminous. There are three naturally occurring gases that contribute to the greenhouse effect: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Ozone (O_3) and water vapour all have GHG properties. Additionally, there are several synthetic GHGs, such as halocarbons (HFCs, CFCs, HCFCs), perfluorocarbons (PFCs such as CF_4 and C_2F_6), and other halogenated compounds (SF_6).[4]

The main source of human-produced CO_2 is the combustion of fossil fuels; the other human-produced GHGs have many sources, including land-use changes, industrial processes, waste handling and agricultural practices. Because a large part of CO_2 emissions comes from the combustion of energy sources traded in markets, and because there has long been an interest in collecting energy statistics according to international norms, there is good international data on CO_2 emissions. Data on GHG emissions, despite the efforts of the United Nations Framework Convention on Climate Change (UNFCCC), are far more uncertain. For certain sectors, such as the fossil-fuel production industry, non-CO_2 GHG emissions are important and must be addressed, but in most sectors non-CO_2 GHG emissions are much less important.

2.2.2 Canada's Absolute Emissions

Canada's CO_2 emissions from combustion, while not absolutely large when compared with those of the more populous countries, have increased significantly since 1990 (Figure 2.2.2.1), mainly due to significant economic and population growth. Canada emitted 2.3% of the world's human-generated CO_2 in 1990, and 2.4% in 2002. From 1990 to 2002, Canada's GDP and population grew by 40.5% and 13.4% respectively, second only to the U.S. among the G7 in both cases, and this growth has had a significant impact on Canada's total emissions.

From 1990 to 2002, total GHG emissions in Canada increased by 20.0%, and emissions of CO_2 increased by 22.3%. In contrast, Canada's commitment under the Kyoto Protocol to the UNFCCC is to reduce its total GHG emissions to 6.0% below 1990 levels over 2008-2012.

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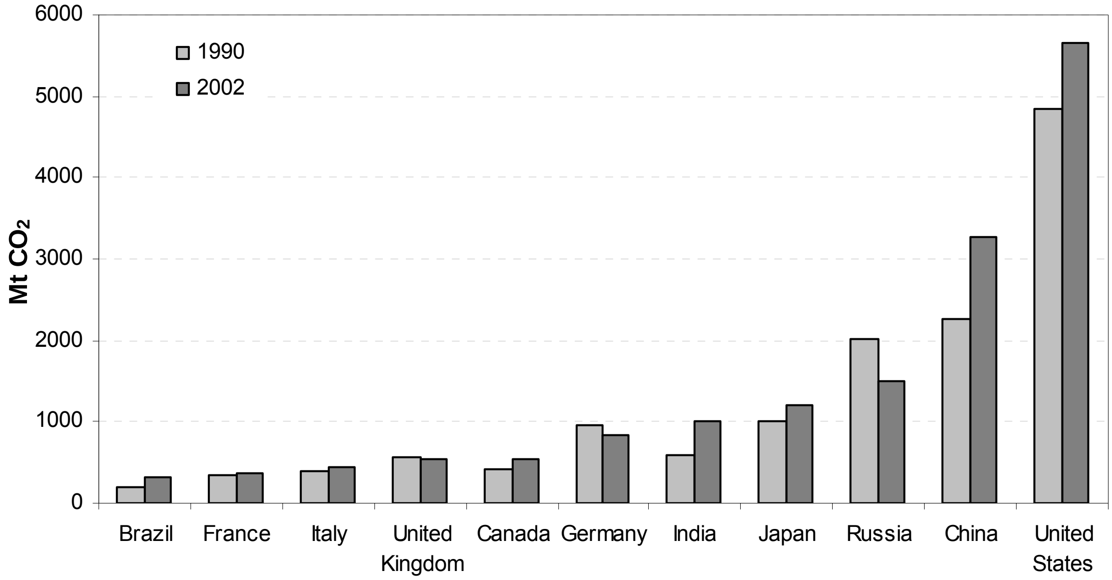
[3] Only the G7 countries are included in the quantitative analysis of national circumstances (Section 2.3) owing to the unavailability of comparable statistics for other countries.

[4] Halocarbons persist in the atmosphere for thousands of years, even in minute amounts. Certain synthetic GHGs are regulated by the Montreal Protocol on Substances that Deplete the Ozone Layer (e.g. CFCs, halons), and their production has been curtailed.

Figure 2.2.2.1: CO_2 emissions for the G7 countries and Brazil, Russia, India and China, 1990 and 2002 (sorted by 2002 emissions)



Source: "CO_2 Indicators, 2002," International Energy Agency

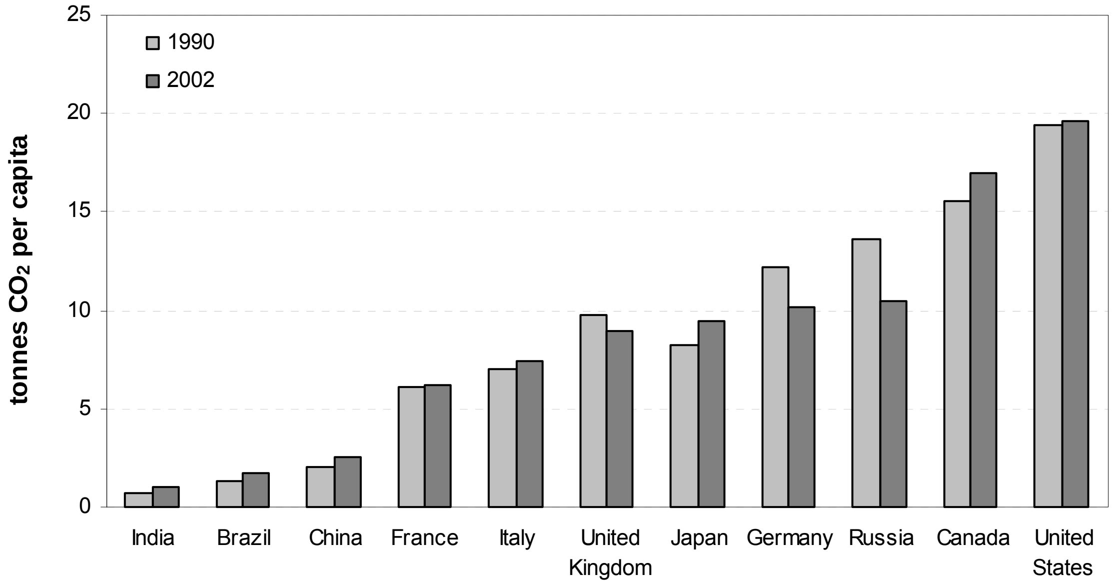
2.2.3 Canada's Emissions Intensity

Canada's CO_2 emissions intensity is high, compared with most other countries. Canada has the second highest CO_2 intensity per capita (Figure 2.2.3.1) and the highest CO_2 intensity per dollar of GDP among the G7 (Figure 2.2.3.2). Canada's per capita CO_2 emissions, like most other countries, increased from 1990 to 2002. In countries where per capita CO_2 emissions decreased between 1990 and 2002, the changes can be attributed to changes in the energy or political economy: the United Kingdom (UK) finished the switch from coal to North Sea gas, begun in the 1980s; after re-unification in 1990, Germany closed some inefficient and polluting industrial and electricity-production operations; and Russia's economy suffered an economic downturn after the collapse of the Soviet Union.

CO_2 emissions per dollar of GDP generally decreased around the world between 1990 and 2002 (Figure 2.2.3.2). This change in intensity can be attributed to a mixture of factors: ongoing increases in energy efficiency; changes in the fuel mix, such as the worldwide movement to natural gas; and structural change, mainly in the form of faster economic growth in the light-manufacturing and high-technology sectors.

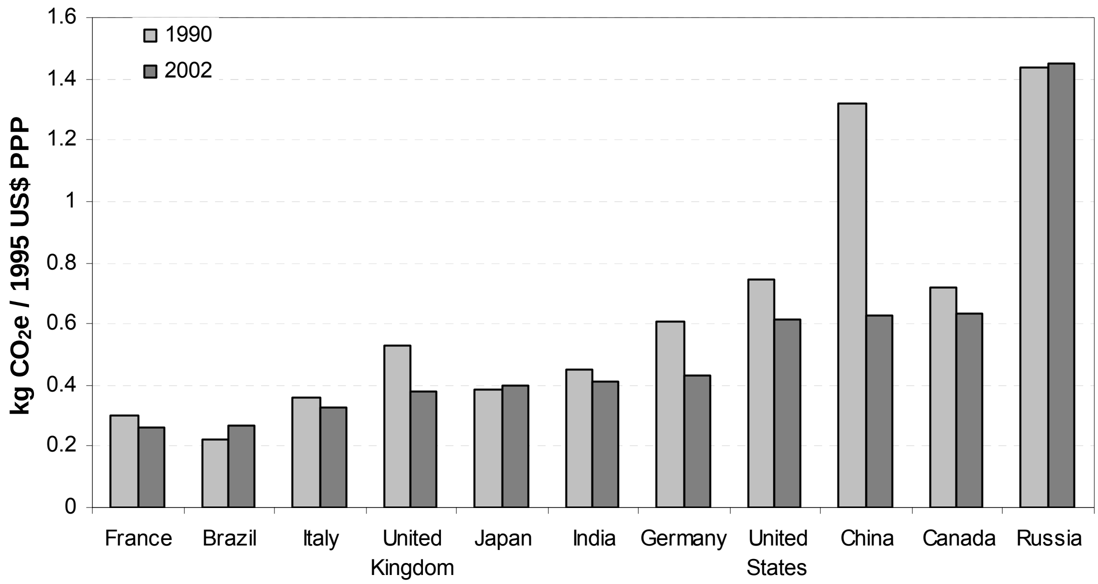
In the developing countries with emerging economies (India, Brazil and China), CO_2 per capita is much lower than in any of the developed counties (Figure 2.2.3.1). This reflects largely the smaller sizes of their emerging economies. Their CO_2 emissions per dollar of GDP are less uniform, however.

Figure 2.2.3.1: CO_2 emissions per capita for the G7 countries and Brazil, Russia, India and China, 1990 and 2002



Source: "CO_2 Indicators, 2002," International Energy Agency

Figure 2.2.3.2: CO_2 emissions per dollar of GDP for the G7 countries and Brazil, Russia, India and China, 1990 and 2002



Source: "CO_2 Indicators, 2002," International Energy Agency
PPP: Purchase Power Parity

The CO_2 emissions intensity of the other nations is heavily influenced by their domestic resources (Figure 2.2.3.2). China's high CO_2 emissions per dollar of GDP, relative to the other developing countries, illustrates its dependence on coal, while Brazil's low emissions intensity partly reflects its abundant hydropower and programs to produce ethanol from sugar as a vehicle fuel.

2.2.4 Canada's Emissions by Sector

Figure 2.2.4.1 shows Canada's GHG emissions by sector in 1990 and 2002. In this figure, the sector that directly emits the GHGs is depicted, so the use of coal or natural gas to produce electricity is allocated to the electricity sector, not the final user of the electricity. The shares are largely the same in 1990 and 2002, with overall emissions having increased by 20%, or 122 Mt. Industry, which emits GHGs directly from combustion and as a by-product of industrial processes, emitted the largest share in both years, but with a slightly smaller share in 2002. The emissions generated by the production of fossil fuels—a process with significant combustion and process emissions—increased from 10 to 13%, primarily because of growth in the production of bitumen and synthetic crude oil. The emissions generated by the production of electricity through the use of turbines powered by fossil fuels and by the production of heat through the burning of fossil fuels increased from 16% to 18%. This situation reflects the increased generation and use of fossil fuels in a country where, historically, electricity has been produced predominantly by hydro and nuclear plants, although hydro plants are still the leading producers.

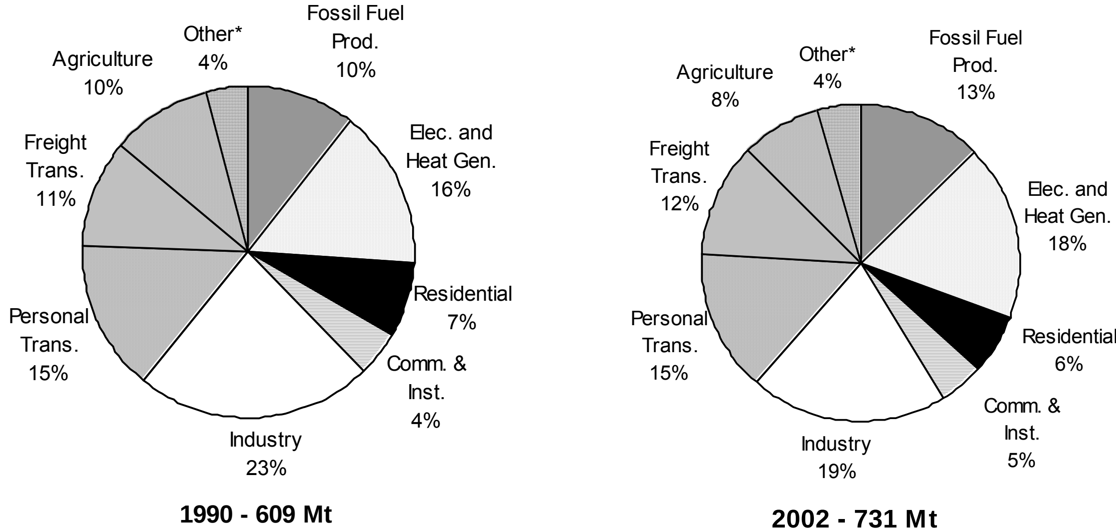
Transportation emissions, stemming mainly from the burning of petroleum products like gasoline and diesel, have remained largely at the same level. The same can be said for the residential and commercial sectors, which emit GHGs mainly through fuel combustion for space- and water-heating purposes.

The emissions stemming from the production of electricity are reported separately from the emissions of the sectors that consume the electricity; accordingly, only those emissions stemming directly from the combustion of fossil fuels and GHG-emitting processes are allocated to each of the other sectors.

Figure 2.2.4.2 puts Canada's GHG emissions per capita in context with those of the rest of the G7 countries. Canada emitted 23.3 tonnes of GHG per capita in 2002, which is 7.0 tonnes of GHG per capita higher than the population-weighted average of the other G7 countries. Canada's 2002 emissions were more than double the per capita emissions of France, Italy, Japan, and the UK, and almost double the per capita emissions of Germany. These differences result mainly from increased emissions in the areas of transportation, industry, electricity production, agriculture and fossil fuel production.

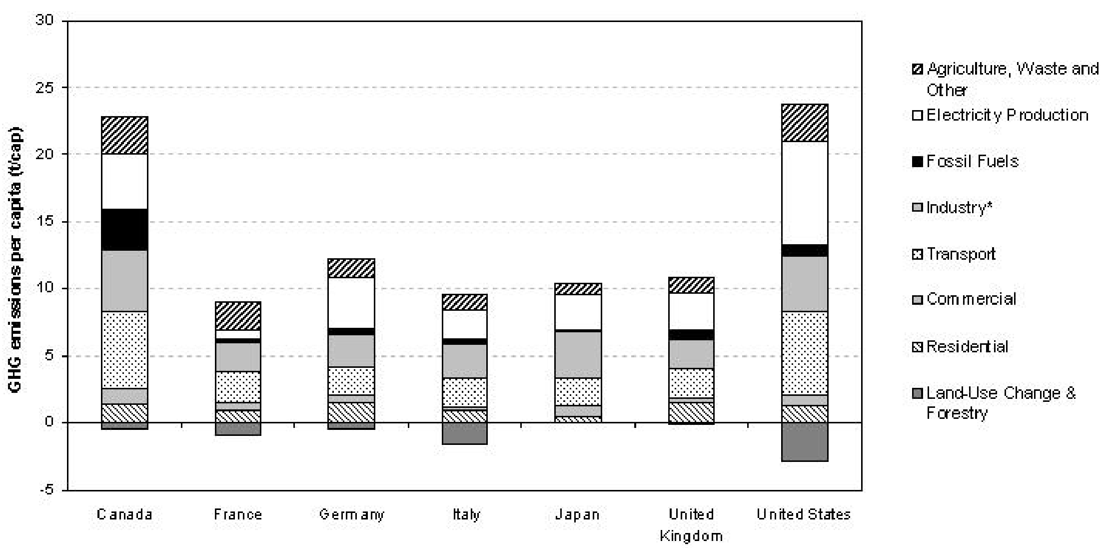
There are also significant differences between the per capita emissions for Canada and the U.S., despite similarities. Canada has much larger per capita emissions in the area of fossil fuel production. Conversely, Canada's per capita emissions from the making of electricity are roughly half those of the U.S., due to Canada's reliance on the low emissions intensity of hydro and nuclear power production. Canada has a relatively high level of electricity production from hydropower compared with the other G7 countries (Figure 2.2.4.3).

Figure 2.2.4.1: GHG emissions by sector in Canada, 1990 and 2002



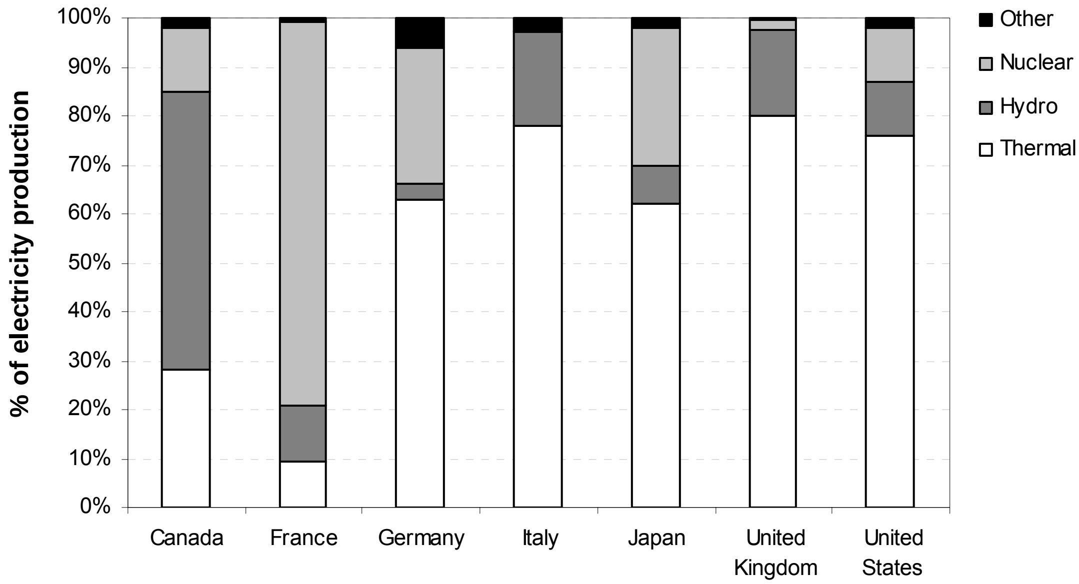
Source: Canada's Greenhouse Gas Inventory, 1990-2002, Environment Canada.
*Waste, CH_4-related Land Use Change, and Forestry. CO_2 from Land Use Change not included, as per Canada's GHG Inventory.

Figure 2.2.4.2: Total GHG emissions per capita of the G7 countries by sector, 2002



Source: UNFCCC National GHG Inventories, 2005.
*Includes petroleum refining, process emissions, solvents, HFCs, PFCs, and SF_6.
Note: Emissions from Land-Use Change and Forestry are shown for information only, as they are not currently accounted for in official emissions numbers.

Figure 2.2.4.3: Production of electricity by source for the G7 countries, 2002



Source: IEA Country Fact sheets

2.3 NATIONAL CIRCUMSTANCES

In this chapter, an attempt is made to assess the extent to which Canada's emissions intensity and growth in emissions since 1990 are the result of national circumstances. A national circumstance is defined as a relatively inflexible characteristic of a nation, not easily shaped by government policy, that significantly influences its GHG emissions. A national circumstance can also be a national characteristic, such as economic structure, that could be altered by government policy but whose alteration would cause the country's inhabitants undue harm outweighing the benefits of the corresponding GHG emissions reduction.

There are two types of national circumstances that affect Canada's ability to address climate change:

1. those that affect absolute emissions; and,
2. those that affect emissions intensity.

Type 1 circumstances involve changes over time and make it more difficult for Canada to meet its absolute emissions target relative to base year 1990. Type 2 circumstances affect Canada's emissions intensity relative to other countries.

Type 1 circumstances make it difficult for Canada to achieve its absolute emissions target. Such circumstances include a faster than normal population growth, a faster than normal GDP growth, and a faster than normal structural shift in the economy to more emission-intensive activities, as well as susceptibility to climatic variability. While Canada has not yet conducted a comprehensive assessment of all Type 1 circumstances, this document quantifies the effect of Canada's faster than normal population growth and qualifies the potential effect of the other three circumstances for further consideration and future analysis.

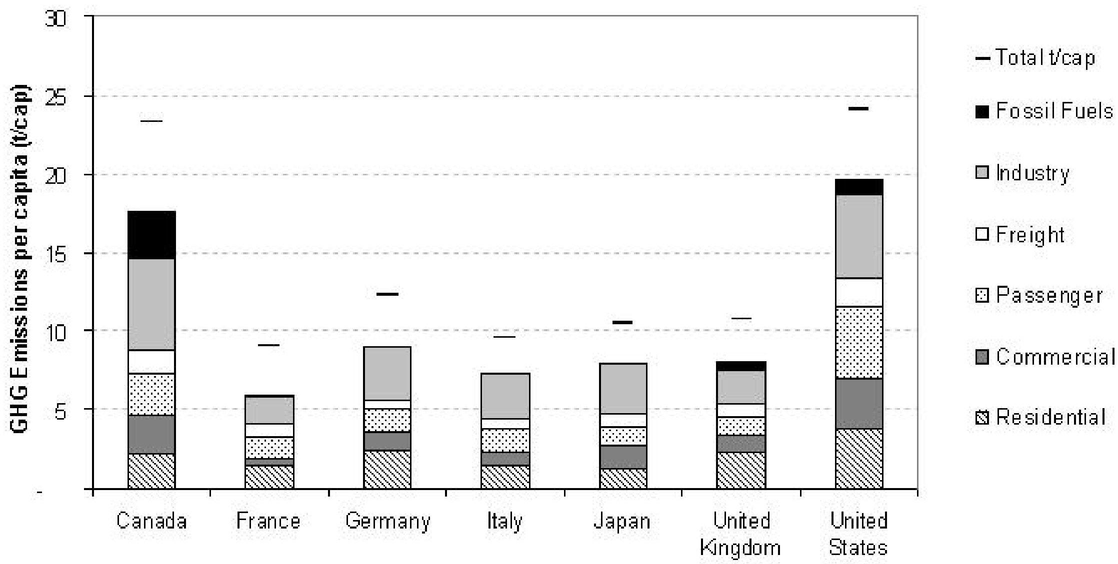
Type 2 circumstances affect Canada's emissions intensity. The Government of Canada has commissioned a study to quantitatively analyze a number of potential circumstances affecting Canada's standing relative to the other G7 countries. The scope of this analysis was determined by the availability of consistent international data; good data is available for energy-related emissions but not for other emissions.

The analysis of Type 2 circumstances covers roughly 75% of the emissions in each of the G7 countries; these are represented as solid histogram bars in Figure 2.3.1 (domestic electricity consumption has been allocated to the consuming sectors). The remaining portion, shown as the space above the histogram bars but below the short horizontal lines, comprises GHG emissions resulting from industrial processes, emissions from the waste, agriculture, and forestry sectors, non-CO_2 emissions from the transport and electricity sectors, and emissions associated with electricity produced for export. National circumstances are associated with these emissions, but it is not possible to quantify them satisfactorily at this time.

Four Type 2 circumstances have been investigated to explain a portion of the difference in Canada's emissions intensity as compared with that of the other G7 countries (MKJA, 2005). They are:

- the effect of climate on the commercial and residential sectors;
- the effect of geography and population distribution on the transportation sector;
- the effect of a large, export-oriented fossil fuel processing sector; and,
- the effect of an energy-intensive industrial structure.

Figure 2.3.1: Analyzed and unanalyzed portions of GHG emissions intensity by G7 country and sector, 2002, tonnes CO_2 eq. per capita[5]



Source: MKJA, 2005
Note: Unanalyzed portions of each country's emissions are indicated by the space between the top of the histogram bar and the horizontal line above it. These emissions result from industrial processes; the waste, agriculture, and forestry sectors; electricity produced for export; and non-CO_2 portions of other sectors—none of which were analyzed for this report.

[5] Emissions stemming from the production of electricity are allocated to the final consuming sector.

2.4 CANADA'S TYPE 1 CIRCUMSTANCES: ABSOLUTE EMISSIONS

A preliminary assessment has uncovered several Type 1 circumstances that make it increasingly more difficult for Canada to meet its GHG emissions targets. The effect of faster-than-G7 average population growth on the rise in Canada's GHG emissions is described quantitatively, while the effects of GDP growth, a structural shift in the economy, and climatic variability are described qualitatively.

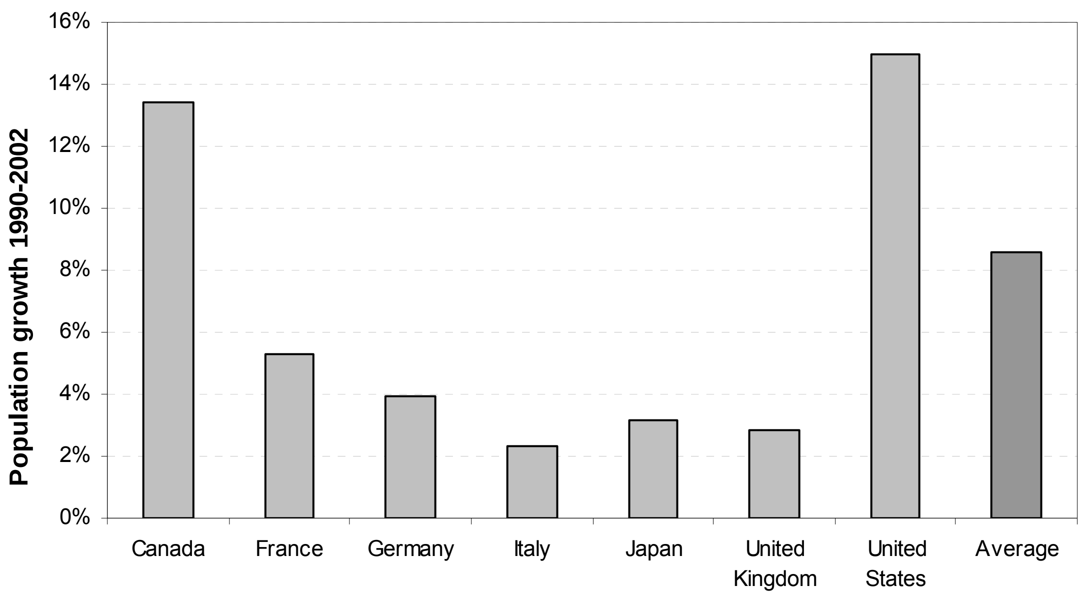
2.4.1 The Effect of Faster Than Normal Population Growth

Canada's population, along with that of the U.S., is growing faster than the G7 average (Figure 2.4.1.1). This extra growth can be expected to significantly increase Canada's total GHG emissions over time. Canada's population grew 13.4% from 1990 to 2002, compared with the G7 population weighted average of 8.5%. If Canada's population had grown at the rate of the average G7 country since 1990, Canada's GHG emissions in 2002 would have been lower by 22.4 Mt. Assuming these trends continue, Canada's CO_2 emissions in 2010, the midpoint of the Kyoto commitment period, will be 38.7 Mt higher than they would be if Canada's population instead grew at the G7's weighted average growth rate for 1990 to 2010.

2.4.2 The Effect of Faster Than Normal GDP Growth

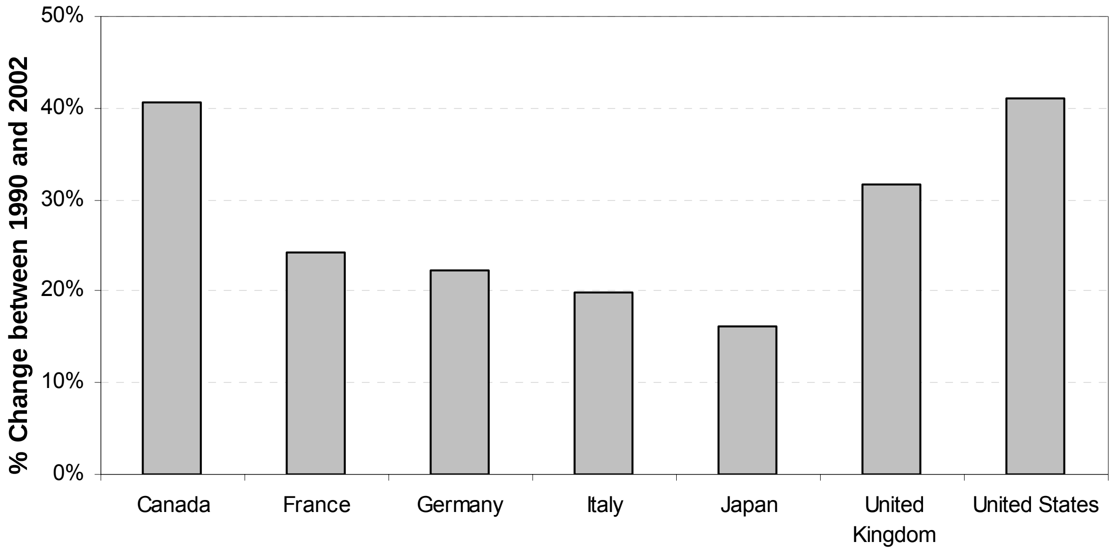
The Canadian economy generally performed well between 1990 and 2002, with a growth in GDP of 40.5% and an average annual growth of 2.9% during that period. Of all the G7 countries, Canada experienced economic growth second only to the U.S. during the assessment period (Figure 2.4.2.1).

Figure 2.4.1.1: Population growth in the G7 countries, 1990-2002



Source: UN Statistical Database

Figure 2.4.2.1: Comparison of changes in GDP in the G7 countries, 1990-2002



Source: "CO_2 Indicators, 2002," International Energy Agency

Canada's economic success also presents a challenge. According to the International Energy Agency, there is a near-linear correlation between GDP and energy use. Approximately 82% of Canada's emissions are associated with energy. Historically, economic growth has been one of the factors (along with weather, carbon intensity, energy intensity of the economy, and others) that caused fluctuations in energy use, and thus in CO_2 emissions.

While world growth in real GDP is expected to slow in the next couple of years, Canada's may not. The International Monetary Fund forecasts that Canada will have the second fastest growth rate in 2005 and 2006 among the G7 countries, second only to the U.S. Therefore, Canadian economic growth can be expected to continue to put upward pressure on emissions in the near future.

2.4.3 The Effect of a Faster Than Normal Structural Shift Towards Emission-Intensive Activities

Canada is unique among the industrialized countries in that it is a net exporter of coal, oil, and natural gas, with large reserves of each. Canada's reserves of bitumen, which can be transformed into synthetic crude oil, are the second largest reserves of crude oil in the world, after Saudi Arabia. With technology improving access to and production from these reserves, Canada has increasing capability to produce large volumes of each of these commodities in excess of what it needs for national consumption.

Canada's oil and gas exports have grown quickly in association with its growth in fossil fuel production. As a nation that applies open-market principles, Canada is obliged to trade its energy products without excessive intervention. The North American Free Trade Agreement (NAFTA) provides the U.S. with access to our fossil-fuel resources, while it also allows Canada to access the significant U.S. market. Canada's net exports grew by 199% between 1990 and 2002, of which almost all went to the U.S. During this period, net oil exports grew by 449% to 1,332 petajoules (PJ) (over 10 times the rate of growth of oil production), while net natural gas exports grew by 162% to 3,962 PJ (more than twice the rate of growth of natural gas production). Emissions associated with net exports of crude oil and natural gas grew by 138% (29.6 Mt) between 1990 and 2002, with an average annual change of 12%. Overall, total energy exported increased 146% between 1990 and 2002, while emissions associated with those exports increased 154%.

In comparison, the UK is the only other net exporter of oil among the G7 countries. The UK, also with a relatively high rate of growth, changed from a fossil fuel net importer to a net exporter between 1990 and 2002. Its annual net exports of oil and gas grew by 46.6 million tonnes of oil equivalent (Mtoe) to a net export of 35.6 Mtoe during that period, while Canada's grew by 84.1 Mtoe to 131.0 Mtoe (IEA 2005). The remaining G7 countries increased net imports of oil and gas over the same period, thereby exporting a portion of the emissions associated with the fossil fuels they consume.

2.4.4 The Effect of Susceptibility to Climatic Variability

Although not causing as significant an effect on emissions as those already described, susceptibility to climatic variability is also a Type 1 circumstance. Canada's ability to achieve success in relative emissions reductions annually is affected when a colder (warmer) year increases building heating (cooling) requirements over the base year of 1990. Canada's buildings sector consumes considerable energy for temperature regulation, with the magnitude of the demand dependent in part on the heating requirements of the year. A heating degree-day (HDD) is a measure of how cold a location is over a period of time relative to the base temperature of 18°C.

The year 1990 happened to have 8% fewer heating degree-days (4,141 HDDs, as measured in Toronto) than the weighted average of the 1951-1980 HDDs observed at a number of weather stations across Canada. Therefore, subsequent years with more typical heating requirements produce more buildings sector emissions compared with the 1990 base year. The year 2002 had 4,194 HDD. The winter in 2002 was colder than in 1990, while the summer was warmer, causing 2.7 Mt more GHG emissions from the buildings sector in 2002 than in 1990.

2.5 CANADA'S TYPE 2 CIRCUMSTANCES: EMISSIONS INTENSITY

Quantifiable and significant results were found for the following effects on Canada's GHG emissions: the effect of climate on the commercial and residential sectors, the effect of geography and population distribution on freight transportation, and the effect of a large export-oriented fossil fuel sector. The effect of geography and population distribution on personal transportation is quantifiable but insignificant, and the effect of energy-intense industrial structure remains uncertain. Each national circumstance is described briefly below.

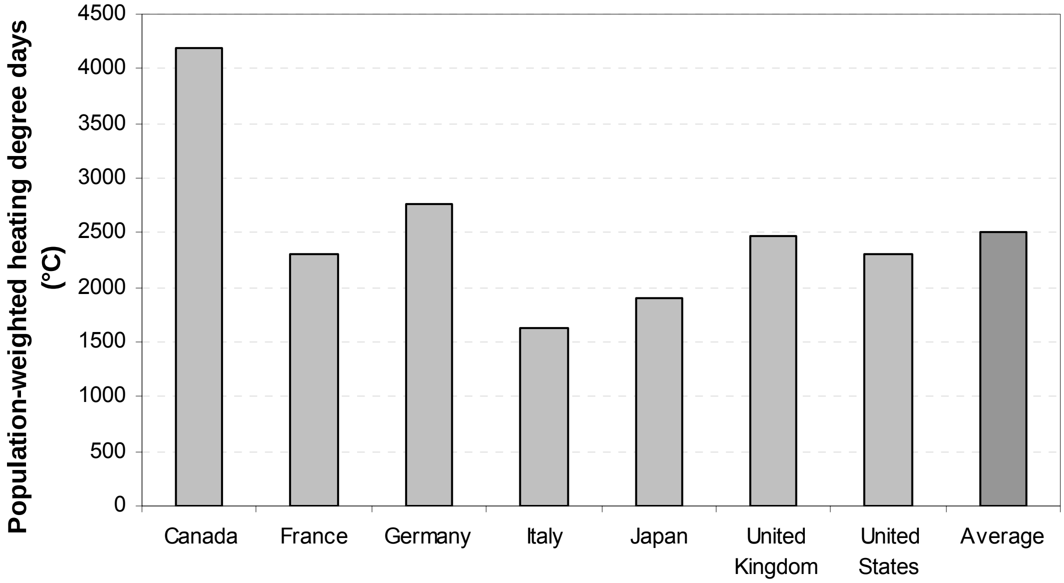
2.5.1 The Effect of Climate on the Commercial and Residential Sectors

Canada has one of the coldest climates of any country, shared only by the Scandinavian countries and Russia, and the coldest climate of the G7 countries by a significant margin. The colder a country is, the larger its space heating requirements will be, and the more effort will be put into energy efficiency.

On average, 57% of energy consumption in G7 residences is for space heating. As measured by population-weighted heating degree-days (based on differences from an average temperature of 18°C), Canadian residences experience much cooler weather than the rest of the G7 (Figure 2.5.1.1). Canada experiences 67% more heating degree-days than the G7 average, and residences in Canada consume 59% of their energy for space heating.

The Canadian residential and commercial /industrial building sectors emitted 2.27 and 2.37 tonnes CO_2 per capita respectively in 2002. Analysis indicates that if Canada's climate were the same as the other G7 countries, these sectors would emit 0.78 and 0.48 tonnes CO_2 per capita less, respectively.

Figure 2.5.1.1: Heating Degree-Days (18°C base) in G7 countries, 2002



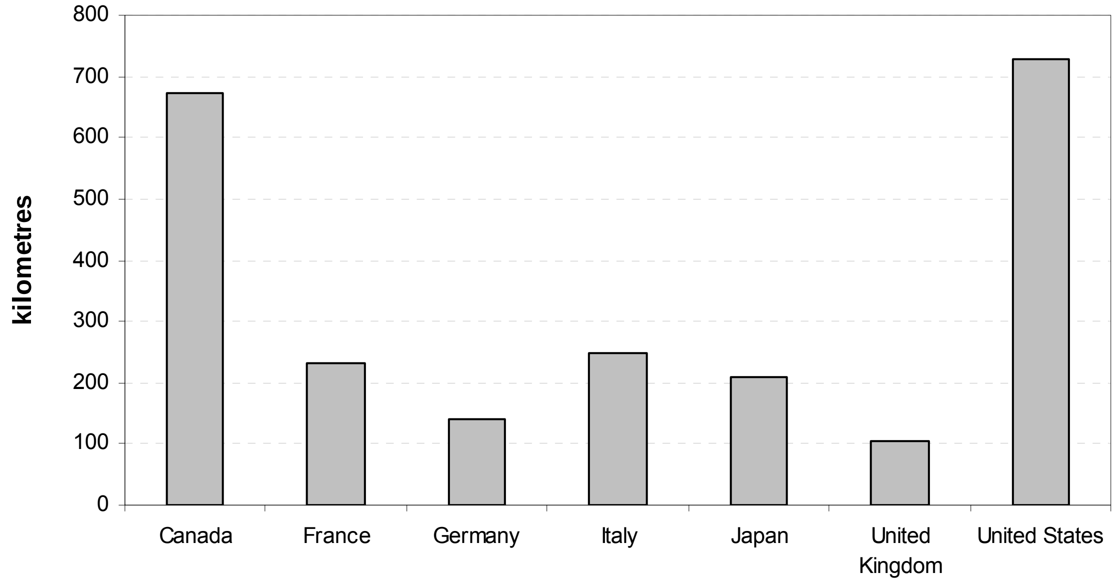
Source: Natural Resources Canada, Lawrence Berkeley National Laboratory, World Resources Institute 2003

2.5.2 The Effect of Geography and Population Distribution on the Freight Transportation Sector

Relative to most other industrialized countries, Canada has a large landmass, combined with a very low overall population density and a population that is widely distributed. These factors may contribute to a higher energy demand (and CO_2 emissions) for transportation of people and goods than for smaller, more densely populated countries. Figure 2.5.2.1 shows the population-weighted average distance between each of the G7 countries' 10 largest metropolitan centres. The U.S., with a large land mass and dispersed urban centres (e.g. Los Angeles, Chicago and New York), has the largest geography effect. Canada has the second largest; it is smaller than that for the U.S. primarily because much of its population is concentrated along the Québec City – Windsor corridor.

The Canadian freight transportation sector emitted 1.54 tonnes CO_2 per capita in 2002, which is 23% greater than the G7 average. The effect of geography on Canada's freight transportation sector is multi-faceted, including dynamics whereby the long distances between Canadian centres adjust the transportation economics such that they permit inherently energy-efficient but logistically complex rail travel. If Canada had the same geography and population distribution as the other G7 countries, its emissions would be 0.19 tonnes CO_2 per capita lower. Passenger transportation was also analyzed, but no substantial effect of geography on emissions was found.

Figure 2.5.2.1: Population-weighted average distances between each G7 country's 10 largest metropolitan areas



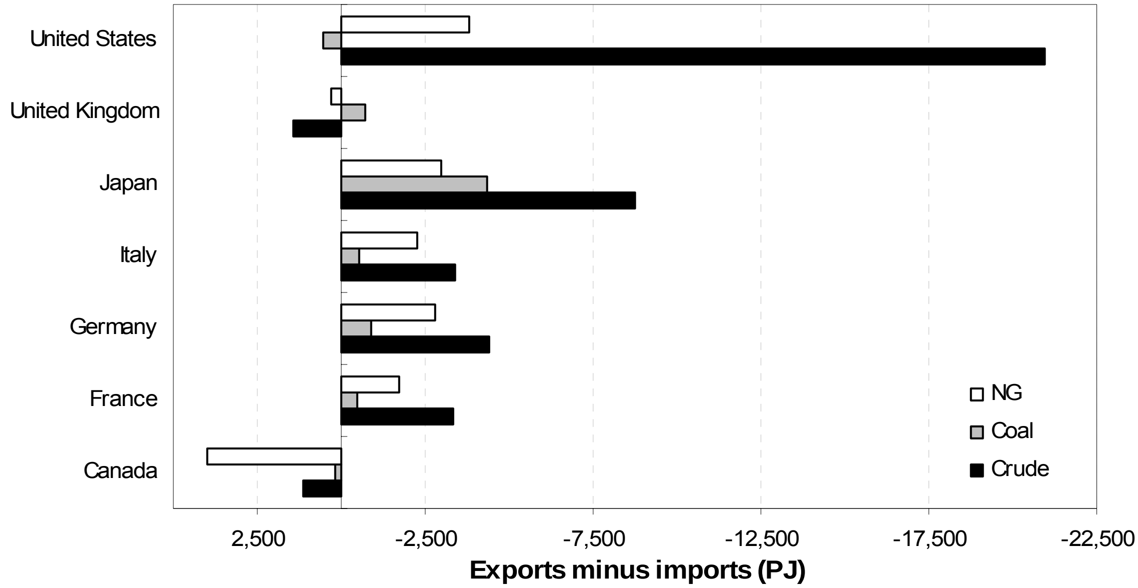
Source: MKJA, 2005.

2.5.3 The Effect of an Export-Oriented Fossil Fuel Processing Sector

Canada is a net exporter of coal, oil and natural gas (Figure 2.5.3.1). It exports roughly half of all the fossil fuels it produces, mainly GHG intense products such as synthetic and heavy crude oil.

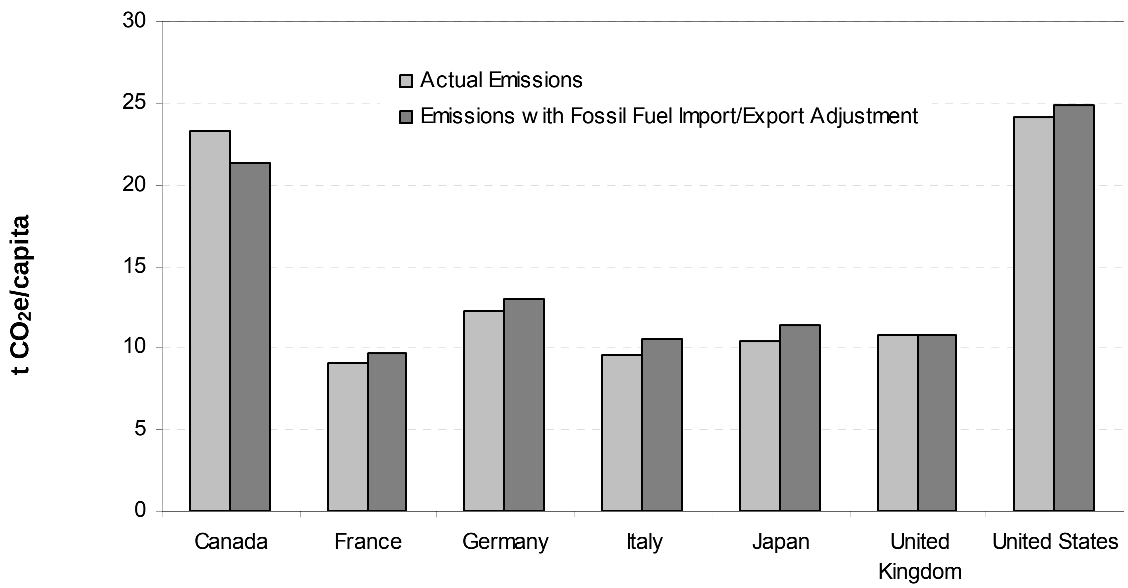
Canada's fossil fuel production sector emitted 3.00 tonnes per capita in 2002. If all countries were self-sufficient in fossil fuels, or were allocated the emissions associated with producing their fossil fuel imports, Canada would emit 2.03 tonnes GHG per capita less, while most of the other G7 countries would emit more (Figure 2.5.3.2). If Canada had the same fossil fuel trade balance as the rest of the G7 countries, its emissions would be lower by 2.73 tonnes per capita. These figures reflect the 2002 mix of conventional and oil sands production; they will increase as oil sands increase their proportion of production in the future, and as Canada's overall fossil fuel exports rise.

Figure 2.5.3.1: Net export of crude oil, natural gas and coal for the G7 countries, 2002



Source: International Energy Agency, 2005, "IEA Oil information, 2005 Edition"; International Energy Agency, 2005, "IEA Natural Gas information, 2005 Edition"; International Energy Agency, 2004, "IEA Coal information, 2004 Edition

Figure 2.5.3.2: CO_2 emissions per capita (plus all GHGs for fossil fuel production) with and without import and export adjustments for the G7 countries, 2002



Source: MKJA, 2005

2.5.4 The Effect of an Energy-Intensive Industrial Structure

Canada's industrial sector emitted 5.81 tonnes CO_2 per capita, which is 51% greater than the G7 average. This higher than average per capita intensity is due to a combination of higher energy intensity within sectors and a more energy-intense industrial structure; if Canada's industry had the same structure and energy intensity as the other G7 countries, it would emit 2.95 tonnes CO_2 per capita less.

It was not possible to separate the intensity and structural effects satisfactorily because the necessary disaggregation of structural data was not available (it was possible to account for only seven consistent industrial sub-sectors across the G7). Analysis of the Canadian pulp and paper sector shows that if consistent subsector structure data were available for all countries, then a larger structural effect may be seen. To illustrate the potential effect of this missing structural data, we have included Table 2.5.4.1. This table shows production of selected primary commodities by each of the G7 countries, as well as Canada's proportion of G7 and world population (4.4% and 0.5% respectively).

For many energy-intense commodities, such as alumina (2% of the world production) and aluminum (10%), copper (5%), gypsum (9%), iron ore (3%), nickel (12%), wood pulp (15%), newsprint (23%) and potash fertilizers (62% of G7 production), Canada produces far more than its population would suggest. Production of these energy-intensive commodities contributes significantly to Canada's overall industrial energy intensity. An analysis of Table 2.5.4.1 does not provide quantitative evidence comparable to other sections of this report, however, and this analysis would greatly benefit from consistently available, sufficiently disaggregated and internationally comparable substructure data.

Canada's industrial sector benefits from low-carbon electricity in Canada; if electricity in Canada were produced using the same fuels as in other G7 countries, emissions would be 0.92 tonnes CO_2 per capita higher.

Table 2.5.4.1: Production of basic commodities as a percentage of G7 and world totals

Commodities (2002 values except where noted)	*Canada*	*France*	*Germany*	*Italy*	*Japan*	*UK*	*US*	*World*	*Can. as % of G7*	*Can. as % of World*
Population (millions)	31.4	61.4	82.5	58.0	127.4	59.3	288.2	6,229.6	4.4%	0.5%
Aluminum										
Bauxite (000 t)	-	-	-	-	-	-	200	144,079	0%	0%
Alumina (000 t)	1,283	585	837	1,010	724	92	4,338	55,743	14%	2%
Aluminum (000 t)	2,709	463	653	191	6	344	2,705	26,022	38%	10%
Copper										
Mine Production (000 t)	604	-	-	-	2	-	1,157	13,500	34%	4%
Smelter Production (000 t)	514	-	295	-	1,283	-	683	10,800	19%	5%
Diamond (000 carats)	4,975	-	-	-	-	-	-	131,100	100%	4%
Gypsum (000 t)	8,913	3,500	1,761	1,531	-	1,700	15,700	94,700	27%	9%
Iron and Steel										
Iron Ore (000 t)	28,704	21	419	-	-	1	51,570	1,118,000	36%	3%
Pig Iron (000 t)	8,670	13,093	29,967	9,746	80,979	8,561	40,700	652,800	5%	1%
Crude Steel(000 t)	15,907	20,258	45,015	26,302	107,745	11,667	91,588	903,000	5%	2%
Nickel										
Mine Production (000 t)	189	-	-	-	-	-	-	1,293	100%	15%
Refinery Production (000 t)	145	11	-	-	158	34	-	1,192	42%	12%
Cement (000 t)	13,700	20,000	30,000	40,000	71,800	12,000	91,300	1,800,000	5%	1%
Lime (000 t) (1997 values)	2,500	3,000	8,000	3,500	7,700	2,500	19,300	124,000	5%	2%
Forestry										
Round wood (000 000 m3)	197	38	42	3	16	7	410	1,581	28%	12%
Sawn wood (000 000 m3)	58	10	17	2	14	3	89		30%	N/A
Pulp and Paper										
Wood Pulp (000 000 t)	26	2	2	0	11	1	54	168	27%	15%
Paperboard / Paper (000 000 t)	20	10	19	9	31	7	82	325	11%	6%
Newsprint (000 000 t)	9	1	2	0	4	1	5	37	40%	23%
Chemicals										
Nitrogenous Fertilizers(000 t)	3,836	1,000	1,013	400	670	540	9,442		23%	N/A
Phosphate Fertilizers (000 t)	296		13	50	368	50	7,967		3%	N/A
Potash Fertilizers (000 t)	8,027	130	3,451			540	696		62%	N/A
Rubber (000 t)	-	-	-	-	-	-	-	7,350	N/A	0%
Agriculture (2003, 2002 for cotton)										
Maize (000 000 t)	10	12	3	9	0	-	257	637	3%	2%
Wheat (000 000 t)	24	31	19	6	1	14	64	549	15%	4%
Rice (000 000 t)	-	0	-	-	10	-	9	589	0%	0%
Cotton (000 000 t)	-	-	-	-	-	-	4	19	0%	0%

Source: US Geological Survey; UK Geological Survey, World Mineral Production, 2005; Canadian Minerals Yearbook, 2003-2004; International Iron and Steel Institute, World Steel in Figures, 2003; Food and Agriculture Organization of the United Nations, Forest Production and Trade, 2005; United Nations Statistics Division, UN Stats Common Database, 2005; Pulp and Paper Products Council, 2004; International Rubber Study Group, Statistics Bulletin; International Cotton Advisory Council, Cotton: World Statistics 2002.

2.6 SUMMARY AND DISCUSSION

This chapter discusses two types of national circumstances: those that put upward pressure on absolute emissions as compared with the amount emitted in Canada in 1990, and those that affect emissions intensity relative to other countries. The Type 1 circumstances outlined are Canada's faster than normal population growth, GDP growth, and structural shift towards emission-intensive activities, as well as climatic variability. The Type 2 circumstances that help to quantitatively explain the difference between Canada's per capita emissions and those of the other G7 countries are: Canada's cold climate, Canada's large geography and distributed population, Canada's energy-intensive industrial structure, and Canada's export-oriented fossil fuel industry. The effect of each of these Type 2 factors, as well as that of the Type 1 factor on population growth, are summarized in Table 2.6.1.

Canada's GHG emissions intensity was 23.3 tonnes per capita in 2002, 7.0 tonnes per capita higher than the population-weighted average of the other G7 countries. The quantitative analysis focuses on a subset of those emissions — CO_2 emissions from combustion of fossil fuels and all emissions associated with the production of fossil fuels; these accounted for 17.7 tonnes per capita in 2002. This is 4.8 tonnes CO_2 per capita higher than the population-weighted average of the other countries; the analysis described in this report sought to determine the amount of this difference that can be explained by Canada's national circumstances.

Each Type 2 circumstance is shown in terms of tonnes CO_2 per capita, and all national circumstances are shown in terms of Mt of CO_2 equivalent. It is important that these values be used in context; they represent the amount of the difference between Canada's emissions per capita and those of other G7 countries that can be explained by the quantitatively analyzed national circumstances. If Canada were instead compared with a set of countries other than the G7 ones, the numbers in Table 2.6.1 would be different.

Overall, the analysis has shown that the national circumstances quantified here explain a significant proportion of the difference between Canada's per capita emissions and rest of the G7 population-weighted average in 2002. It was not possible to document any further emissions that may be explained by industrial structure or other national circumstances that exist but were not quantified, all of which warrant further analysis in the future. These values will change over time.

Table 2.6.1: Impacts of Canada's quantified national circumstances relative to other G7 countries, 2002

	Tonnes per capita*	Effect in Mt of CO_2e in 2002	% of 731 Mt CO_2e in 2002
Type 1: Absolute emissions			
The effect of faster than normal population growth (1990-2002)	**N/A**	**22.4**	**3.1%**
Type 2: Emissions intensity			
The effect of climate on the residential sector	0.78	24.5	3.4%
The effect of climate on the commercial sector	0.48	15	2.1%
The effect of geography on passenger transport	0	0	0.0%
The effect of geography on freight transport	0.19	6	0.8%
Embodied energy of fossil fuels for export	2.73**	85.6	11.7%
Structure in the industrial sector	N/A	0.3	0.0%
Emissions intensity from Type 2 circumstances	**4.18**	**131.4**	**18.0%**

* All of the national circumstances affecting emissions intensity are calculated in tonnes of CO_2 per capita, except for the national circumstance on fossil fuel export, which includes CH_4 as well as CO_2 in the calculations.
** Reflects 2002 mix of conventional and oil sands production in Canada. This will increase as oil sands increases its proportion of the mix.

Table 2.6.1 indicates that Canada's cold climate and large geography explain about 1.45 tonnes per capita of the difference between Canada's emissions and that of other countries.

While the analysis of Canada's industrial structure showed a very small positive effect of structure (0.01 tonnes per capita), it did not permit full quantification of the difference between Canada's per capita emissions and those of other countries because sufficiently detailed structural data were not available. A detailed examination of the pulp and paper sector and a more general examination of Canada's production of energy-intense commodities as a proportion of world production suggest that Canada experiences at least some level of national circumstances attached to producing a larger relative amount of energy-intense primary commodities. These analyses could not, however, provide tonnes per capita estimates of the effect of industrial structure, as a decomposition analysis might have done. Better data on the international structure of energy-intensive primary commodity production might have lead to an analysis revealing that Canada's industrial structure does help to explain the emissions-per-capita difference between Canada and the other G7 countries.

The analysis shows that if the emissions associated with the production of fossil fuels were allocated to final consuming countries rather than producing countries, Canada's emissions would be lower by 2.03 tonnes per capita, and if it had the same import and export pattern as the rest of the G7 countries, its emissions would be lower by 2.73 tonnes per capita.

The presence of these national circumstances does not, in and of itself, mean that it is more difficult for Canada than for other countries to reduce its GHG emissions over time. That depends on how circumstances are changing over time.

The effect of Canada's relatively fast population growth between 1990 and 2002 was an example of how national factors can disadvantage attempts to mitigate GHG emissions. Canada's population grew 13.4% from 1990 to 2002, compared with the G7 population-weighted average of 8.5%. If Canada's population had grown at the same rate as the average G7 country from 1990 to 2002, Canada's CO_2 emissions in 2002 would have been lower by 22.4 Mt.

Other changes in national circumstances have been identified that, it would appear, are affecting Canada's ability to reduce its absolute level of GHG emissions—GDP growth, structural shift towards fossil fuel production and, potentially, climate variability. Further analysis is required to quantify the potential impacts of these factors.

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CHAPTER 3 GREENHOUSE GAS INVENTORY INFORMATION

This chapter summarizes the anthropogenic (human-induced) emissions by sources, and removals by sinks, of all greenhouse gases (GHGs) not controlled by the Montreal Protocol for Canada in 2004, as submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in May 2006. It also discusses underlying trends in emissions for the period 1990 to 2004 inclusive.

A complete report on GHG emissions, removals and their associated estimation methodologies for the period 1990 to 2004 can be found in Canada's 2006 submission to the UNFCCC titled *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2004* (Environment Canada, 2006) and is available online.[6]

3.1 INTRODUCTION

The GHGs for which emissions and removals have been estimated in Canada's national inventory are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs).

The inventory uses the UNFCCC-agreed upon reporting format that groups GHG estimates into the following six sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Waste and Land Use, Land-Use Change and Forestry (LULUCF). Each of these categories is further subdivided within the inventory and follows, as closely as possible, the UNFCCC sector and sub-sector divisions.

[6] For further information related to Canada's National System, please see Annex 3.2.

3.2 CANADA'S 2004 GREENHOUSE GAS INVENTORY

In 2004, Canadians contributed about 758,000 gigagrams (Gg)[7] or 758 megatonnes (Mt) of CO_2 equivalent (CO_2 eq.[8]) of GHGs to the atmosphere (excluding LULUCF estimates) (Table 3.2.1). Trends in Canada's 2004 GHG emissions and removals estimates are presented in the UNFCCC Common Reporting Format (CRF) in Annex 3.1.

Approximately 73% of total GHG emissions in 2004 resulted from the combustion of fossil fuels. Another 9% were from fugitive sources, with the result that 82% of emissions were from the Energy Sector (Table 3.2.1 and Figure 3.2.1).

On an individual GHG basis, CO_2 contributed 78% of the total emissions, while CH_4 accounted for 15%. N_2O accounted for 6% of the emissions, while PFCs, SF_6, and HFCs constituted the remaining 1%.

[7] For the UNFCCC Common Reporting Format (CRF) quantities are expressed in gigagrams (Gg), where 1 gigagram is equivalent to 1 kilotonne (kt). In this report, for ease of reporting and discussion, certain GHG estimates have been rounded and are reported in kt or megatonnes (Mt).

[8] Each of the GHGs has a unique average atmospheric lifetime over which it is an effective climate-forcing agent. The concept of global warming potential (GWP) was introduced to equate the climate-forcing potential of different GHGs to that of CO_2. GWP is a relative measure of the warming effect that the emission of a radiative gas might have on the surface troposphere and, unless otherwise indicated, GHG emissions and removal estimates are expressed as CO_2 equivalents (CO_2 eq.).

Table 3.2.1: Canada's GHG Emissions and Removals, 2004

Greenhouse Gas Categories	Greenhouse Gases								
	CO_2	CH_4	CH_4	N_2O	N_2O	HFCs	PFCs	SF_6	TOTAL
Global Warming Potential			21		310				
Unit	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
TOTAL[1]	**593 000**	**5 200**	**110 000**	**140**	**44 000**	**4 700**	**3 060**	**3 000**	**758 000**
ENERGY	**553 000**	**3 000**	**60 000**	**30**	**10 000**	**-**	**-**	**-**	**620 000**
a. Stationary Combustion Sources	**352 000**	**200**	**5 000**	**9**	**3 000**	**-**	**-**	**-**	**360 000**
Electricity and Heat Generation	129 000	4.7	99	2	700	-	-	-	130 000
Fossil Fuel Industries	75 000	100	3 000	2	500	-	-	-	79 000
Petroleum Refining and Upgrading	29 000	0.6	10	0.5	200	-	-	-	29 000
Fossil Fuel Production	46 200	100	3 000	1	400	-	-	-	49 000
Mining	15 300	0.3	6	0.3	100	-	-	-	15 400
Manufacturing Industries	50 300	3	60	2	500	-	-	-	50 900
Iron and Steel	6 480	0.3	5	0.2	60	-	-	-	6 550
Non-Ferrous Metals	3 220	0.07	2	0.05	20	-	-	-	3 230
Chemical	6 250	0.13	2.7	0.1	30	-	-	-	6 290
Pulp and Paper	8 990	2	40	0.9	300	-	-	-	9 310
Cement	4 310	0.09	2	0.05	20	-	-	-	4 330
Other Manufacturing	21 100	0.4	9	0.4	100	-	-	-	21 200
Construction	1 340	0.02	0.5	0.03	9	-	-	-	1 350
Commercial & Institutional	37 700	0.7	10	0.8	200	-	-	-	37 900
Residential	40 700	90	2 000	2	500	-	-	-	43 000
Agriculture & Forestry	2 080	0.04	0.7	0.06	20	-	-	-	2 100
b. Transportation[2]	**185 000**	**30**	**600**	**30**	**8 000**	**-**	**-**	**-**	**190 000**
Domestic Aviation	7 590	0.4	9	0.7	200	-	-	-	7 800
Road Transportation	140 000	12	260	16	5 100	-	-	-	145 000
Light-Duty Gasoline Vehicles	47 800	3.5	74	6.0	1 900	-	-	-	49 800
Light-Duty Gasoline Trucks	41 000	4.5	95	8.3	2 600	-	-	-	43 600
Heavy-Duty Gasoline Vehicles	4 010	0.57	12	0.60	190	-	-	-	4 210
Motorcycles	214	0.17	3.6	0.00	1.3	-	-	-	219
Light-Duty Diesel Vehicles	750	0.02	0.4	0.05	20	-	-	-	768
Light-Duty Diesel Trucks	873	0.02	0.5	0.06	20	-	-	-	893
Heavy-Duty Diesel Vehicles	44 400	2	50	1	400	-	-	-	44 900
Propane & Natural Gas Vehicles	837	1	30	0.02	5	-	-	-	870
Railways	5 350	0.3	6	2	700	-	-	-	6 000
Domestic Marine	6 260	0.5	10	1	400	-	-	-	6 600
Others	26 000	10	300	6	2 000	-	-	-	30 000
Off-Road Gasoline	4 000	4	90	0.08	20	-	-	-	4 000
Off-Road Diesel	14 000	0.7	10	5	2 000	-	-	-	20 000
Pipelines	8 280	8.3	170	0.2	70	-	-	-	8 520
c. Fugitive Sources	**16 000**	**2 400**	**50 000**	**0.1**	**40**	**-**	**-**	**-**	**66 500**
Coal Mining	-	50	1 000	-	-	-	-	-	1 000
Oil and Natural Gas	16 000	2 300	49 000	0	40	-	-	-	65 500
Oil	3 650	300	6 300	-	-	-	-	-	9 900
Natural Gas	7 200	1 000	21 000	-	-	-	-	-	28 000
Venting	160	1 000	22 000	0.1	40	-	-	-	22 000
Flaring	5 350	3.91	82.2	0.00	0.06	-	-	-	5 400
INDUSTRIAL PROCESSES	**39 600**	**-**	**-**	**12.7**	**3 920**	**4 700**	**3 060**	**3 020**	**54 300**
a. Mineral Products	**9 500**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**9 500**
Cement Production	7 100	-	-	-	-	-	-	-	7 100
Lime Production	2 000	-	-	-	-	-	-	-	2 000
Mineral Product Use[3]	630	-	-	-	-	-	-	-	630
b. Chemical Industry	**5 700**	**-**	**-**	**12.7**	**3 920**	**-**	**-**	**-**	**9 600**
Ammonia Production	5 700	-	-	-	-	-	-	-	5 700
Nitric Acid Production	-	-	-	2.7	830	-	-	-	830
Adipic Acid Production	-	-	-	9.98	3 090	-	-	-	3 090
c. Metal Production	**12 000**	**-**	**-**	**-**	**-**	**-**	**3 030**	**2 220**	**17 600**
Iron and Steel Production	8 160	-	-	-	-	-	-	-	8 160
Aluminium Production	4 200	-	-	-	-	-	3 030	-	7 280
SF_6 Used in Magnesium Smelters and Casters	-	-	-	-	-	-	-	2 190	2 190
d. Consumption of Halocarbons and SF_6	**-**	**-**	**-**	**-**	**-**	**4 700**	**30**	**800**	**5 500**
e. Other & Undifferentiated Production	**12 000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**12 000**
SOLVENT & OTHER PRODUCT USE	**-**	**-**	**-**	**1.6**	**480**	**-**	**-**	**-**	**480**
AGRICULTURE	**-**	**1 290**	**27 200**	**89**	**28 000**	**-**	**-**	**-**	**55 000**
a. Enteric Fermentation	-	1 140	24 000	-	-	-	-	-	24 000
b. Manure Management	-	150	3 200	17	5 300	-	-	-	8 400
c. Agricultural Soils	-	-	-	72	22 000	-	-	-	22 000
Direct Sources	-	-	-	37	12 000	-	-	-	12 000
Pasture, Range, and Paddock Manure	-	-	-	14	4 300	-	-	-	4 300
Indirect Sources	-	-	-	20	7 000	-	-	-	7 000
WASTE	**200**	**1 300**	**28 000**	**3**	**1 000**	**-**	**-**	**-**	**29 000**
a. Solid Waste Disposal on Land	-	1 300	27 000	-	-	-	-	-	27 000
b. Wastewater Handling	-	12	250	3	1 000	-	-	-	1 200
c. Waste Incineration	200	0.06	1	0.2	50	-	-	-	250
LAND USE, LAND-USE CHANGE AND FORESTRY	**59 000**	**640**	**14 000**	**27**	**8 400**	**-**	**-**	**-**	**81 000**
a. Forest Land	51 000	640	13 000	27	8 300	-	-	-	73 000
b. Cropland	- 140	5	100	0.3	100	-	-	-	58
c. Grassland	-	-	-	-	-	-	-	-	-
d. Wetlands	1 000	0.1	3	0.01	2	-	-	-	1 000
e. Settlements	7 000	3	60	0	30	-	-	-	7 000

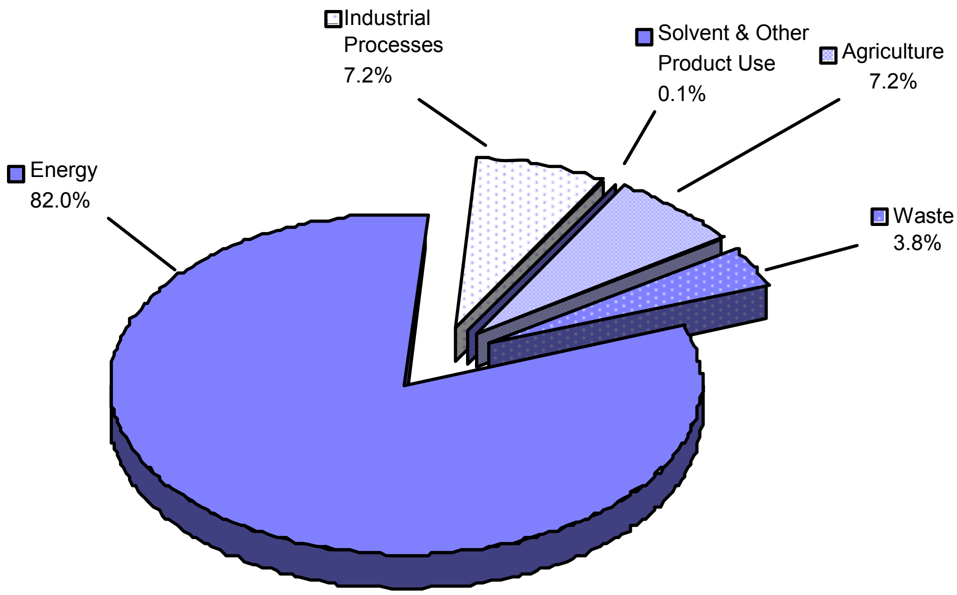
[1]National totals exclude all GHGs from the Land Use, Land-Use Change and Forestry Sector.

[2] Emissions from fuel ethanol are reported within the gasoline transportation subcategories.

[3] The category mineral product use includes CO_2 emissions from the use of limestone & dolomite, soda ash, and magnesite.

Note: Totals may not add due to rounding.

Figure 3.2.1: Sectoral Breakdown of Canada's GHG Emissions (without LULUCF), 2004



It is of note that in Canada, a significant portion of the emissions in the Energy sector are associated with fossil-fuel energy production. A large percentage of those production emissions are related to the export of fossil fuels such as natural gas and crude oil.

Carbon dioxide emissions and removals associated with the LULUCF sector are not included in the inventory totals. In 2004, total emissions for the LULUCF sector are estimated at about 81,000 kt.

3.2.1 Continuous Improvements

Each year, in meeting the UNFCCC requirements, Environment Canada reviews and, if necessary, revises and recalculates the emissions and removals estimates for all years in the inventory. This work is an integral part of a continuous improvement cycle by which the transparency, completeness and accuracy, consistency and comparability of the national inventory are improved and refined. Improvements take into account results of quality assurance and control procedures, reviews and verification and result in updated methods, models and documentation to ensure internationally-agreed-upon standards are met.

For example, for the 2006 inventory submission to the UNFCCC, significant improvements were implemented as a result of: detailed studies on emissions from facilities in the upstream oil and gas and oil refining industries; a revision to the model for estimating emissions from landfills; and improved country specific methods and factors for agricultural soil nitrous oxide emissions estimates.

Moreover, the LULUCF methodologies have been entirely upgraded. In addition, in developing the inventory, Tier 1 quality assurance/quality control (QA/QC) procedures continue to be used to formally ensure and document the quality of the estimates. In addition, some Tier 2 QA/QC has been conducted as time and resources permit.

3.3 TRENDS IN GHG EMISSIONS AND REMOVALS 1990-2004

Total GHG emissions in Canada in 2004, were 758 Mt which represents a 0.6% increase over the 2003 total of 754 Mt and a 26.6% increase over the 1990 total of 599 Mt and 34.6% above the Kyoto target of 563 Mt (Figure 3.3.1). The increase from 2003 to 2004 was small primarily due to significantly reduced emissions from electricity production (less coal and more nuclear power), and a reduced demand for heating fuel due to warmer weather.

It is important to note that Canada's GHG emissions vary from region to region. This is linked to the distribution of natural resources and to the location of large population centres and heavy industry within the country. While the use of natural resources and industrial products benefits all regions, emissions from their production tend to be concentrated in particular geographic regions. Thus, particular jurisdictions in Canada tend to produce more GHG emissions because of their economic and industrial structure and their relative dependence on fossil fuels for producing energy. Figure 3.3.2 illustrates the provincial/territorial distribution of emissions and the change in these emissions between 1990 and 2004.

Figure 3.3.1: Canadian GHG Emission Trend and the Kyoto Target

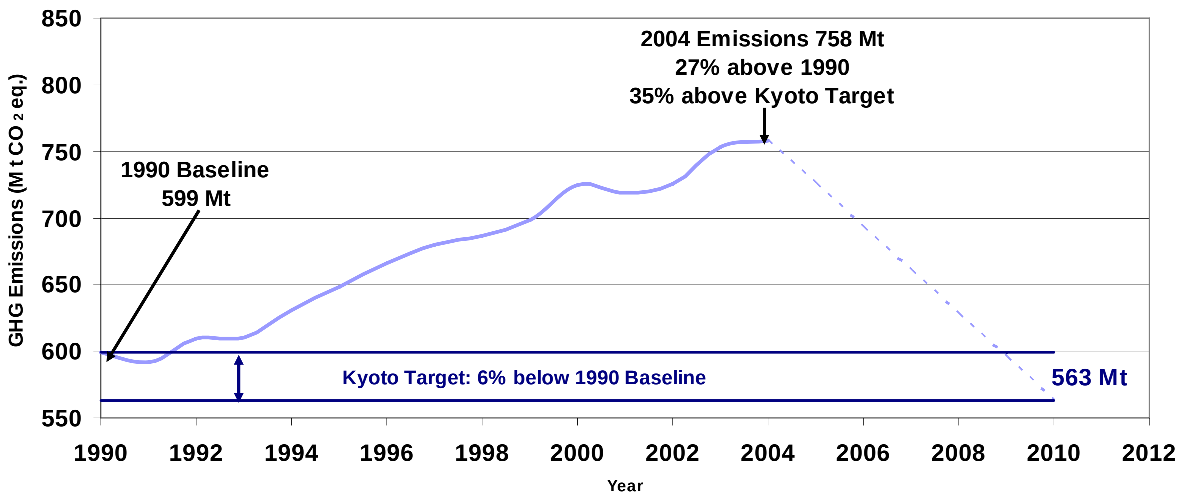
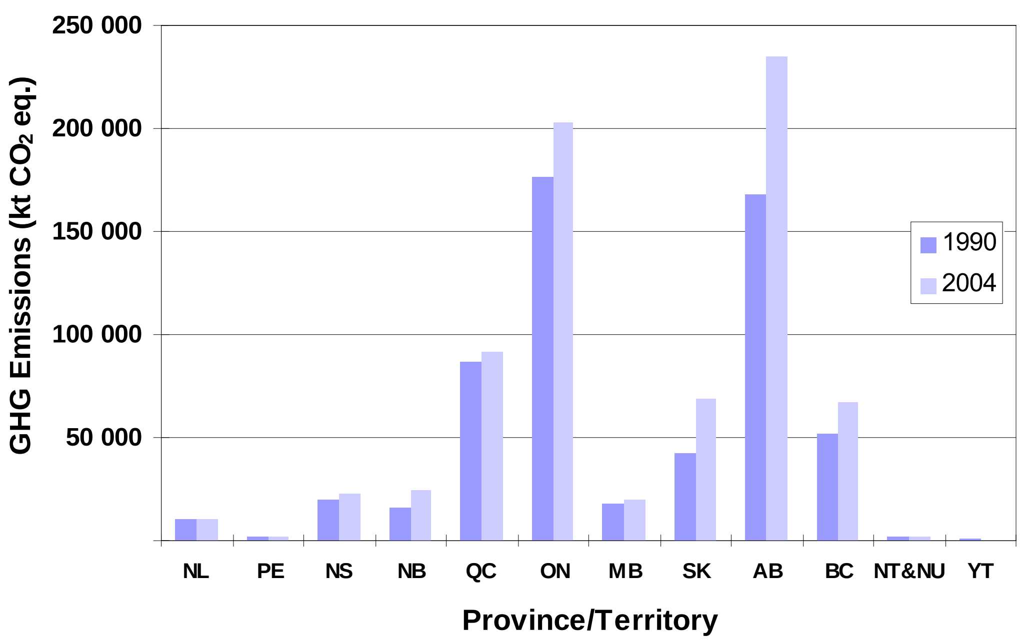


Figure 3.3.2: Provincial and Territorial GHG Emissions, 1990 and 2004



The emission/removal trends also vary by UNFCCC sector and subsector. The data in Table 3.3.1 illustrate the net emission/removals from 1990 to 2004 inclusive. Table 3.3.2 provides an indication of HFCs, PFCs and SF_6 emissions trends from 1990 to 2004.

Table 3.3.3 depicts Canada's total GHG emissions from 1990 to 2004, along with several primary indicators: gross domestic product (GDP), population, energy use, energy production, and energy export. From the table, it is evident that the 27% increase in GHG emissions during the 14-year period outpaced increases in population (which totalled 15%) and approximately equalled the increase in energy use (which was 26%). However, the growth in total emissions was well short of the 47% growth in GDP between 1990 and 2004 (Statistics Canada, #13-213: millions of chained 1997 dollars).

The result is that economic GHG intensity has decreased by a total of 14% over the period, an average of 1% per year. More goods were manufactured, more commercial activity occurred, and more travel took place per unit of GHG emissions. The data clearly show that GHG emissions per unit of energy use remained static over the period, while the economic GHG intensity decreased. This is to some extent related to energy efficiency improvements that have taken place in the Canadian economy since 1990 (NRCan, 2005).

Another trend worth noting is the much larger growth in energy *production* than energy *use* between 1990 and 2004. This is a consequence of Canada's large fossil fuel resources and an economy geared to take advantage of them, with increasing quantities of energy being delivered to the international market. The resultant sharp growth in energy exports over the period has had a significant impact on the emission trend. In this period, net oil exports (exports minus imports) grew by 513% to 1572 petajoules (PJ) (almost 10 times the rate of growth of oil production), while net exports of natural gas increased 138% to 3600 PJ (almost twice the rate of growth of natural gas production). The portion of emissions from all oil and gas production, processing, and transmission activities that is attributable to net exports rose from about 22 Mt in 1990 to 48 Mt in 2004 (123% increase).

In a global context, Canada contributes about 2% of total global GHG emissions and ranks 6th among the nine Annex 1 Parties whose emissions increased more than 20% over the 1990-2003 period (UNFCCC, 2005). The country is one of the highest per capita emitters, largely the result of its size, climate (i.e. significant energy demands), and resource-based economy, as described in Chapter 2. In 2004, Canada emitted over 23 tonnes of GHGs per capita, a 9.7% growth since 1990 (Table 3.3.3 and Figure 3.3.3).

Table 3.3.1: GHG Emissions Trends, 1990 to 2004

Greenhouse Gas Categories		1990	1995	2000	2003	2004
				kt CO_2 equivalent		
TOTAL		**599 000**	**649 000**	**725 000**	**754 000**	**758 000**
ENERGY		**475 000**	**517 000**	**596 000**	**622 000**	**620 000**
a.	**Stationary Combustion Sources**	**283 000**	**296 000**	**347 000**	**368 000**	**360 000**
	Electricity and Heat Generation	95 300	101 000	132 000	139 000	130 000
	Fossil Fuel Industries	53 000	56 000	70 000	77 000	79 000
	Petroleum Refining and Upgrading	23 000	25 000	24 000	30 000	29 000
	Fossil Fuel Production	30 000	32 000	45 000	47 000	49 000
	Mining	6 200	7 860	10 400	15 700	15 400
	Manufacturing Industries	54 900	53 100	53 200	49 500	50 900
	Iron and Steel	6 490	7 040	7 190	6 370	6 550
	Non-Ferrous Metals	3 230	3 110	3 190	3 200	3 230
	Chemical	7 100	8 460	7 860	5 820	6 290
	Pulp and Paper	13 600	11 700	11 000	9 010	9 310
	Cement	3 590	3 420	3 970	4 180	4 330
	Other Manufacturing	20 900	19 400	20 000	20 900	21 200
	Construction	1 880	1 180	1 080	1 300	1 350
	Commercial & Institutional	25 800	29 000	33 200	37 900	37 900
	Residential	44 000	45 000	45 000	45 000	43 000
	Agriculture & Forestry	2 420	2 790	2 570	2 210	2 100
b.	**Transportation**[2]	**150 000**	**160 000**	**180 000**	**190 000**	**190 000**
	Domestic Aviation	6 400	5 900	6 600	7 300	7 800
	Road Transportation	107 000	119 000	131 000	140 000	145 000
	Light-Duty Gasoline Vehicles	53 800	51 400	48 300	49 400	49 800
	Light-Duty Gasoline Trucks	21 700	28 400	37 600	41 900	43 600
	Heavy-Duty Gasoline Vehicles	3 140	4 760	4 370	4 140	4 210
	Motorcycles	230	214	238	226	219
	Light-Duty Diesel Vehicles	672	594	604	722	768
	Light-Duty Diesel Trucks	591	417	645	796	893
	Heavy-Duty Diesel Vehicles	24 500	30 800	38 700	42 300	44 900
	Propane & Natural Gas Vehicles	2 200	2 100	1 100	820	870
	Railways	7 000	6 000	7 000	6 000	6 000
	Domestic Marine	5 000	4 400	5 100	6 100	6 600
	Others	20 000	30 000	30 000	30 000	30 000
	Off-Road Gasoline	5 000	4 000	6 000	4 000	4 000
	Off-Road Diesel	10 000	10 000	20 000	10 000	20 000
	Pipelines	6 900	12 000	11 300	9 110	8 520
c.	**Fugitive Sources**	**43 300**	**57 000**	**64 900**	**66 200**	**66 500**
	Coal Mining	2 000	2 000	900	1 000	1 000
	Oil and Natural Gas	41 400	55 300	64 000	65 200	65 500
	Oil	6 700	8 400	9 400	10 000	9 900
	Natural Gas	18 000	23 000	27 000	28 000	28 000
	Venting	13 000	18 000	22 000	22 000	22 000
	Flaring	4 400	5 400	5 500	5 700	5 400
INDUSTRIAL PROCESSES		**53 300**	**55 500**	**49 800**	**50 100**	**54 300**
a.	**Mineral Products**	**8 300**	**8 800**	**9 600**	**9 100**	**9 500**
	Cement Production	5 400	6 100	6 700	6 800	7 100
	Lime Production	2 000	2 000	2 000	2 000	2 000
	Mineral Product Use[3]	1 100	880	1 000	610	630
b.	**Chemical Industry**	**15 000**	**17 000**	**7 100**	**7 000**	**9 600**
	Ammonia Production	3 900	5 300	5 400	5 100	5 700
	Nitric Acid Production	780	780	800	810	830
	Adipic Acid Production	10 700	10 700	900	1 090	3 090
c.	**Metal Production**	**19 500**	**19 200**	**18 900**	**17 200**	**17 600**
	Iron and Steel Production	7 060	7 880	7 890	7 040	8 160
	Aluminium Production	9 310	9 160	8 220	7 660	7 280
	SF_6 Used in Magnesium Smelters and Casters	3 110	2 110	2 770	2 490	2 190
d.	**Consumption of Halocarbons and SF_6**	**1 800**	**2 100**	**4 500**	**6 000**	**5 500**
e.	**Other & Undifferentiated Production**	**8 300**	**8 700**	**9 700**	**11 000**	**12 000**
SOLVENT & OTHER PRODUCT USE		**420**	**440**	**460**	**480**	**480**
AGRICULTURE		**45 000**	**49 000**	**51 000**	**53 000**	**55 000**
a.	**Enteric Fermentation**	18 400	21 100	21 700	22 600	24 000
b.	**Manure Management**	6 700	7 400	7 800	8 100	8 400
c.	**Agricultural Soils**	20 000	21 000	22 000	22 000	22 000
	Direct Sources	11 000	11 000	11 000	11 000	12 000
	Pasture, Range, and Paddock Manure	3 200	3 700	3 900	4 000	4 300
	Indirect Sources	6 000	6 000	6 000	6 000	7 000
WASTE		**25 000**	**26 000**	**28 000**	**29 000**	**29 000**
a.	**Solid Waste Disposal on Land**	23 000	25 000	27 000	27 000	27 000
b.	**Wastewater Handling**	1 100	1 100	1 200	1 200	1 200
c.	**Waste Incineration**	400	330	250	240	250
LAND USE, LAND-USE CHANGE AND FORESTRY		**-82 000**	**190 000**	**-130 000**	**-11 000**	**81 000**
a.	**Forest Land**	-110 000	180 000	-140 000	-20 000	73 000
b.	**Cropland**	14 000	7 000	3 100	830	58
c.	**Grassland**	-	-	-	-	-
d.	**Wetlands**	6 000	3 000	2 000	1 000	1 000
e.	**Settlements**	8 000	7 000	7 000	7 000	7 000

[1]National totals exclude all GHGs from the Land Use, Land-Use Change and Forestry Sector.
[2] Emissions from fuel ethanol are reported within the gasoline transportation subcategories.
[3] The category mineral product use includes CO_2 emissions from the use of limestone & dolomite, soda ash, and magnesite.
Note: Totals may not add due to rounding.

Table 3.3.2: HFCs, PFCs and SF_6 Emissions Trends, 1990 to 2004

HFCs, PFCs and SF_6	1990	2004	Change
	kt CO_2 eq.		%
Emissions of HFCs	NO	**4 677.95**	**–**
Emissions of PFCs	**6 538.83**	**3 056.65**	**–53.25**
Emissions of SF_6	**4 996.16**	**3 024.36**	**–39.47**

NO - Not Occurring

Table 3.3.3: Canada's GHG Emissions and Economic Variables, 1990–2004

Year	1990	1995	2000	2003	2004
Total GHG (Mt)	**599**	**649**	**725**	**754**	**758**
Growth Since 1990	*N/A*	*8.3%*	*21.1%*	*25.9%*	*26.6%*
Annual Change	*N/A*	*2.8%*	*3.8%*	*3.9%*	*0.6%*
Average Annual Change	*N/A*	*1.7%*	*2.1%*	*2.0%*	*1.9%*
GDP - Expense[1]	**712 019**	**773 355**	**946 014**	**1 012 635**	**1 045 643**
Growth Since 1990	*N/A*	*8.6%*	*32.9%*	*42.2%*	*46.9%*
Annual Change	*N/A*	*2.7%*	*5.5%*	*2.4%*	*3.3%*
Average Annual Change	*N/A*	*1.7%*	*3.3%*	*3.2%*	*3.3%*
GHG Intensity (Mt/$B GDP)	**0.84**	**0.84**	**0.77**	**0.744**	**0.725**
Growth Since 1990	*N/A*	*-0.3%*	*-8.9%*	*-11.5%*	*-13.8%*
Annual Change	*N/A*	*0.1%*	*-1.6%*	*1.5%*	*-2.6%*
Average Annual Change	*N/A*	*-0.1%*	*-0.9%*	*-0.9%*	*-1.0%*
GHG Efficiency ($GDP/kt GHG)	**1.19**	**1.19**	**1.30**	**1.343**	**1.379**
Growth Since 1990	*N/A*	*0.3%*	*9.7%*	*13.0%*	*16.0%*
Annual Change	*N/A*	*-0.1%*	*1.6%*	*-1.5%*	*2.7%*
Average Annual Change	*N/A*	*0.1%*	*1.0%*	*1.0%*	*1.1%*
Population (000s)[2]	**27 698**	**29 302**	**30 689**	**31 660**	**31 946**
Growth Since 1990	*N/A*	*5.8%*	*10.8%*	*14.3%*	*15.3%*
Annual Change	*N/A*	*1.0%*	*0.9%*	*0.9%*	*0.9%*
Average Annual Change	*N/A*	*1.2%*	*1.1%*	*1.1%*	*1.1%*
GHG Per Capita (tonnes/person)	**21.6**	**22.1**	**23.6**	**23.81**	**23.73**
Growth Since 1990	*N/A*	*2.4%*	*9.3%*	*10.1%*	*9.7%*
Annual Change	*N/A*	*1.8%*	*2.9%*	*2.9%*	*-0.3%*
Average Annual Change	*N/A*	*0.5%*	*0.9%*	*0.8%*	*0.7%*
Energy Use (PJ)[3]	**9 230**	**9 695**	**10 830**	**11 479**	**11 618**
Growth Since 1990	*N/A*	*5.0%*	*17.3%*	*24.4%*	*25.9%*
Annual Change	*N/A*	*1.4%*	*3.0%*	*3.6%*	*1.2%*
Average Annual Change	*N/A*	*1.0%*	*1.7%*	*1.9%*	*1.8%*
Energy Produced (PJ)[4]	**7 746**	**10 299**	**11 729**	**12 492**	**12 784**
Growth Since 1990	*N/A*	*33.0%*	*51.4%*	*61.3%*	*65.0%*
Annual Change	*N/A*	*4.6%*	*3.8%*	*1.3%*	*2.3%*
Average Annual Change	*N/A*	*6.6%*	*5.1%*	*4.7%*	*4.6%*
Net Energy Exported (PJ)[4]	**1 769**	**4 056**	**4 851**	**4 958**	**5 172**
Growth Since 1990	*N/A*	*129.2%*	*174.2%*	*180.2%*	*192.3%*
Annual Change	*N/A*	*14.8%*	*6.1%*	*-6.3%*	*4.3%*
Average Annual Change	*N/A*	*25.8%*	*17.4%*	*13.9%*	*13.7%*
Emissions Associated with Net Exports (Mt)[4]	**21.5**	**42.9**	**47.5**	**46.2**	**47.8**
Growth Since 1990	*N/A*	*99.5%*	*121.0%*	*115.1%*	*122.6%*
Annual Change	*N/A*	*17.9%*	*4.7%*	*-9.6%*	*3.5%*
Average Annual Change	*N/A*	*19.9%*	*12.1%*	*8.9%*	*8.8%*

PJ = petajoule. A petajoule is a measure of the energy content of fuels.

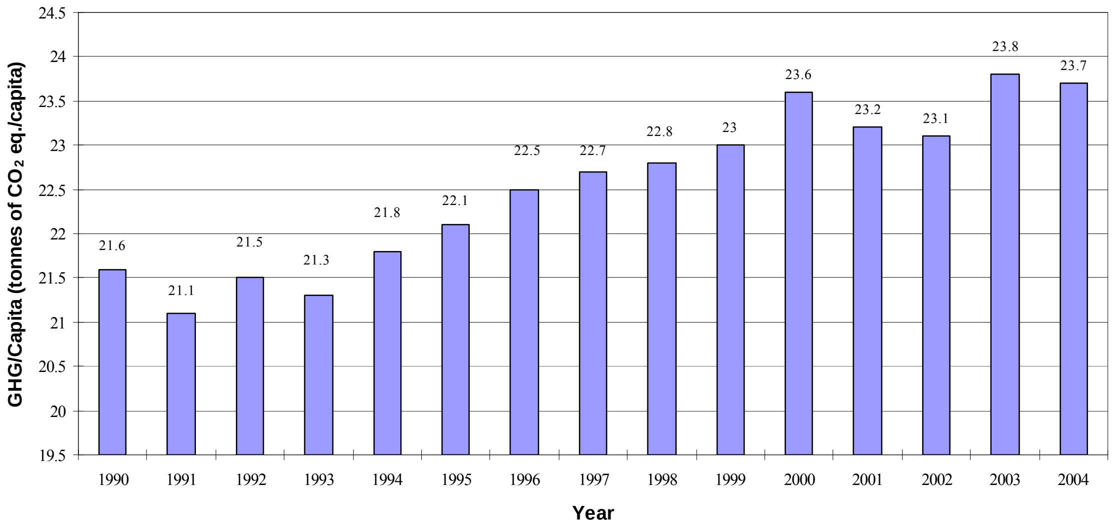
[1] GDP, expenditure-based (million 1997 chained dollars), Informetrica, January 11, 2006.

[2] Source: Statistics Canada, Demographic Statistics 2003, Catalogue Number 91-213-XPB

[3] Statistics Canada (2004), #57-003, Table S, Line 2 - Availability, Total Primary.

[4] Natural gas and crude oil only.

Figure 3.3.3: Trend in Canada's Per Capita GHG Emissions, 1990-2004



3.4 GREENHOUSE GAS TRENDS BY UNFCCC SECTOR 1990-2004

In Canada, between 1990 and 2004, emissions in all of the UNFCCC sectors increased (Table 3.4.1). Since 1990, growth in emissions has resulted primarily from Electricity and Heat Generation and areas such as Fossil Fuel Industries, Mining, Transportation, Consumption of Halocarbons and SF_6, Enteric Fermentation, and Waste. There have been overall decreases in Manufacturing Industries and Construction (excluding Mining), the Chemical Industry, and Metal Production.

Table 3.4.1: Canada's GHG Emission Trends by UNFCCC Sector, 1990-2004

UNFCCC Sectors	1990 *Mt CO_2 eq.*	2004 *Mt CO_2 eq.*	Change 1990 to 2004 *Mt CO_2 eq.*	Change 1990 to 2004 *(%)*
1. Energy	475	620	144.0	30.3
2. Industrial Processes	53.3	54.3	1.0	1.9
3. Solvent and Other Product Use	0.42	0.48	0.06	15.3
4. Agriculture	45	55	10.1	22.6
5. LULUCF	-82	81	162.6	198.9
6. Waste	25	29	4.0	15.9
Totals (NOT including LULUCF)	**599**	**758**	**159.2**	**26.6**

Note: Totals may not add due to rounding.

3.4.1 Energy

2004 GHG Emissions, 620 Mt

The largest portion of the growth in GHG emissions/removals from 1990 to 2004 inclusive is observed in the Energy sector (Table 3.4.1.1).

In terms of relative growth, fugitive emissions from Oil and Natural Gas (including production, processing, transmission, and distribution activities) have increased faster than any other category in the Energy Sector — between 1990 and 2004, they rose by 58%.

Table 3.4.1.1: Energy Sector Emissions, 1990-2004

GHG Sources	GHG Emissions				
	1990	1995	2000	2003	2004
	(Mt CO_2 eq.)				
1. Energy	**475**	**517**	**596**	**622**	**620**
A. Fuel Combustion	**432**	**460**	**531**	**556**	**553**
(Sectoral Approach)					
1. Energy Industries	148	157	202	216	209
2. Manufacturing Industries and Construction	63.0	62.1	64.6	66.5	67.7
3. Transport	150	160	180	190	190
4. Other Sectors	72	77	81	85	83
B. Fugitive Emissions	**43.3**	**57.0**	**64.9**	**66.2**	**66.5**
1. Solid Fuels (Coal)	2	2	1	1	1
2. Oil and Natural Gas	41.4	55.3	64.0	65.2	65.5

A. Fuel Combustion Activities

A.1 Energy Industries – 2004 GHG Emissions, 209 Mt

In 2004, combustion emissions from the Energy Industries category totalled 209 Mt, an increase of 41% from the 1990 level of 148 Mt (Table 3.4.1.2). This UNFCCC subsector comprises emissions from the Public Electricity and Heat Production, Petroleum Refining, and the Manufacture of Solid Fuels and Other Energy Industries subsectors.

Table 3.4.1.2: Energy Industries GHG Contribution

GHG Source Category	GHG Emissions		
	1990	2003	2004
	(kt CO_2 eq.)		
Energy Industries TOTAL	**148 000**	**216 000**	**209 000**
Public Electricity and Heat Production	**95 300**	**139 000**	**130 000**
Electricity Generation — Utilities	92 400	133 000	124 000
Electricity Generation— Industry	2 200	4 650	4 300
Heat/Steam Generation	700	1 700	2 000
Petroleum Refining (including oil sands upgrading activities)	**23 000**	**30 000**	**29 000**
Manufacture of Solid Fuels and Other Energy Industries	**30 000**	**47 000**	**49 000**

A.1.i Public Electricity and Heat Production - 2004 GHG Emissions, 130 Mt

This category accounted for 17% (130 Mt) of Canada's 2004 GHG emissions and was responsible for 22% of the total emissions growth between 1990 and 2004 — more than any other category in the national inventory. Overall, emissions increased 37%, or almost 35 Mt, since 1990 (Table 3.4.1.2).

Hydroelectric and coal-fired generation continue to be the major sources of Canadian electricity, accounting for 58.6% and 16.5%, respectively, of national electricity generation in 2004. Nuclear energy provided 14.8% of the generated electricity, followed by natural gas with 5.2% and oil with 3.4%. In comparison, in 1990, coal accounted for 16.4% of Canadian electricity generation, oil 3.1%, natural gas 1.9%, nuclear energy 14.7%, and hydro 62.9%. Total annual electricity generation increased by 23% between 1990 and 2004. This rate of growth exceeds the population growth rate of 15.3% for the same period, pointing to an increase in demand from economic sectors that depend on electric power and an ever-growing number of electrical appliances.

Contributions from both nuclear and hydro generation declined in the latter part of the 1990s, when nuclear facilities in Ontario were decommissioned for maintenance and refurbishment. The peak production was in 1994, and the low was in 1998. Since then, nuclear generation has been brought back into service in Ontario, and new hydroelectric capacity has been added throughout the country. Between 1998 and 2004, there was a 26% increase in the amount of electricity from nuclear generation. Hydroelectric generation increased nearly 15% from 1990 to 2004.

A.1.ii Petroleum Refining - 2004 Net Emissions, 29 Mt

The Petroleum Refining subsector includes emissions from the combustion of fossil fuels during the production of refined petroleum products. In 2004 GHG emissions from the Petroleum Refining subsector totalled approximately 29 Mt.

A.1.iii Manufacture of Solid Fuels and Other Energy Industries - 2004 Net Emissions, 49 Mt

The Manufacture of Solid Fuels and Other Energy Industries subsector encompasses fuel combustion emissions associated with the upstream oil and gas industry (including upgrading of bitumen to synthetic crude oil). In 2004 GHG emissions totalled about 49 Mt from this subsector.

Between 1990 and 2004, combined emissions from the Petroleum Refining and the Manufacture of Solid Fuels and Other Energy Industries subsectors increased by about 26 Mt, or 49%. This growth is due to increases in oil and natural gas production, largely for export.

A.2 Manufacturing Industries and Construction - 2004 GHG Emissions, 67.7 Mt

Emissions from the Manufacturing Industries and Construction subsector include the combustion of fossil fuels by the iron and steel, non-ferrous metals, chemicals, cement, pulp, paper and print, construction, mining, and all other manufacturing industries.

In 2004, GHG emissions were 67.7 Mt, an increase of 7% from the 1990 level of 63 Mt; over the short term (2003–2004), emissions increased by 2%. Overall, this subsector was responsible for 8.9% of Canada's total GHG emissions for 2004.

Mining showed a large increase in emissions between 1990 and 2004 — 9.2 Mt (about 149%), when excluding the portion related to oil sands activities — on the basis of a 48% growth in sector GDP.

A.3 Transport - 2004 GHG Emissions, 190 Mt

Transport is a large and diverse subsector that includes emissions from fuel combustion for the transport of passengers and freight in five subcategories: Civil Aviation, Road Transportation, Railways, Navigation (Domestic Marine), and Other Transportation. The Other Transportation subsector includes off-road ground transport e.g., construction or agriculture vehicles and both oil and gas Pipelines.

From 1990 to 2004, GHG emissions from transport, driven primarily by energy used for personal transportation, rose 30%, or over 40 Mt. Overall, Transport was the second largest emissions-producing category in 2004, contributing 190 Mt and accounting for 28% of Canada's emissions growth from 1990 to 2004.

Emissions from Light-Duty Gasoline Trucks (LDGTs), the subcategory that includes SUVs, pickups, and vans, increased 101% between 1990 and 2004 (from 22 Mt in 1990 to 44 Mt in 2004), while emissions from cars (LDGVs) decreased 7.4% (from 54 Mt in 1990 to 50 Mt in 2004) (Table 3.4.1.3). The growth in road transport emissions is due not only to the 24% increase in the total vehicle fleet, but also to a shift in light-duty vehicle purchases from cars (LDGVs) to trucks (LDGTs), which, on average, emit 40% more GHGs per kilometre.

Table 3.4.1.3: GHG Emissions from Transport, 1990–2004

GHG Source Category	GHG Emissions (kt CO_2 eq.)		
	1990	**2003**	**2004**
Transport TOTAL	**150 000**	**190 000**	**190 000**
Civil Aviation	**6 400**	**7 300**	**7 800**
Road Transport	**107 000**	**140 000**	**145 000**
Light-Duty Gasoline Vehicles	53 800	49 400	49 800
Light-Duty Gasoline Trucks	21 700	41 900	43 600
Heavy-Duty Gasoline Vehicles	3 140	4 140	4 210
Motorcycles	230	226	219
Light-Duty Diesel Vehicles	672	722	768
Light-Duty Diesel Trucks	591	796	893
Heavy-Duty Diesel Vehicles	24 500	42 300	44 900
Propane & Natural Gas Vehicles	2 200	820	870
Railways	**7 000**	**6 000**	**6 000**
Navigation (Marine)	**5 000**	**6 100**	**6 600**
Other Transport	**20 000**	**30 000**	**30 000**
Off-Road Gasoline	5 000	4 000	4 000
Off-Road Diesel	10 000	10 000	20 000
Pipelines	6 900	9 110	8 520

Note: Totals may not add due to rounding.

In 2004, emissions from Heavy-Duty Diesel Vehicles (HDDVs) contributed 45 Mt to Canada's total GHG emissions (an increase of 83% from 1990 emissions). Emissions from heavy-duty gasoline vehicles (HDGVs) were substantially lower, at 4 Mt for 2004, but this figure represents an increase of 34% over the 1990 level.

The pipeline emissions included in the Transport subsector are combustion emissions primarily from natural gas transport. Due to increasing activity in the Energy Sector, these emissions rose 24%, from 6.9 Mt in 1990 to 8.5 Mt in 2004.

A.4 Other Sectors - 2004 GHG Emissions, 83.2 Mt

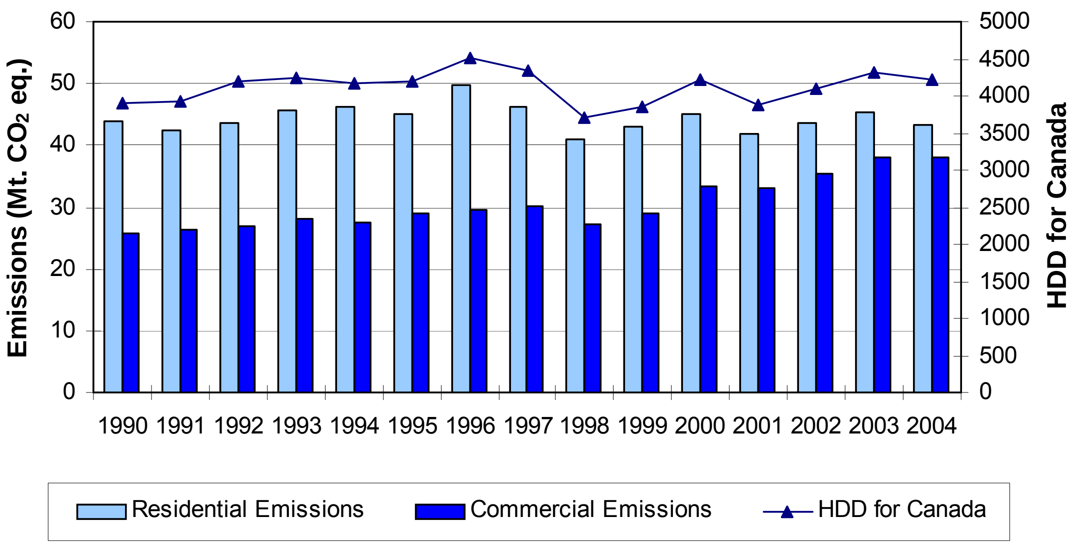
The Other Sectors subsector comprises fuel combustion emissions from the residential and commercial categories, as well as stationary fuel combustion emissions from the agriculture and forestry category.[9] Overall, this subsector exhibited increases in GHG emissions of 15% from 1990 to 2004, while individual subcategories within it demonstrated a variety of changes (Table 3.4.1.1).

[9] The UNFCCC Other Sectors category comprises the following NIR sectors: *Residential*, *Commercial and Institutional*, and *Other* (listed under energy, fuel combustion in Annex 8).

Fuel combustion in the Residential and Commercial/Institutional categories accounted for 5.7% (43 Mt) and 5.0% (38 Mt), respectively, of all GHG emissions in 2004. As shown in Figure 3.4.1.1, residential emissions have remained fairly constant between 1990 and 2004, decreasing 0.8 Mt or 1.8% over this period. In the short term, emissions decreased by 2.2 Mt or 4.8% between 2003 and 2004. Commercial/Institutional emissions increased 12 Mt or 47% between 1990 and 2004. The combined effect between 1990 and 2004 for the two categories was an increase of 11 Mt, or 16%.

GHG emissions, particularly in the residential sector, track heating degree-days (HDDs) closely.[10] This close tracking indicates the important influence of weather on space heating requirements and therefore on the demands for natural gas, home heating oil, and biomass fuels. Between 2003 and 2004, there was a 2.3% decrease in HDDs below 18.0°C (Statistics Canada, 2005).

Figure 3.4.1.1: Residential and Commercial Emissions Relative to HDDs, 1990–2004*



*HDDs - heating degree-days

[10] HDDs are calculated by determining the average number of days across Canada where the temperature is below 18ºC and multiplying this value by the corresponding number of degrees below this temperature.

This subsector also includes emissions from stationary fuel combustion in the agricultural, forestry, and fisheries industries. However, emission estimates are included for the Agriculture and Forestry portion of the subsector only. Fishery emissions are reported in either the Transport or Manufacturing Industries and Construction (i.e., Food Processing, Beverages and Tobacco) subsectors. Mobile emissions associated with this subsector were not disaggregated and are included as off-road or marine emissions reported under Transport. Emissions are based on fuel-use data reported for agriculture and forestry (Statistics Canada, 2003-2).

Stationary fuel combustion–related emissions from the Agriculture and Forestry category amounted to 2.1 Mt in 2004, a decrease of 13% since 1990. Emissions decreased 4.9% between 2003 and 2004.

B. Fugitive Emissions from Fuels – 2004 GHG Emissions, 66.5 Mt

Fugitive emissions from fossil fuels are the intentional or unintentional releases of GHGs from the production, processing, transmission, storage, and delivery of fossil fuels. Released gases that are combusted before disposal (e.g., flaring of natural gases at oil and gas production and processing facilities) are also considered fugitive emissions.

The UNFCCC separates these fugitive emissions into those associated with Solid Fuels (Coal Mining and Handling and Solid Fuel Transformation) and activities related to the Oil and Natural Gas. The Oil and Natural Gas subsector is further divided into Oil, Natural Gas, and the Venting and Flaring subsectors.

In total, fugitive emissions grew by about 53% between 1990 and 2004, from 43.3 Mt to 66.5 Mt, with emissions from the Oil and Natural Gas category contributing 98% of the total fugitive emissions in 2004, far overshadowing the 2% contribution from coal mining. Although fugitive releases from the solid fuels category (i.e., Coal Mining) decreased by almost 1 Mt (over 48%) between 1990 and 2004 due to the closing of many mines in eastern Canada, emissions from oil and natural gas increased 58% during the same period.

This rise in emissions is a result of the increased production of natural gas and heavy oil since 1990, largely for export to the United States. Since 1990, there has been a 192% increase in the net energy exported from Canada, accompanied by a 123% increase in GHG emissions associated with those net energy exports.

3.4.2 Industrial Processes

2004 GHG Emissions, 54.3 Mt

The Industrial Processes Sector includes GHG emissions that are direct by-products of processes, including Mineral Production, Chemical Industry, Metal Production, Consumption of Halocarbons and SF_6, and Other and Undifferentiated Production (Table 3.4.2.1).

Table 3.4.2.1: GHG Emissions from Industrial Processes, 1990–2004

GHG Source Category	GHG Emissions				
	1990	1995	2002	2003	2004
	(Mt CO_2 eq.)				
Industrial Processes (Total)	**53.3**	**55.5**	**48.3**	**50.1**	**54.3**
Mineral Production	**8.3**	**8.8**	**9.0**	**9.1**	**9.5**
Cement	5.4	6.1	6.7	6.8	7.1
Lime	2	2	2	2	2
Limestone and Dolomite Use	0.73	0.53	0.30	0.28	0.29
Soda Ash Use	0.21	0.20	0.17	0.14	0.15
Magnesite Use	0.15	0.15	0.18	0.19	0.19
Chemical Industry	**15**	**17**	**6.8**	**7.0**	**9.6**
Ammonia Production	3.9	5.3	4.8	5.1	5.7
Nitric Acid Production	0.78	0.78	0.81	0.81	0.83
Adipic Acid Production	10.7	10.7	1.25	1.09	3.09
Metal Production	**19.5**	**19.2**	**17.5**	**17.2**	**17.6**
Iron and Steel Production	7.06	7.88	7.11	7.04	8.16
Aluminium Production	9.31	9.16	7.46	7.66	7.28
Magnesium Production	2.87	1.88	2.7	2.2	2.0
Magnesium Casting	0.24	0.23	0.26	0.26	0.19
Consumption of Halocarbons	**0**	**0.51**	**4.0**	**4.4**	**4.7**
SF_6 Use in Electric Utilities and Semiconductors	**1.8**	**1.6**	**1.0**	**1.6**	**0.81**
Other & Undifferentiated Production	**8.3**	**8.7**	**9.9**	**11**	**12**

As shown in Table 3.4.2.1, the GHG emissions from the Industrial Processes Sector contributed 54 Mt to the 2004 national GHG inventory, as compared with 53 Mt in 1990. These emissions represented 7% of the total Canadian GHG emissions in 2004. The overall increase of 1.9% (as compared with the 1990 level) in this sector could be explained by significant emission growths in four categories: consumption of halocarbons, other and undifferentiated production, ammonia production, and cement production.

Emissions from HFC consumption were considered negligible for the period 1990–1994. However, since the Montreal Protocol came into effect in 1996, the progressive replacement of chlorofluorocarbons (CFCs) by HFCs has resulted in an upward trend in HFC emissions.

The use of fuels such as butane and ethane for non-energy purposes (i.e., use as feedstock) has also considerably increased over the years. This has caused an important emission growth of 45% from 1990 to 2004 for the category of other and undifferentiated production.
For cement production, the expansion in clinker production capacity may explain the emission increase of 31% from 1990 to 2004. The rise in ammonia production volume justifies by and large the emission growth of 44% that this industry has experienced since 1990.

Although an overall increase from the 1990 level was observed in 2004, some categories in the Industrial Processes Sector showed noticeable emission reductions. From 1990 to 2004, emissions coming from limestone and dolomite use, adipic acid production, aluminium production, magnesium smelting, and magnesium casting dropped by 60%, 71%, 22%, 30%, and 18%, respectively.

3.4.3 Solvent and Other Product Use

2004 GHG Emissions, 0.48 Mt

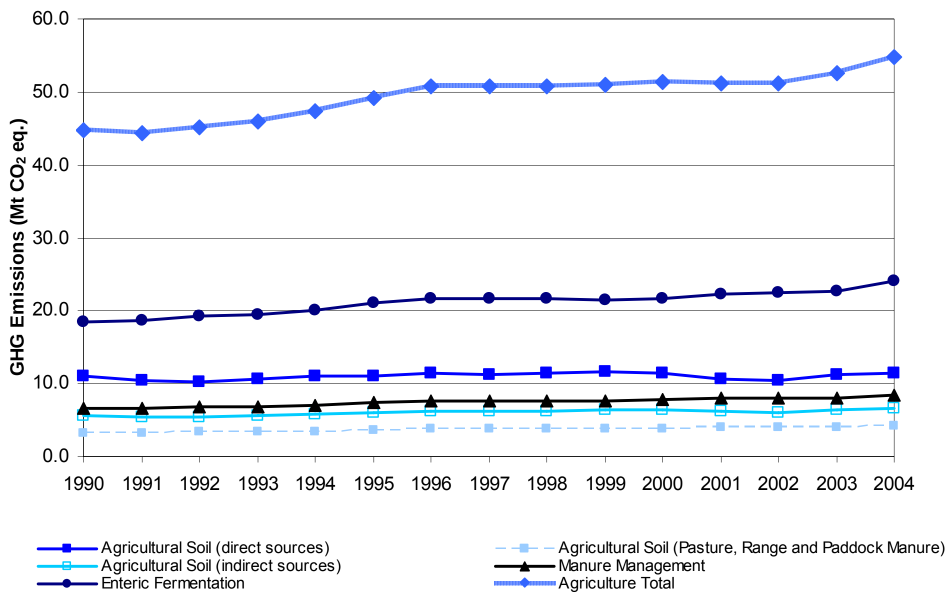
The Solvent and Other Product Use Sector accounts for emissions related to the use of N_2O as an anaesthetic in medical applications and as a propellant in aerosol products. It contributed 480 kt CO_2 eq. to the 2004 national GHG inventory, as compared with 420 kt CO_2 eq. in 1990 (Table 3.4.1). Although the emissions coming from this sector represented less than 1% of the total Canadian GHG emissions in 2004, they were 15% and 1% above their 1990 and 2003 levels, respectively.

3.4.4 Agriculture

2004 GHG Emissions, 55 Mt

Agricultural emissions accounted for 55 Mt or 7.2% of total 2004 GHG emissions for Canada, an increase of 10 Mt since 1990 (Table 3.3.1 and Table 3.4.1). All these emissions are from non-energy sources, with N_2O accounting for 50.5% of sectoral emissions and CH_4 for 49.5% in 2004.

Figure 3.4.4.1: GHG Emissions from Agricultural Sources, 1990 to 2004



In the period from 1990 to 2004, enteric emissions increased by 30%, emissions from manure management systems by 26%, and soil N_2O emissions by 14% (Figure 3.4.4.1). These increases result mainly from the expansion of the beef cattle, swine, and poultry industry, as well as the increase in consumption of synthetic nitrogen fertilizer.

Between 2003 and 2004, there was a noticeable increase in agricultural emissions, amounting to 2 Mt. Most of this increase resulted from enteric fermentation, manure applied as fertilizers to cropland, manure on pasture, and animal waste management systems (AWMS), primarily because of a significant increase in the beef cattle population (about 8% increase from 2003 to 2004).

3.4.5 Waste

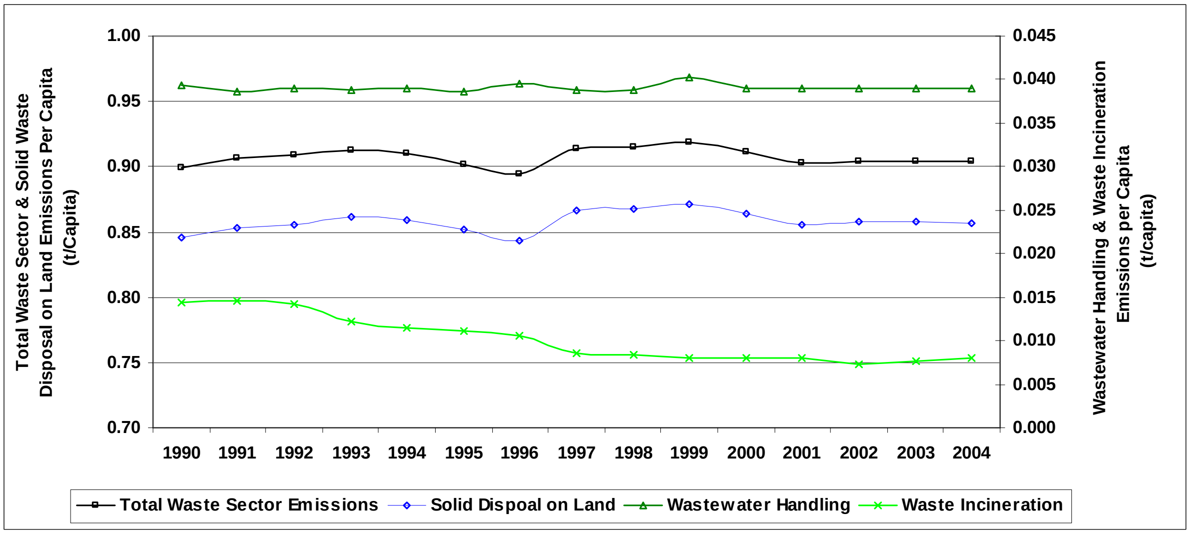
2004 GHG Emissions, 29 Mt

In 2004, the GHG emissions from the Waste Sector contributed 29 Mt to the national inventory as compared with 25 Mt for 1990, representing an increase of 16%. The emissions from this sector represented 3.8% and 4.2% of the overall Canadian GHG emissions in 2004 and 1990, respectively.

Of the 29 Mt total emissions from this sector in 2004, solid waste disposal on land, which includes municipal solid waste (MSW) landfills and wood waste landfills, accounted for 27 Mt. CH_4 emissions produced by the decomposition of biomass in MSW were responsible for 95% of the emissions from this sector.

Emissions from municipal wastewater treatment and incineration of waste (excluding emissions from incineration of biomass material) contributed 1.2 Mt and 0.25 Mt, respectively, to the total from the Waste Sector.

Figure 3.4.5.1: Per Capita GHG Emission Trend – Waste, 1990 to 2004



Methane emissions from MSW landfills increased by 18% between 1990 and 2004, despite an increase in landfill gas capture and combustion of 48% over the same period. The quantity of CH_4 captured in 2004 was assumed to be the same as the 2003 value.

Per capita emissions from the Waste Sector increased 0.5% from 1990 to 2004 due primarily to increasing emissions from landfills. The decline in the growth of emissions per capita observed in the mid-1990s, shown in Figure 3.4.5.1, is directly attributable to CH_4 capture at landfills and waste diversion programs. However, in 1997, there was a reduction in landfill gas collection, which was followed by an increase in 2000. These changes have an inversely proportional influence on the emissions per capita, which is apparent in Figure 3.4.5.1.

3.4.6 Land Use, Land-Use Change and Forestry

2004 Net GHG Emissions, 81 Mt

The LULUCF Sector reports GHG fluxes between the atmosphere and Canada's managed lands, as well as those associated with land-use changes. The LULUCF UNFCCC categories include the Forest Land, Cropland, Grassland, Wetlands, Settlements, Other Land, and Other subsectors.

The net LULUCF flux, calculated as the sum of CO_2 emissions and removals and non-CO_2 emissions, displays high interannual variability over the reporting period. In 2004, this net flux amounted to emissions of 81 Mt (Table 3.4.6.1 and Figure 3.4.6.1).

All emissions and removals in the LULUCF Sector are excluded from the national totals. In 2004, the estimated 81 Mt would, if included, increase the total Canadian GHG emissions by 11%.

The Forest Land category includes GHG emissions to and removals from Canada's managed forests. This category displays the highest interannual variability and exerts an overriding influence on the net sectoral GHG balance and trend. The net GHG flux reflects the difference between carbon uptake by tree growth and emissions due to anthropogenic and natural disturbances, specifically forest management activities, wildfires, and insect infestations. The high variability in the net flux from managed forests is associated with the immediate impact of wildfires, which alone accounted for annual emissions between 14 and 342 Mt over the period from 1990 to 2004.

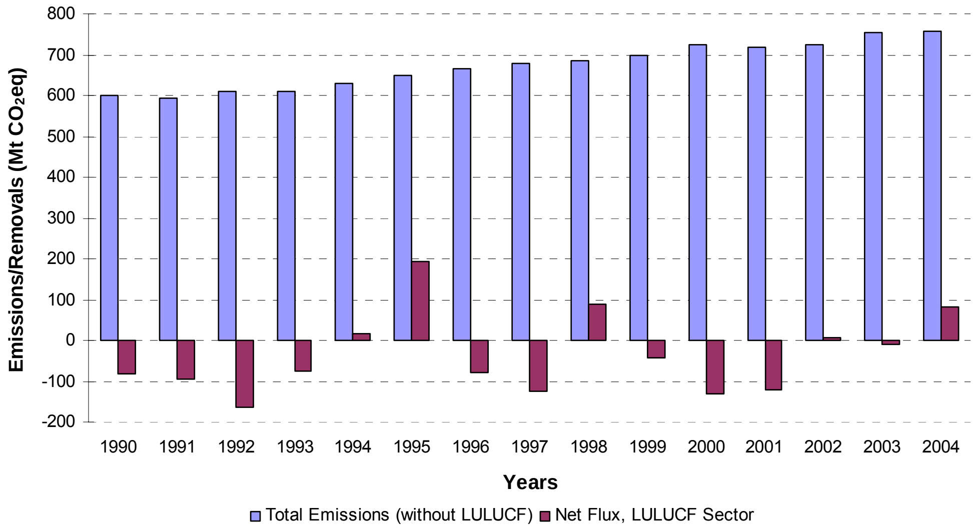
Both short- and long-term trends should therefore be interpreted with caution, given that the sector as a whole retains the important interannual variability resulting from large fluctuations in the severity of the fire season, with an additional random effect due to the location of fires with respect to managed forests (as opposed to non-managed). The largest carbon fluxes to and from managed forests consist of carbon uptake by growing trees and its release due to the decay of organic matter (respectively −3200 and 2900 Mt in 2004). These large, opposite fluxes more or less balance each other throughout the 15 years covered by this assessment. Forest management activities account for annual average emissions of 122 Mt. In spite of the large uncertainties attached to LULUCF estimates, the fluctuating pattern illustrates how the interplay of natural disturbances and management activities ultimately affects the net GHG balance in this sector.

Table 3.4.6.1: LULUCF Sector Net GHG Flux Estimates

Sectoral Category	Net GHG Flux		
	1990	**2003**	**2004**
		(kt CO_2 eq.)	
Land Use, Land-Use Change and Forestry TOTAL[1]	**−82 000**	**−11 000**	**81 000**
a. Forest Land	**−110 000**	**−20 000**	**73 000**
Forest Land Remaining Forest Land	−110 000	−19 000	74 000
Land Converted to Forest Land	−1 300	−1 200	−1 200
b. Cropland	**14 000**	**830**	**58**
Cropland Remaining Cropland	−2 300	−8 500	−9 000
Land Converted to Cropland	16 000	9 300	9 100
c. Grassland			
Grassland Remaining Grassland	NE	NE	NE
Land Converted to Grassland	NE	NE	NE
d. Wetlands	**6 000**	**1 000**	**1 000**
Wetlands Remaining Wetlands	80	100	100
Lands Converted to Wetlands	6 000	1 000	1 000
e. Settlements	**8 000**	**7 000**	**7 000**
Settlements Remaining Settlements	−100	−200	−200
Land Converted to Settlements	8 000	7 000	7 000
Forest conversion (memo item)[2]	28 000	17 000	16 000
Grassland conversion (memo item)[2,3]	800	600	500

1 Totals may not add up due to rounding.
2 Already included in lands converted to cropland, wetlands, and settlements.
3 Conversion of non-agricultural grassland (tundra).
NE = Not estimated

Figure 3.4.6.1: Net fluxes from LULUCF Sector in comparison with national total emissions, 1990 to 2004



3.5 UNCERTAINTIES

Uncertainty estimates are an essential element of a comprehensive emissions inventory. Assigning uncertainty levels to the data does not impugn the validity of the inventory estimates but helps to indicate a level of priority regarding efforts to improve the accuracy of the inventory and to guide decisions regarding the choice of methods.

Canada's GHG inventory level uncertainty currently falls within a range of −3% to +6% for all GHGs combined without consideration of the uncertainty within the GWPs. With GWP uncertainty considered, the overall uncertainty falls within a range of −5% to +10%. This compares with other Annex 1 Parties' reported uncertainties and reflects the range of uncertainties that such countries would see in their inventories.

In regards to the particular gases, N_2O exhibits the highest uncertainty range in the national inventory, with a range of −8% to +80%, followed by HFCs, with a range of −22% to +60%. CO_2 exhibits an uncertainty of −4% to 0%. The overall Canadian inventory uncertainty estimate falls within the range of the uncertainties reported by other Annex 1 countries. The use of IPCC default uncertainty ranges in certain categories (e.g., uncertainty associated with national cement production, with a value of 35%) is believed to have generated a larger uncertainty range for the overall inventory. In the coming years, the overall uncertainty estimates should be improved further once national uncertainty ranges for certain variables are obtained.

3.6 REFERENCES

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ANNEX 3.1: SELECTED COMMON REPORTING FORMAT TABLES

For purposes of consistency, the following CRF tables have been adapted such that emissions/removals of all gases are treated in a similar manner when comparing totals with and without LULUCF.

Table A3.1.1 Emissions Trends (CO_2)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**429,760.67**	**420,243.96**	**434,435.22**	**432,759.17**	**446,758.75**	**458,908.75**	**471,083.88**	**482,424.32**	**491,291.90**	**505,756.31**
A. Fuel Combustion (Sectoral Approach)	419,209.79	409,581.67	423,194.61	420,584.93	433,494.10	444,498.46	455,750.94	467,137.09	474,283.18	490,561.03
1. Energy Industries	145,494.63	145,083.56	153,681.55	145,390.02	148,563.05	154,356.35	153,708.06	161,743.76	177,083.29	185,520.14
2. Manufacturing Industries and Construction	62,368.38	58,523.55	57,809.33	57,494.89	60,676.84	61,495.22	64,201.05	64,337.60	61,110.98	60,917.78
3. Transport	141,931.48	137,153.80	140,612.81	143,818.44	150,764.79	154,691.67	158,367.09	164,480.11	168,004.15	172,295.94
4. Other Sectors	69,415.30	68,820.75	71,090.92	73,881.57	73,489.42	73,955.22	79,474.73	76,575.63	68,084.77	71,827.18
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	10,550.88	10,662.29	11,240.61	12,174.24	13,264.65	14,410.29	15,332.94	15,287.23	17,008.72	15,195.27
1. Solid Fuels	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
2. Oil and Natural Gas	10,550.88	10,662.29	11,240.61	12,174.24	13,264.65	14,410.29	15,332.94	15,287.23	17,008.72	15,195.27
2. Industrial Processes	**30,302.81**	**31,387.36**	**31,548.98**	**32,091.53**	**32,678.02**	**34,307.51**	**35,083.11**	**35,947.23**	**35,382.34**	**36,368.55**
A. Mineral Products	8,275.73	7,311.98	7,362.40	7,200.25	8,056.41	8,807.23	8,435.22	8,981.74	9,129.57	9,455.34
B. Chemical Industry	3,941.71	3,896.34	4,151.98	4,509.94	4,472.26	5,261.82	5,430.03	5,299.27	5,326.41	5,429.18
C. Metal Production	9,773.05	11,462.81	11,772.61	12,090.39	11,308.11	11,520.84	11,608.09	11,477.54	11,662.10	11,839.48
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	8,312.32	8,716.23	8,261.99	8,290.96	8,841.24	8,717.62	9,609.77	10,188.66	9,264.26	9,644.56
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry[(2)]	**-87,394.63**	**-105,606.29**	**-165,190.42**	**-86,424.82**	**-5,808.34**	**155,961.82**	**-85,469.90**	**-127,476.30**	**64,054.65**	**-54,941.52**
A. Forest Land	-114,270.29	-131,168.59	-187,489.31	-106,786.04	-23,412.38	139,335.87	-101,219.16	-142,870.48	49,776.43	-68,496.63
B. Cropland	13,321.77	12,210.97	11,093.48	9,417.33	8,126.59	6,761.37	5,918.52	5,507.61	4,836.98	3,958.35
C. Grassland	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO
D. Wetlands	5,545.54	5,195.71	3,420.17	3,204.03	2,153.46	2,612.92	2,414.39	2,373.44	2,416.12	2,397.77
E. Settlements	8,008.34	8,155.62	7,785.25	7,739.86	7,323.99	7,251.66	7,416.34	7,513.13	7,025.12	7,198.99
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
G. Other	NE	NE	NE	NE	NE	IE	IE	IE	IE	IE
6. Waste	**267.39**	**271.77**	**260.72**	**242.27**	**230.39**	**220.42**	**212.38**	**206.25**	**202.03**	**196.28**
A. Solid Waste Disposal on Land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Waste-water Handling										
C. Waste Incineration	267.39	271.77	260.72	242.27	230.39	220.42	212.38	206.25	202.03	196.28
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF[(3)]	**372,936.24**	**346,296.79**	**301,054.51**	**378,668.15**	**473,858.82**	**649,398.50**	**420,909.46**	**391,101.49**	**590,930.92**	**487,379.61**
Total CO_2 emissions excluding net CO_2 from LULUCF[(3)]	**460,330.87**	**451,903.09**	**466,244.92**	**465,092.97**	**479,667.16**	**493,436.68**	**506,379.36**	**518,577.79**	**526,876.27**	**542,321.13**
Memo Items:										
International Bunkers	**9,862.58**	**9,304.18**	**9,928.71**	**9,328.02**	**10,135.36**	**10,694.09**	**11,753.93**	**11,930.44**	**12,940.18**	**13,195.98**
Aviation	6,867.77	6,205.65	6,747.90	6,490.28	6,946.48	7,381.65	8,668.41	8,884.48	9,164.46	9,800.67
Marine	2,994.81	3,098.54	3,180.81	2,837.75	3,188.89	3,312.44	3,085.52	3,045.96	3,775.73	3,395.31
Multilateral Operations	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CO_2 Emissions from Biomass	44,495.00	45,309.51	45,428.47	44,602.58	48,650.51	51,008.59	49,164.35	53,061.60	50,267.66	53,876.71

Note: All footnotes for this table are given at the end of Table A3.1.5.

(Table A3.1.1 continued on next page)

Table A3.1.1 Emissions Trends (CO_2) (continued)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
1. Energy	**529,601.33**	**524,042.05**	**532,037.61**	**556,198.12**	**553,249.29**	**28.73**
A. Fuel Combustion (Sectoral Approach)	513,847.45	507,914.48	515,579.29	539,815.25	536,893.99	28.07
1. Energy Industries	198,096.43	201,556.18	201,366.13	212,175.21	204,787.07	40.75
2. Manufacturing Industries and Construction	63,951.28	59,609.12	61,502.82	65,784.89	66,977.93	7.39
3. Transport	173,733.80	172,132.87	174,448.24	179,153.91	184,679.93	30.12
4. Other Sectors	78,065.94	74,616.31	78,262.11	82,701.24	80,449.06	15.90
5. Other	NA	NA	NA	NA	NA	0.00
B. Fugitive Emissions from Fuels	15,753.88	16,127.57	16,458.31	16,382.87	16,355.29	55.01
1. Solid Fuels	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.00
2. Oil and Natural Gas	15,753.88	16,127.57	16,458.31	16,382.87	16,355.29	55.01
2. Industrial Processes	**36,456.12**	**35,695.47**	**35,243.59**	**36,674.08**	**39,641.83**	**30.82**
A. Mineral Products	9,617.76	9,023.66	9,042.59	9,074.89	9,544.61	15.33
B. Chemical Industry	5,361.28	4,822.46	4,774.60	5,083.13	5,659.53	43.58
C. Metal Production	11,791.65	11,481.06	11,532.20	11,621.70	12,385.34	26.73
D. Other Production	NA	NA	NA	NA	NA	0.00
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	9,685.43	10,368.29	9,894.20	10,894.36	12,052.35	44.99
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.00
4. Agriculture						
A. Enteric Fermentation						
B. Manure Management						
C. Rice Cultivation						
D. Agricultural Soils						
E. Prescribed Burning of Savannas						
F. Field Burning of Agricultural Residues						
G. Other						
5. Land Use, Land-Use Change and Forestry[(2)]	**-133,237.28**	**-125,025.22**	**-9,781.45**	**-24,489.97**	**58,863.78**	**-167.35**
A. Forest Land	-145,381.76	-135,330.79	-19,279.00	-33,074.77	51,011.06	-144.64
B. Cropland	2,949.16	1,766.85	1,404.70	617.10	-144.74	-101.09
C. Grassland	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	0.00
D. Wetlands	2,251.86	1,655.40	1,331.18	1,063.13	1,074.40	-80.63
E. Settlements	6,943.47	6,883.32	6,761.67	6,904.58	6,923.05	-13.55
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
G. Other	IE	IE	IE	IE	IE	0.00
6. Waste	**199.92**	**199.95**	**181.40**	**190.50**	**201.49**	**-24.64**
A. Solid Waste Disposal on Land	NA	NA	NA	NA	NA	0.00
B. Waste-water Handling						
C. Waste Incineration	199.92	199.95	181.40	190.50	201.49	-24.64
D. Other	NA	NA	NA	NA	NA	0.00
7. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00**
Total CO_2 emissions including net CO_2 from LULUCF [(3)]	**433,020.10**	**434,912.25**	**557,681.14**	**568,572.74**	**651,956.38**	**74.82**
Total CO_2 emissions excluding net CO_2 from LULUCF [(3)]	**566,257.38**	**559,937.47**	**567,462.59**	**593,062.71**	**593,092.60**	**28.84**
Memo Items:						
International Bunkers	**13,383.50**	**12,628.20**	**11,789.79**	**9,925.22**	**11,326.42**	**14.84**
Aviation	9,937.62	8,915.94	8,974.85	8,302.38	9,349.29	36.13
Marine	3,445.88	3,712.26	2,814.93	1,622.83	1,977.12	-33.98
Multilateral Operations	IE	IE	IE	IE	IE	0.00
CO_2 Emissions from Biomass	54,897.63	51,618.51	54,308.40	54,376.98	55,268.01	24.21

Note: All footnotes for this table are given at the end of Table A3.1.5.

Table A3.1.2 Emissions Trends (CH_4)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Total CH_4 emissions	**4,065.54**	**4,232.73**	**4,220.85**	**4,593.85**	**5,014.30**	**5,708.87**	**4,978.68**	**4,937.04**	**5,664.32**	**5,210.98**
1. Energy	1,774.36	1,829.02	1,955.68	2,034.56	2,131.77	2,246.85	2,390.42	2,453.69	2,502.16	2,477.22
A. Fuel Combustion (Sectoral Approach)	214.23	203.64	209.00	213.49	219.27	218.05	218.77	213.21	229.72	250.96
1. Energy Industries	80.06	75.28	79.85	79.43	83.62	85.62	86.99	81.43	96.05	118.40
2. Manufacturing Industries and Construction	2.82	2.78	2.76	2.69	2.89	3.02	3.00	3.13	2.98	3.11
3. Transport	30.52	30.11	31.62	32.17	32.79	33.61	34.31	33.98	35.22	34.15
4. Other Sectors	100.83	95.48	94.76	99.19	99.98	95.79	94.48	94.66	95.47	95.30
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	1,560.13	1,625.38	1,746.68	1,821.08	1,912.50	2,028.80	2,171.64	2,240.48	2,272.45	2,226.26
1. Solid Fuels	91.16	99.35	87.35	87.32	84.09	81.58	84.13	78.07	64.95	51.48
2. Oil and Natural Gas	1,468.97	1,526.02	1,659.33	1,733.75	1,828.41	1,947.23	2,087.51	2,162.41	2,207.49	2,174.78
2. Industrial Processes	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
C. Metal Production	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3. Solvent and Other Product Use										
4. Agriculture	**1,000.59**	**1,010.63**	**1,041.16**	**1,047.39**	**1,079.12**	**1,137.06**	**1,168.62**	**1,168.21**	**1,163.88**	**1,159.73**
A. Enteric Fermentation	877.31	887.75	915.43	923.38	953.22	1,004.57	1,034.56	1,033.81	1,027.63	1,023.01
B. Manure Management	123.28	122.88	125.73	124.02	125.90	132.50	134.05	134.40	136.25	136.71
C. Rice Cultivation	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
D. Agricultural Soils	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**164.48**	**244.10**	**57.38**	**324.66**	**605.93**	**1,125.19**	**218.12**	**70.88**	**741.36**	**300.16**
A. Forest Land	152.79	233.25	47.19	315.63	597.30	1,117.59	209.96	62.96	732.95	291.80
B. Cropland	8.91	7.71	7.45	6.07	5.78	4.72	4.95	5.10	5.49	5.70
C. Grassland	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
D. Wetlands	0.08	0.09	0.08	0.09	0.13	0.13	0.12	0.13	0.12	0.16
E. Settlements	2.69	3.05	2.65	2.87	2.73	2.75	3.10	2.69	2.79	2.50
F. Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
G. Other	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
6. Waste	**1,126.12**	**1,148.98**	**1,166.63**	**1,187.23**	**1,197.48**	**1,199.77**	**1,201.53**	**1,244.25**	**1,256.92**	**1,273.89**
A. Solid Waste Disposal on Land	1,115.04	1,138.73	1,155.84	1,176.66	1,186.65	1,189.19	1,189.65	1,233.52	1,246.22	1,260.95
B. Waste-water Handling	10.65	9.80	10.30	10.26	10.52	10.23	11.55	10.70	10.67	12.90
C. Waste Incineration	0.44	0.45	0.49	0.31	0.31	0.34	0.33	0.02	0.03	0.04
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:										
International Bunkers	0.48	0.47	0.50	0.46	0.50	0.53	0.55	0.55	0.63	0.61
Aviation	0.22	0.19	0.21	0.20	0.22	0.23	0.27	0.28	0.29	0.31
Marine	0.26	0.27	0.28	0.25	0.29	0.30	0.27	0.27	0.34	0.31
Multilateral Operations	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CO_2 Emissions from Biomass										

Note: All footnotes for this table are given at the end of Table A3.1.5.

(Table A3.1.2 continued on next page)

Table A3.1.2 Emissions Trends (CH_4) (continued)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
Total CH_4 emissions	**5,111.15**	**5,233.15**	**5,576.82**	**5,536.62**	**5,894.04**	**44.98**
1. Energy	2,594.36	2,633.64	2,595.89	2,619.68	2,640.42	48.81
A. Fuel Combustion (Sectoral Approach)	253.50	248.22	249.60	250.62	255.05	19.06
1. Energy Industries	122.53	120.32	122.69	125.06	130.82	63.41
2. Manufacturing Industries and Construction	3.21	3.01	3.14	3.27	3.34	18.30
3. Transport	32.60	30.01	29.15	27.83	26.68	-12.59
4. Other Sectors	95.17	94.87	94.62	94.46	94.22	-6.56
5. Other	NA	NA	NA	NA	NA	0.00
B. Fugitive Emissions from Fuels	2,340.86	2,385.42	2,346.29	2,369.06	2,385.36	52.90
1. Solid Fuels	45.19	47.15	47.15	47.15	47.15	-48.27
2. Oil and Natural Gas	2,295.66	2,338.27	2,299.14	2,321.91	2,338.21	59.17
2. Industrial Processes	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**0.00**
A. Mineral Products	NA	NA	NA	NA	NA	0.00
B. Chemical Industry	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
C. Metal Production	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.00
D. Other Production						
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	NE	NE	NE	NE	NE	0.00
3. Solvent and Other Product Use						
4. Agriculture	**1,175.31**	**1,209.66**	**1,221.63**	**1,225.93**	**1,293.45**	**29.27**
A. Enteric Fermentation	1,035.14	1,064.63	1,072.53	1,077.03	1,142.74	30.26
B. Manure Management	140.18	145.03	149.10	148.90	150.71	22.25
C. Rice Cultivation	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.00
D. Agricultural Soils	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.00
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	0.00
F. Field Burning of Agricultural Residues	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00
G. Other	NA	NA	NA	NA	NA	0.00
5. Land Use, Land-Use Change and Forestry	**66.87**	**114.73**	**466.37**	**385.82**	**644.87**	**292.07**
A. Forest Land	59.30	107.11	458.20	377.66	637.07	316.95
B. Cropland	4.94	4.77	5.32	5.39	4.99	-43.99
C. Grassland	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
D. Wetlands	0.15	0.13	0.12	0.15	0.14	64.47
E. Settlements	2.47	2.72	2.74	2.62	2.67	-0.92
F. Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.00
G. Other	IE	IE	IE	IE	IE	0.00
6. Waste	**1,274.62**	**1,275.12**	**1,292.92**	**1,305.19**	**1,315.30**	**16.80**
A. Solid Waste Disposal on Land	1,263.29	1,263.69	1,281.46	1,293.57	1,303.48	16.90
B. Waste-water Handling	11.29	11.38	11.41	11.57	11.76	10.50
C. Waste Incineration	0.04	0.04	0.05	0.05	0.06	-86.35
D. Other	NA	NA	NA	NA	NA	0.00
7. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00**
Memo Items:						
International Bunkers	0.62	0.62	0.53	0.41	0.47	-0.66
Aviation	0.31	0.28	0.28	0.26	0.29	36.13
Marine	0.31	0.34	0.25	0.15	0.18	-31.03
Multilateral Operations	IE	IE	IE	IE	IE	0.00
CO_2 Emissions from Biomass						

Note: All footnotes for this table are given at the end of Table A3.1.5.

Table A3.1.3 Emissions Trends (N_2O)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Total N_2O emissions	**152.58**	**151.94**	**146.79**	**159.25**	**182.16**	**206.45**	**173.68**	**162.59**	**176.00**	**148.45**
1. Energy	**27.33**	**27.68**	**29.58**	**31.69**	**34.30**	**35.42**	**35.41**	**36.04**	**36.06**	**36.73**
A. Fuel Combustion (Sectoral Approach)	27.23	27.58	29.48	31.59	34.20	35.32	35.31	35.94	35.96	36.63
1. Energy Industries	2.91	2.88	3.04	2.93	2.99	3.17	3.16	3.15	3.52	3.66
2. Manufacturing Industries and Construction	1.74	1.71	1.72	1.69	1.77	1.85	1.85	1.91	1.83	1.87
3. Transport	20.31	20.75	22.46	24.63	27.04	27.89	27.85	28.44	28.33	28.75
4. Other Sectors	2.26	2.23	2.27	2.35	2.40	2.42	2.45	2.43	2.28	2.35
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
1. Solid Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Oil and Natural Gas	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2. Industrial Processes	**37.08**	**34.73**	**34.60**	**31.80**	**37.85**	**37.12**	**39.56**	**34.43**	**18.83**	**8.18**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	37.08	34.73	34.60	31.80	37.85	37.12	39.56	34.43	18.83	8.18
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3. Solvent and Other Product Use	1.35	1.36	1.38	1.39	1.41	1.42	1.44	1.45	1.47	1.48
4. Agriculture	**76.60**	**74.55**	**75.43**	**77.40**	**79.78**	**81.77**	**84.71**	**84.42**	**85.18**	**86.13**
A. Enteric Fermentation										
B. Manure Management	13.16	13.26	13.62	13.70	14.11	14.80	15.24	15.31	15.31	15.32
C. Rice Cultivation										
D. Agricultural Soils	63.45	61.29	61.81	63.70	65.67	66.97	69.48	69.11	69.87	70.81
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**7.02**	**10.37**	**2.51**	**13.75**	**25.58**	**47.43**	**9.27**	**3.08**	**31.27**	**12.72**
A. Forest Land	6.43	9.81	1.98	13.28	25.12	47.02	8.83	2.65	30.83	12.27
B. Cropland	0.49	0.44	0.42	0.36	0.34	0.30	0.31	0.32	0.33	0.34
C. Grassland	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
E. Settlements	0.10	0.12	0.10	0.11	0.11	0.10	0.12	0.10	0.11	0.10
F. Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**3.20**	**3.24**	**3.28**	**3.21**	**3.24**	**3.28**	**3.30**	**3.17**	**3.20**	**3.22**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	2.80	2.83	2.86	2.90	2.93	2.96	2.99	3.02	3.04	3.07
C. Waste Incineration	0.40	0.41	0.42	0.32	0.31	0.32	0.31	0.15	0.15	0.15
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:										
International Bunkers	**0.99**	**0.90**	**0.94**	**0.89**	**0.95**	**1.01**	**1.13**	**1.12**	**1.19**	**1.24**
Aviation	0.67	0.61	0.66	0.64	0.68	0.72	0.85	0.87	0.90	0.96
Marine	0.32	0.29	0.28	0.26	0.27	0.29	0.28	0.25	0.29	0.28
Multilateral Operations	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
CO_2 Emissions from Biomass										

Note: All footnotes for this table are given at the end of Table A3.1.5.

(Table A3.1.3 continued on next page)

Table A3.1.3 Emissions Trends (N_2O) (continued)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
Total N_2O emissions	**135.85**	**133.85**	**148.05**	**148.39**	**169.08**	**10.82**
1. Energy	**36.93**	**35.55**	**34.75**	**34.73**	**34.94**	**27.85**
A. Fuel Combustion (Sectoral Approach)	36.83	35.45	34.65	34.62	34.82	27.87
1. Energy Industries	3.91	4.00	3.98	4.05	4.04	38.74
2. Manufacturing Industries and Construction	1.96	1.85	1.92	1.99	2.04	17.05
3. Transport	28.49	27.18	26.27	26.03	26.22	29.08
4. Other Sectors	2.46	2.42	2.48	2.54	2.52	11.35
5. Other	NA	NA	NA	NA	NA	0.00
B. Fugitive Emissions from Fuels	0.10	0.10	0.10	0.11	0.12	22.94
1. Solid Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00
2. Oil and Natural Gas	0.10	0.10	0.10	0.11	0.12	22.94
2. Industrial Processes	**5.48**	**5.16**	**6.66**	**6.10**	**12.66**	**-65.87**
A. Mineral Products	NA	NA	NA	NA	NA	0.00
B. Chemical Industry	5.48	5.16	6.66	6.10	12.66	-65.87
C. Metal Production	NA	NA	NA	NA	NA	0.00
D. Other Production						
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	NE	NE	NE	NE	NE	0.00
3. Solvent and Other Product Use	1.49	1.51	1.52	1.54	1.55	15.34
4. Agriculture	**85.79**	**83.42**	**82.09**	**86.34**	**89.34**	**16.62**
A. Enteric Fermentation						
B. Manure Management	15.51	15.93	16.00	16.05	16.94	28.76
C. Rice Cultivation						
D. Agricultural Soils	70.28	67.49	66.09	70.29	72.40	14.11
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	0.00
F. Field Burning of Agricultural Residues	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00
G. Other	NA	NA	NA	NA	NA	0.00
5. Land Use, Land-Use Change and Forestry	**2.90**	**4.92**	**19.71**	**16.33**	**27.21**	**287.67**
A. Forest Land	2.50	4.51	19.28	15.89	26.78	316.73
B. Cropland	0.31	0.31	0.33	0.33	0.32	-34.98
C. Grassland	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
D. Wetlands	0.01	0.00	0.00	0.01	0.01	67.43
E. Settlements	0.09	0.11	0.10	0.10	0.10	-0.53
F. Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	0.00
G. Other	NE	NE	NE	NE	NE	0.00
6. Waste	**3.25**	**3.29**	**3.31**	**3.35**	**3.39**	**6.07**
A. Solid Waste Disposal on Land						
B. Waste-water Handling	3.10	3.13	3.17	3.20	3.22	15.34
C. Waste Incineration	0.15	0.16	0.15	0.16	0.17	-58.62
D. Other	NA	NA	NA	NA	NA	0.00
7. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00**
Memo Items:						
International Bunkers	**1.26**	**1.15**	**1.13**	**0.95**	**1.06**	**7.38**
Aviation	0.97	0.87	0.88	0.81	0.92	36.13
Marine	0.29	0.28	0.25	0.14	0.15	-53.55
Multilateral Operations	IE	IE	IE	IE	IE	0.00
CO_2 Emissions from Biomass						

Note: All footnotes for this table are given at the end of Table A3.1.5.

Table A3.1.4 Emission Trends (HFCs, PFCs and SF_6)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of HFCs[(4)] - (Gg CO_2 equivalent)	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**479.41**	**868.99**	**1,412.21**	**1,946.75**	**2,463.80**
HFC-23	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.00	0.00	0.00
HFC-32	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.00	0.00	0.00	0.00
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.00	0.00
HFC-125	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.02	0.03	0.08	0.11	0.15
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
HFC-134a	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.28	0.54	0.74	0.96	1.22
HFC-152a	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.00	0.02	0.04	0.04	0.03
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
HFC-143a	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.01	0.02	0.05	0.08	0.11
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.01	IE,NA,NE,NO	IE,NA,NE,NO	0.03	0.01
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.00	0.00
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO
Unspecified mix of listed HFCs[(5)] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Emissions of PFCs[(4)] - (Gg CO_2 equivalent)	**6,538.83**	**6,949.98**	**6,556.82**	**6,450.32**	**5,965.33**	**5,489.50**	**5,539.35**	**5,461.62**	**5,595.80**	**4,643.30**
CF_4	0.91	0.96	0.91	0.89	0.83	0.76	0.76	0.75	0.77	0.64
C_2F_6	0.07	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.05
C_3F_8	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00	0.00	0.00	0.00	0.00
C_4F_{10}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
$c\text{-}C_4F_8$	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00	0.00	0.00	NA,NE,NO
C_5F_{12}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00	0.00	0.00	0.00	0.00
C_6F_{14}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00	0.00	0.00	0.00	0.00
Unspecified mix of listed PFCs[(5)] - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Emissions of SF_6[(4)] - (Gg CO_2 equivalent)	**4,996.16**	**5,547.20**	**4,228.32**	**4,267.38**	**4,180.31**	**3,726.69**	**2,794.44**	**3,039.04**	**3,705.17**	**3,751.30**
SF_6	0.21	0.23	0.18	0.18	0.17	0.16	0.12	0.13	0.16	0.16

Note: All footnotes for this table are given at the end of Table A3.1.5.

(Table A3.1.4 continued on next page)

Table A3.1.4 Emission Trends (HFCs, PFCs and SF_6) (continued)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
Emissions of HFCs[(4)] - (Gg CO_2 equivalent)	**2,993.79**	**3,545.71**	**3,923.01**	**4,367.66**	**4,677.95**	**100.00**
HFC-23	0.00	0.00	0.00	0.00	0.00	100.00
HFC-32	0.00	0.00	0.00	0.00	0.00	100.00
HFC-41	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.00
HFC-43-10mee	0.00	0.00	0.00	0.00	0.00	100.00
HFC-125	0.18	0.21	0.24	0.27	0.30	100.00
HFC-134	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.00
HFC-134a	1.47	1.73	1.87	1.99	2.06	100.00
HFC-152a	0.04	0.03	0.02	0.02	0.02	100.00
HFC-143	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.00
HFC-143a	0.14	0.18	0.20	0.24	0.27	100.00
HFC-227ea	0.01	0.01	0.01	0.03	0.03	100.00
HFC-236fa	0.00	0.00	0.00	0.00	0.00	100.00
HFC-245ca	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO	0.00
Unspecified mix of listed HFCs[(5)] - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00
Emissions of PFCs[(4)] - (Gg CO_2 equivalent)	**4,308.23**	**3,492.35**	**2,991.94**	**3,034.53**	**3,056.65**	**-53.25**
CF_4	0.59	0.48	0.41	0.42	0.42	-53.50
C_2F_6	0.05	0.04	0.03	0.03	0.03	-51.45
C_3F_8	0.00	0.00	0.00	0.00	0.00	100.00
C_4F_{10}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00
c-C_4F_8	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00
C_5F_{12}	0.00	0.00	0.00	0.00	0.00	100.00
C_6F_{14}	0.00	0.00	0.00	0.00	0.00	100.00
Unspecified mix of listed PFCs[(5)] - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0.00
Emissions of SF_6[(4)] - (Gg CO_2 equivalent)	**4,346.53**	**4,389.82**	**4,064.23**	**4,179.24**	**3,024.36**	**-39.47**
SF_6	0.18	0.18	0.17	0.17	0.13	-39.47

Note: All footnotes for this table are given at the end of Table A3.1.5.

Table A3.1.5 Emission Trends Summary

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)
CO_2 emissions including net CO_2 from LULUCF(3)	372,936.24	346,296.79	301,054.51	378,668.15	473,858.82	649,398.50	420,909.46	391,101.49	590,930.92	487,379.61
CO_2 emissions excluding net CO_2 from LULUCF(3)	460,330.87	451,903.09	466,244.92	465,092.97	479,667.16	493,436.68	506,379.36	518,577.79	526,876.27	542,321.13
CH_4	85,376.44	88,887.23	88,637.80	96,470.81	105,300.26	119,886.35	104,552.35	103,677.79	118,950.72	109,430.67
N_2O	47,298.47	47,100.18	45,506.22	49,367.64	56,468.49	63,998.09	53,841.00	50,401.51	54,560.19	46,020.97
HFCs	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	479.41	868.99	1,412.21	1,946.75	2,463.80
PFCs	6,538.83	6,949.98	6,556.82	6,450.32	5,965.33	5,489.50	5,539.35	5,461.62	5,595.80	4,643.30
SF_6	4,996.16	5,547.20	4,228.32	4,267.38	4,180.31	3,726.69	2,794.44	3,039.04	3,705.17	3,751.30
Total (including net CO_2 from LULUCF)(3)	**517,146.14**	**494,781.37**	**445,983.66**	**535,224.29**	**645,773.20**	**842,978.55**	**588,505.59**	**555,093.66**	**775,689.56**	**653,689.65**
Total (excluding net CO_2 from LULUCF)(3), (6)	**604,540.77**	**600,387.67**	**611,174.08**	**621,649.11**	**651,581.54**	**687,016.73**	**673,975.50**	**682,569.96**	**711,634.91**	**708,631.17**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)
1. Energy	475,494.45	467,234.50	484,674.95	485,309.17	502,158.99	517,073.55	532,259.35	545,123.35	555,016.37	569,165.69
2. Industrial Processes	53,333.12	54,651.05	53,061.06	52,666.20	54,557.56	55,511.40	56,548.18	56,532.49	52,466.15	49,761.58
3. Solvent and Other Product Use	417.29	422.32	427.37	432.12	436.90	441.47	446.12	450.58	454.35	458.06
4. Agriculture	44,759.40	44,334.17	45,248.77	45,990.38	47,394.17	49,226.44	50,802.40	50,702.14	50,846.33	51,054.44
5. Land Use, Land-Use Change and Forestry(7)	-81,765.08	-97,265.92	-163,206.58	-75,344.28	14,844.40	194,293.66	-78,016.97	-125,034.35	89,317.41	-44,695.73
6. Waste	24,906.96	25,405.25	25,778.09	26,170.70	26,381.18	26,432.03	26,466.52	27,319.44	27,588.95	27,945.61
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(7)	**517,146.14**	**494,781.37**	**445,983.66**	**535,224.29**	**645,773.20**	**842,978.55**	**588,505.59**	**555,093.66**	**775,689.56**	**653,689.65**

(Table A3.1.5 continued on next page)

Table A3.1.5 Emission Trends Summary (continued)

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	2004	Change from base to latest reported year
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	(%)
CO_2 emissions including net CO_2 from LULUCF(3)	433,020.10	434,912.25	557,681.14	568,572.74	651,956.38	74.82
CO_2 emissions excluding net CO_2 from LULUCF(3)	566,257.38	559,937.47	567,462.59	593,062.71	593,092.60	28.84
CH_4	107,334.21	109,896.16	117,113.20	116,268.93	123,774.82	44.98
N_2O	42,112.62	41,493.27	45,896.48	46,001.54	52,416.35	10.82
HFCs	2,993.79	3,545.71	3,923.01	4,367.66	4,677.95	100.00
PFCs	4,308.23	3,492.35	2,991.94	3,034.53	3,056.65	-53.25
SF_6	4,346.53	4,389.82	4,064.23	4,179.24	3,024.36	-39.47
Total (including net CO_2 from LULUCF)(3)	**594,115.48**	**597,729.57**	**731,670.01**	**742,424.64**	**838,906.52**	**62.22**
Total (excluding net CO_2 from LULUCF)(3), (6)	**727,352.76**	**722,754.79**	**741,451.45**	**766,914.61**	**780,042.74**	**29.03**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	Change from base to latest reported year
	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	CO_2 equivalent (Gg)	(%)
1. Energy	595,530.74	590,368.86	597,324.56	621,978.25	619,530.10	30.29
2. Industrial Processes	49,804.21	48,722.80	48,287.31	50,146.35	54,324.33	1.86
3. Solvent and Other Product Use	462.36	467.37	472.66	477.00	481.30	15.34
4. Agriculture	51,275.91	51,263.21	51,102.34	52,511.26	54,856.90	22.56
5. Land Use, Land-Use Change and Forestry(7)	-130,932.73	-121,089.36	6,123.00	-11,326.80	80,839.90	-198.87
6. Waste	27,974.98	27,996.68	28,360.15	28,638.58	28,873.98	15.93
7. Other	NA	NA	NA	NA	NA	0.00
Total (including LULUCF)(7)	**594,115.48**	**597,729.57**	**731,670.01**	**742,424.64**	**838,906.52**	**62.22**

(1) The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the COP. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.
(2) Fill in net emissions/removals as reported in table Summary 1.A. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).
(3) The information in these rows is requested to facilitate comparison of data, because Parties differ in the way they report CO_2 emissions and removals from LULUCF.
(4) Enter actual emissions estimates. If only potential emissions estimates are available, these should be reported in this table and an indication for this should be provided in the documentation box. Only in these rows are the emissions expressed as CO_2 equivalent emissions.
(5) In accordance with the UNFCCC reporting guidelines, HFC and PFC emissions should be reported for each relevant chemical. However, if it is not possible to report values for each chemical (i.e. mixtures, confidential data, lack of disaggregation), this row could be used for reporting aggregate figures for HFCs and PFCs, respectively. Note that the unit used for this row is Gg of CO_2 equivalent and that appropriate notation keys should be entered in the cells for the individual chemicals.
(6) These totals will differ from the totals reported in table Summary 2 if Parties report non-CO_2 emissions from LULUCF.
(7) Includes net CO_2, CH_4 and N_2O from LULUCF.

NA = not applicable, NE = not estimated; NI = not inventoried; NO = not occurring

ANNEX 3.2: DESCRIPTION OF CANADA'S NATIONAL SYSTEM

The information on Canada's National System will be contained in Canada's Initial Report under the Kyoto Protocol to facilitate the calculation of Canada's assigned amount pursuant to Articles 3.7 and 3.8 of the Kyoto Protocol and to demonstrate Canada's capacity to account for its emissions and assigned amount under Article 7.4 of the Kyoto Protocol. All specific Article 7.2 National System requirements are described in the Initial Report and cross references to their location are provided in the following table.

Article 7.2 National System requirements	**Cross-reference to Initial Report (IR)**
Name and Contact of entity and responsible	IR section 5.2.1
Roles and responsibilities of agencies	IR section 5.2.3
Process description for data collection and emission estimation	IR section 5.3.2
Process description and results of key source identification, and archiving	IR section 5.3.3
Process description for recalculations	IR section 5.3.4
Description of QA/QC plan, implementation and objectives	IR section 5.4
Description of procedure for inventory approval	IR section 5.5

Readers are therefore referred to Canada's Initial Report for reference.

CHAPTER 4 POLICIES AND MEASURES

4.1 INTRODUCTION

The Government of Canada (GoC) is committed to the transformative, long-term change required to make reductions in greenhouse gas (GHG) emissions while ensuring continued economic growth. Canada's climate change policy has evolved considerably during the last fifteen years, through initiatives undertaken by all orders of government.

Section 4.2 describes the evolution of the domestic policy environment between 1990 and 2005. The measures in place, as of December 31, 2005, can be categorized into six streams of activity, as illustrated in Table 4.1.1. The two streams that are the focus of this chapter are mitigation and the development of long-term solutions through advanced technology and innovation.

The aim of mitigation is to reduce or remove emissions in the near term; primarily through the more widespread deployment of established technologies. The aim of technology and innovation is to reduce or remove emissions in the long term; primarily through the advancement of new technological solutions.

Section 4.3 describes mitigation measures to support Canada's climate change policies across six sectors of the Canadian economy: buildings, transportation, industry, agriculture, forestry, and waste. Section 4.4 describes technology and innovation measures. Measures under the other four streams of activities are discussed, as appropriate, in subsequent chapters.

Table 4.1.1: Six Streams of Activity to Address Climate Change

Mitigation: To reduce or remove GHG emissions in the near term.

Technology & Innovation: To advance climate change mitigation technologies through R&D, demonstration and early adoption initiatives.

Public Education & Outreach: To encourage individual Canadians to be aware and take action on climate change.

Climate Change Science: To provide a science-based understanding of climate change and manage its risk.

Impacts and Adaptation: To reduce Canada's vulnerability to a changing climate.

International and Domestic Policy: To participate in international agreements and develop domestic strategies to address climate change.

4.2 EVOLUTION OF CLIMATE CHANGE POLICY IN CANADA

Canada's climate change policy has evolved considerably since 1990. This section outlines three main phases in Canada's climate change policy evolution over the last fifteen years (as summarized in Table 4.2.1).

Table 4.2.1: Evolution of Canadian Climate Change Policy

Post-Kyoto Ratification: 2003-2005

- *National process shifts to bilateral approach; provincial/territorial initiatives advanced.*

2005:	Notice of Intent to Regulate GHG emissions through the Canadian Environmental Protection Act (CEPA).
	Release of *Moving Forward on Climate Change: A Plan for Honouring our Kyoto Commitment*.
	Automobile Industry and Government agree on climate change action.
2003:	Bilateral MOU negotiations initiated with the provinces and territories and some concluded.
	Large Final Emitters (LFEs) consultations and discussion papers released.

National Climate Change Process: 1997-2002

- *Focus on voluntary and incentive based actions including technology; increase in federal funding.*

2002:	Ratification of the Kyoto Protocol.
	Release of the *Climate Change Plan for Canada*.
	Consultations by federal government on climate change discussion paper.
2001:	Wind Power Production Incentive (WPPI).
2000:	Action Plan 2000 (AP2000) released.
	National Implementation Strategy (NIS) and First National Business Plan released (FNBP).
	Green Municipal Fund (GMF) established.
	Technology Early Action Measures (TEAM) established.
1998:	Federal budget announced Climate Change Action Fund (CCAF).
	Issues Tables created.
	Joint Ministers Meetings met regularly and established the National Climate Change Process.

First Steps: 1990-1996

- *Nationally coordinated approach; "no regrets" approach focusing on energy efficiency & voluntary action.*

1995:	National Action Program on Climate Change (NAPCC) released.
1994:	Voluntary Challenge and Registry (VCR) established.
1992:	Energy Efficiency Act passed.
	Ratification of the United Nations Framework Convention on Climate Change (UNFCCC).
1991:	Efficiency and Alternative Energy Program created.

4.2.1 An Initial National Strategy and International Negotiations (1990-1996)

Domestically, federal, provincial and territorial Ministers of environment and energy began a coordinated approach to addressing climate change with the release of a *National Action Strategy on Global Warming* in 1990. The National Strategy proposed that a strategic framework for action be undertaken jointly by federal and provincial/territorial governments.

During the early 1990s, climate change policy in Canada focussed mainly on affecting behavioural change through a "no-regrets" approach – one that emphasized measures that produced benefits beyond those directly related to climate change. The *Green Plan*, published by the federal government in 1990, resulted in the creation of the Efficiency and Alternative Energy Program (1991), as well as public information programs, and established the national energy use database.

In addition, the *Energy Efficiency Act* (1992) provided Canada with the authority to make and enforce regulations concerning minimum energy performance levels for energy using products, as well as the labelling of energy using products and the collection of data on energy use. These early actions were important in laying the foundation for future efforts on climate change. The emphasis on energy efficiency resulted in improvements, for example, in the energy efficiency of various consumer products.

Following the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, Canada ratified the United Nations Framework Convention on Climate Change (UNFCCC).

From 1993 until 2002, coordination between federal and provincial/territorial environment and energy administrations took place primarily through joint meetings of the Canadian Council of Ministers of the Environment and the Council of Energy Ministers. These joint meetings of environment and energy Ministers are often referred to as Joint Ministers Meetings (JMM). The first JMM was held in 1993 to approve and provide direction on the Comprehensive Air Quality Management Framework Agreement. The Agreement provided a formal basis for all jurisdictions to coordinate management of the climate change issue and other air issues.

JMM met regularly during this time and, in 1995, approved the National Action Program on Climate Change (NAPCC), which set the strategic course on climate change and established principles and direction for joint action. A prominent element of the NAPCC, the national Voluntary Challenge and Registry (VCR) was established in late 1994 and has since evolved into the Canadian Standards Association-managed Canadian GHG Challenge Registry.

Reflecting the regional diversity of the country, in the early 1990s, most provinces and territories began working on climate change action plans and strategies for their own jurisdictions. Several provinces, including Saskatchewan, Alberta and British Columbia, also undertook extensive public consultations. Internationally, in the 1990s, Canada was involved in climate change discussions and negotiations that led to the signing of the UNFCCC in 1992 and later to agreement on the Kyoto Protocol.

4.2.2 National Climate Change Process (1997-2002)

In 1997 the Kyoto Protocol was agreed to internationally and in 1998 JMM established the National Climate Change Process (NCCP) to examine the various implementation options open to Canada and their impacts, costs and benefits. The National Climate Change Secretariat, comprised of representatives from federal, provincial and territorial governments was created to manage the NCCP. JMM was in charge of the national process to develop direction and statements of intent on climate change and met regularly between 1998 and 2002.

As part of the NCCP, sixteen Issues Tables, or working groups, comprising 450 experts from government, industry, academia and non-governmental organizations (NGOs), were created. Experts met regularly to examine and analyze the impacts, costs and benefits of options to address climate change. Two key documents were produced for each of the tables: an initial Foundation Paper and a final Options Report. The Foundation Paper reviewed the current status of the sector, including challenges and opportunities. The Options Report carried out sector-specific and cross-cutting analysis of emissions reductions opportunities and barriers, and identified options for consideration in the development of Canada’s national strategy on climate change. Once complete, these documents significantly informed climate change policy in Canada.

While the Issues Tables’ work was ongoing in the late 1990s, government increased its investment in climate change initiatives. The focus was still primarily on voluntary and incentive-based actions, including improved energy efficiency, public awareness, alternative energy and the promotion of technological solutions. The 1998 federal budget established the Climate Change Action Fund (CCAF) with $150 million over three years to support initiatives to advance science, increase public awareness and diminish GHG emissions.

The 2000 federal budget extended the CCAF for three more years with an additional $150 million. Recognizing that technological innovation is an important part of addressing climate change, Technology Early Action Measures (TEAM) was designed under the CCAF to bring climate change technology to domestic and international markets as quickly as possible. TEAM works in partnership with provinces/territories, municipalities, industry and others to help fund demonstrations of climate change technology while promoting sustainable economic development in Canada. Budget 2000 also established the Green Municipal Fund (GMF) with an investment of $125 million to stimulate investment in innovative municipal infrastructure projects. The Fund supports partnerships, leveraging public and private sector funding to encourage municipal actions to improve air, water and soil quality as well as to reduce GHG emissions.

Following the completion of the Issues Tables and a series of cross-country stakeholder sessions, the NCCP developed the National Implementation Strategy (NIS) on Climate Change in 2000. It was part of a coordinated national response to climate change. Federal, provincial and territorial governments planned to implement this broad climate change strategy through individual and joint action. The first initiatives were outlined in the First National Climate Change Business Plan (FNBP), released concurrently with the NIS.

In 2000, the federal government announced Action Plan 2000 (AP2000), its contribution to the FNBP. AP2000 was a package of concrete measures to reduce GHG emissions representing a proposed investment of $500 million over 5 years. It was the federal government's first comprehensive package of measures to address climate change. Developed from the results of the Issues Tables, AP2000 targeted key sectors and included initiatives in transportation, energy, industry, buildings, forestry and agriculture, international projects, technology, science and adaptation.

The 2001 federal budget allocated $260 million in funding for the Wind Power Production Incentive (WPPI), which was launched in 2002, and doubled its funding for GMF to $250 million. WPPI represented a milestone in Canada's support for, and implementation of, emerging renewable energy sources by providing a financial incentive for the development of wind energy, while the GMF helped remove impediments to innovative emission reduction projects by municipalities.

All provinces and territories were engaged on the climate change issue during this time. Most were in the process of developing their own strategies or action plans, or detailing their climate change activities. In 2000, Quebec, for example, released its Action Plan on Climate Change. The Plan proposed a number of measures affecting government, transportation, industry, waste, education and research. Climate change plans were also released by Saskatchewan (1997), Alberta (1998) and the Northwest Territories (2001). As well, the Premiers of eastern provinces were working together with New England Governors and created a Climate Change Action Plan (2001).

A number of climate change hubs were also being established across the country. For example, Climate Change Central, a public-private partnership promoting the development of innovative responses to climate change and its impacts, was created in Alberta in 1999. As well, the Northern Climate ExChange opened in 2000. Its mission is to provide information, develop shared understanding and promote action on climate change in northern Canada.

As Canada moved closer to the Kyoto ratification decision, a number of provinces and territories produced jurisdictional climate change plans, including Alberta and Manitoba, who released their plans in 2002. The federal government put forward a discussion paper on Canada's contribution to addressing climate change in 2002.

The federal discussion paper presented four major policy options for addressing Canada's climate change commitment, along with analysis of their impacts. These options were characterized under four headings: (1) "broad as practical" domestic emissions trading; (2) all targeted measures; (3) a mixed approach (domestic emissions trading, targeted measures and international permits); and, (4) an adjusted mixed approach – similar to option 3 but with a different approach to allocating permits, the inclusion of an offsets system, and the selection of targeted measures that would consider goals beyond climate change. At the request of federal, provincial and territorial energy and environment Ministers, a series of workshops were held across the country to consult with stakeholders and obtain their views on the options or mix of policy instruments that could be used in the design of a plan to meet the Kyoto target. Views were sought on the four options, including on the adoption and design of a domestic emissions trading system.

Following consultations with stakeholders and the Canadian public, the federal government released the Climate Change Plan for Canada (2002), which outlined how Canada could make further progress towards meeting the GHG reduction target set out in the Kyoto Protocol. It contained measures to support action by individual Canadians, industrial emitters and governments and was intended to provide a framework that would evolve over time. The Plan proposed a comprehensive approach for large final emitters (LFEs) and during 2002, and thereafter, discussions took place between the federal government and industry representatives on the role the sectors would play in contributing to Canada's emissions mitigation objectives.

The 2002 Plan moved beyond the "no-regrets" approach taken in the 1990s and focused on steps to reduce the gap between "business as usual" (BAU) estimates and Canada's Kyoto target. In December 2002, the GoC ratified the Kyoto Protocol.

4.2.3 Post-Kyoto Ratification (2003-2005)

With the federal government's ratification of the Kyoto Protocol, the national process shifted away from a multilateral approach towards a bilateral approach. In 2003, a series of bilateral meetings were conducted between the federal Deputy Ministers of environment and energy and each province/territory. Discussions were aimed at renewing relationships and focused on the way forward in terms of climate change action. These bilateral meetings were crucial in identifying areas of common interest and partnership opportunities.

During the federal-provincial/territorial bilateral meetings in early 2003, some provinces and territories expressed an interest in pursuing a Memorandum of Understanding (MOU) on Climate Change with the federal government, as a way to cooperate on climate change. Five MOUs were negotiated and signed with the federal government between 2003 and 2005: with Nunavut, Prince Edward Island, Manitoba, Ontario and Newfoundland.

Provinces and territories continued to meet to discuss specific initiatives such as the proposal to regulate targets for LFEs. The federal government released many technical discussion papers on the design of the LFE system in 2003 and 2004 and consulted with industry, provinces and territories, and the public. In 2003, the federal government and the oil and gas industry agreed to principles intended to increase certainty in long-term development of the oil sands and the implementation of Canada's climate change goals.

The 2003 federal budget set aside $2 billion over five years to help implement the Government of Canada's *Climate Change Plan for Canada*. A major announcement took place in August 2003 to allocate funds to a series of new and existing initiatives. Emission reductions in the Kyoto time frame was the key focus of this announcement, with measures to promote energy efficiency, renewable energy, sustainable transportation and new alternative fuels. The government also announced increases in investments in technology. The new investments were intended to act as a catalyst for, and a complement to, actions by individual Canadians, industry and business, and governments and communities.

As part of the 2003 budget, the federal government announced $160 million over three years for an Opportunities Envelope (OE) to provide financial support for cost-effective GHG reducing projects and programs brought forward by provinces and territories.

The federal government and the automotive industry reached an agreement on emission reductions in 2005. In the voluntary agreement, automobile manufacturers agreed to reduce GHG emissions from new vehicles in Canada. The agreement is expected to result in the reduction of GHG emissions through: improvements in advanced vehicle emissions and diesel technology; production of more alternative fuel and hybrid vehicles; and, development and application of high fuel efficiency technologies. A key component of this agreement is the joint government-industry monitoring of annual industry performance against projected interim GHG reduction goals in order to ensure progress.

In February 2005, the GoC announced its intention in Budget 2005 to significantly expand federal initiatives with respect to home energy efficiency retrofits and wind power production. It also announced the creation of a new incentive to encourage other green energy forms. Budget 2005 made a commitment towards expanding funding for sustainable energy, science and technology as well.

In April 2005 the federal government released an updated climate change plan, Moving Forward on Climate Change: A Plan for Honouring Our Kyoto Commitment, which focused on GHG emissions mitigation. The Plan built on existing measures and on the announcements in the 2005 federal budget.

With varying views on how to address climate change, all provinces and territories are actively engaged in the issue and some have released climate change plans or energy strategies during this time, namely: Northwest Territories (2003), Nunavut (2003), British Columbia (2004), and Newfoundland and Labrador (2005). Many climate change initiatives have advanced. For example, in 2005, the government of Quebec announced plans to expand wind energy in the province by authorizing Hydro-Quebec to acquire 2000 megawatts of new power projects.

4.2.4 Supplementarity With Respect to the Flexibility Mechanisms of the Kyoto Protocol

While Canada's climate change policy has evolved during the last 15 years, it has maintained a focus on domestic action to reduce or remove GHG emissions over the short and medium term and on implementing transformative change to facilitate reductions in emissions over the longer-term. Other means to reduce GHGs, including any potential use of the Kyoto Mechanisms, continues to be supplemental to Canada's domestic action. The GoC does not currently have a plan to include international purchases under the Kyoto Mechanisms in its effort to reduce GHG emissions.

4.2.5 Legislative Arrangements, Institutional Enforcement and Administrative Procedures

Canada has undertaken a number of significant legal and institutional steps towards implementation of the Kyoto Protocol. These steps are outlined below.

A *Notice of Intent to Regulate Greenhouse Gas Emissions by Large Final Emitters* was published in the *Canada Gazette*, Part I on July 16, 2005. It outlined a proposal for reducing emissions of GHGs from large industrial sources. The Canadian Environmental Protection Act 1999 (CEPA), an "act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development", was amended in November 2005 to include the six GHGs listed in Annex A of the Kyoto Protocol in its Schedule 1 (List of Toxic Substances). This inclusion enables the making of regulation in respect of these substances by the federal Government.

In October 2006, the GoC introduced proposed legislation in Parliament to strengthen its legislative basis for taking action on reducing air pollution and GHGs. This proposal (Bill C-30: Canada's Clean Air Act) is accessible at www.ec.gc.ca or www.parl.gc.ca/legisinfo. It aims to amend the Canadian Environmental Protection Act, 1999, the Energy Efficiency Act and the Motor Vehicle Fuel Consumption Standards Act.

The effect of the proposed legislation would be to strengthen the government's ability to take action to reduce air emissions (air pollutants and GHG emissions), and to require the Ministers of the Environment and of Health to establish national air quality objectives, as well as to monitor and report publicly on their attainment. It would also facilitate the government's ability to regulate the blending of fuels and their components. This will be an important step towards meeting 5% renewable fuel content in motor fuels by 2010.

Canada's Clean Air Act would amend the *Motor Vehicle Fuel Consumption Standards Act* to enhance the GoC's authority to regulate vehicle fuel efficiency. Setting mandatory fuel consumption standards would help ensure reduced GHG emissions from vehicles purchased in Canada. *Canada's Clean Air Act* would expand authorities under the *Energy Efficiency Act* to allow the government to set energy efficiency standards and labeling requirements for a wider range of consumer and commercial products. Achieving the same comfort and convenience for less energy is one of the most sensible and effective ways of reducing emissions and saving money.

Subsequent to the introduction of Bill C-30, the GoC published a *Notice of Intent to Develop and Implement Regulations and other Measures to Reduce Air Emissions* (air pollutants and GHGs) in the *Canada Gazette* (October 21, 2006), which is publicly accessible. This *Notice of Intent* provides that the GoC will implement a one-window regulatory compliance tool to ensure that industry is on track to meet regulatory obligations, and will require maximum use of continuous emissions monitoring technology to ensure effective compliance and enforcement. As is standard procedures for publications in the *Canada Gazette*, the *Notice of Intent* is open for public comment, for a 60-day period, ending December 20, 2006. Bill C-30 was referred to the Legislative Committee of the House of Commons on December 4, 2006.

The GoC has also implemented the first phase of mandatory reporting of GHG emissions. This phase focuses on a limited number of emitters and basic reporting requirements. It also lays the foundation for the development of a single harmonized system for mandatory reporting of all air pollutants and GHG emissions.

The information on Canada's National Registry will be contained in Canada's Initial Report under the Kyoto Protocol to facilitate the calculation of Canada's assigned amount pursuant to Articles 3.7 and 3.8 of the Kyoto Protocol and to demonstrate Canada's capacity to account for its emissions and assigned amount under Article 7.4 of the Kyoto Protocol. Readers are therefore referred to Canada's Initial Report for further details.

Canada's Clean Development Mechanism (CDM) and Joint Implementation (JI) Office, located within the Department of Foreign Affairs and International Trade (DFAIT), serves as the official Designated National Authority (DNA) for CDM activities and the focal point for JI activities. The Office provides approval letters confirming voluntary participation of private and/or public entities in the CDM and approves JI projects. To be authorized as a legal entity for the purposes of participation in the CDM, a private and/or public entity must demonstrate its legal entity status in Canada. Further guidance on this requirement is available at www.cdm-ji.ca.

4.3 SECTORAL REVIEW OF MITIGATION MEASURES

In meeting Canada's current and future climate change challenges, federal, provincial, and territorial governments and stakeholders have identified a series of opportunities for GHG emissions abatement within and between sectors of the Canadian economy. At the federal level, a Results-Based Management and Accountability Framework (RMAF) was developed to ensure coordination of activities. Some of the measures that have been implemented are cross-sectoral. Other measures are sector specific. The sectors categorised in this report are: buildings; transportation; industry, including oil and gas, electricity generation, and mining and manufacturing; agriculture; forestry; and, waste. The RMAF helps public service managers to define strategic outcomes, focus attention on results achievement, measure performance, learn from this information, and adjust to improve efficiency and effectiveness.[11] The following sub-sections provide an overview of each sector, including trends in energy use and GHG emissions, key policies and measures used to address the GHG challenges, and indicators of performance.

The examples of policies and measures provided in the following sub-sections represent those that Canadian governments either have implemented or are in the process of implementing. For a more comprehensive listing of those currently planned or adopted by governments – and a number of initiatives by the private sector and municipalities – refer to Appendix 1, *Summary of Policies and Measures*.

4.3.1 Cross-Sectoral

The cross-sectoral section presents GHG emissions trends, and the policies and measures designed to address them, that cut across more than one of the following sectors; buildings, transportation, industry, agriculture,

[11] For further information on RMAF, refer to the *Guide for the Development of Results-based Management and Accountability Fra*meworks (2001) at www.tbs-sct.gc.ca/eval/pubs/RMAF-CGRR/RMAF_Guide_e.pdf.

forestry and waste. While cross-sectoral measures are described here, they are also referenced later in each of the sectors in which they have specific application.

4.3.1.1 Economy-Wide Trends

The amount of atmospheric carbon dioxide (CO_2) emissions is a function of Canada's population, economic activity per capita, energy intensity of the economy and the carbon intensity of the energy supply. Canada does not control CO_2 emissions by regulating population or Gross Domestic Product (GDP) per capita, but rather focuses on energy conservation (switching to less energy-intensive activities and enhancing energy efficiency), fuel switching, and carbon sequestration.

Thus economy-wide trends in energy supply and use are key indicators of Canada's GHG emissions. Energy-related emissions contributed 82% (619.5 Mt CO_2 eq.)[12] of Canada's total emissions in 2004. These emissions are affected by multiple energy supply and demand factors, which are investigated in the following section.

The following pages present a review of three main aspects of energy use trends that relate to GHG emissions:

A. The level of Canada's production and use;
B. The carbon-intensity of Canada's energy production and use;
C. The level of efficiency in Canada's energy usage.

A. Canada's Energy Production and Use

In 2004, Canada's domestic primary energy production was 16 593.8 PJ, up 44% from 1990 (Figure 4.3.1.1). The largest primary energy growth occurred in natural gas and natural gas liquids (NGL), which grew by 70% (3,212.3 PJ). Crude oil production increased by 56% (2,104.2 PJ) and non-carbon energy sources (i.e. hydro and other renewable energy sources, nuclear energy) grew by 15% (200.3 PJ). Coal production, on the other hand, declined by 15% (257.4 PJ).

[12] Throughout Section 4.3, the emissions figures provided may not exactly match those presented in the Tables in Chapter 3 as a result of rounding and differences in categorizations.

Figure 4.3.1.1: Canada's Primary Energy Production (PJ), 1990 – 2004

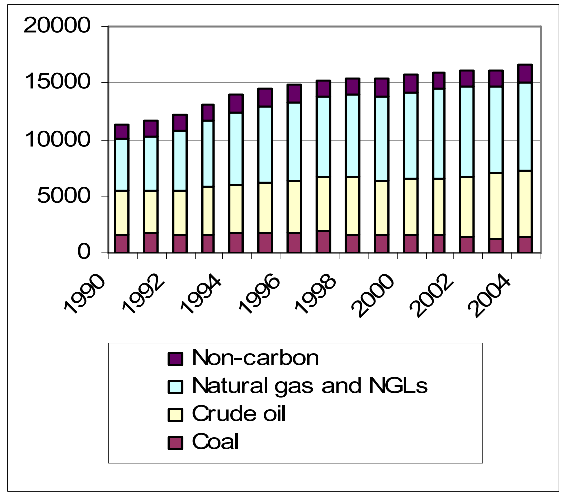


Table 4.3.1.1 shows the resulting changes in the share of primary energy production among these types of energy.

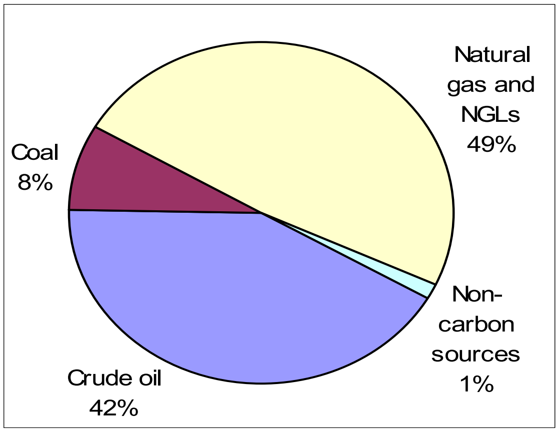
Table 4.3.1.1: Share of Primary Energy Production by Type (PJ), 1990 and 2004

Source	1990	*share*	2004	*share*
Non-carbon	1,321.9	*12%*	1,522.5	*9%*
Crude oil	3,765.2	*33%*	5,869.4	*35%*
Natural gas and NGL	4,574.1	*40%*	7,786.4	*47%*
Coal	1,673.1	*15%*	1,415.7	*9%*
Total	11,334.3	*100%*	16,593.8	*100%*

Canada uses primary energy in a variety of ways, including exporting it to other countries, producing secondary types of energy, and consuming in the various sectors of the economy.

Of the primary energy produced in Canada in 2004, exports claimed 53% of it, or 8,814.2 PJ. The majority of the 91% growth in primary energy exported from Canada was carbon-based fuel. Natural gas and NGL exports rose by 150% (or 2,572.6 PJ), crude oil rose by 151% (2,228.3 PJ), and non-carbon rose by 83% (54.4 PJ). Coal exports declined by 25% (down 239.6 PJ). Figure 4.3.1.2 demonstrates that natural gas and NGLs made up nearly half the primary energy exported from Canada in 2004, and most of the remainder was crude oil.

Figure 4.3.1.2: Share of Primary Energy Exported from Canada, by fuel type, 2004



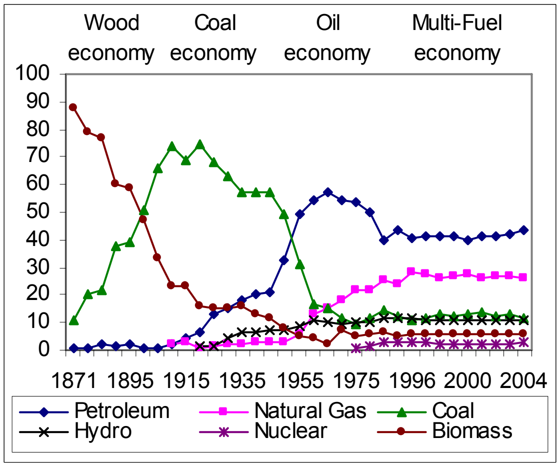
Another portion of the primary energy was transformed into secondary energy. Crude oil can be transformed into refined petroleum products. Natural gas can be transformed into electricity and steam. Coal can be transformed into electricity, as well as coke and manufactured gases. The transformation of primary to secondary energy in Canada rose by 27% between 1990 and 2004.

Total energy final demand in Canada is the summation of the various domestic primary and secondary energy demands. The evolution of energy demand in Canada reflects changes over several decades – changes in energy-consuming equipment and buildings, and in the behaviour of energy users. Between 1990 and 2004, Canada's total energy demand increased by 22%, from 6,299.4 PJ in 1990 to 7,690.1 PJ in 2004.

B. Carbon Intensity of Canada's Energy Mix

The carbon intensity of energy demand is an important driver of the economy's GHG intensity. In Canada, the energy mix has diversified over time. Unlike the wood, coal and then oil economies of the past 150 years, Canada currently operates in a multi-fuel economy. Figure 4.3.1.3 demonstrates how the proportion of various energy types (e.g. petroleum, natural gas, coal, hydro, nuclear, and wood) consumed domestically has evolved over time. Changes in the energy supply during the 20th century lowered the economy's GHG intensity. Diversity has enhanced energy security and sustainability, and allows for new fuels and technologies to continually be introduced.

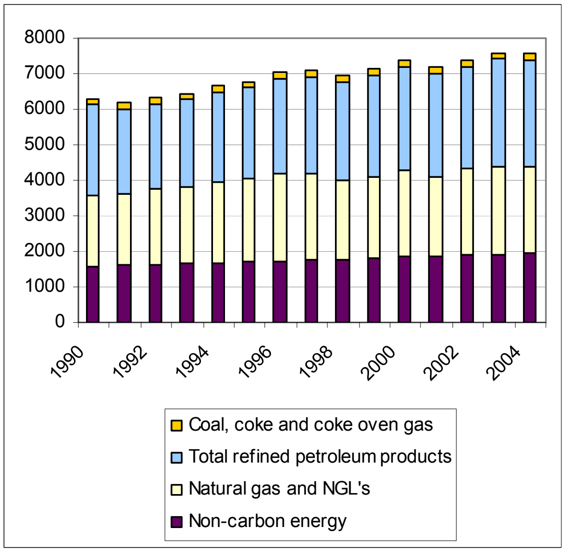
Figure 4.3.1.3: Diversification of Canada's Energy Supply Mix (% of Energy Consumption), 1871 – 2004



During the 1990-2004 analysis period, while the carbon intensity of the energy mix produced in Canada increased as a result of increased fossil fuel exports, the carbon intensity of the energy that Canada consumed domestically did not change significantly. Canada's final demand for primary and secondary energy has increased, but the energy mix has remained nearly constant (Figure 4.3.1.4). In 2004, the final demand energy mix consisted 39% of refined petroleum products, 32% of natural gas and natural gas liquids, 25% of non-carbon sources (e.g. hydro and nuclear) and 3% of coal, coke and coke oven gas.[13]

[13] Note that percentages may not add up to 100% due to rounding.

Figure 4.3.1.4: Canada's Total Energy (Primary and Secondary) (PJ) Final Domestic Demand, by fuel type, 1990-2004[14]



C. Canada's Energy Efficiency

Secondary energy, a measure of the end use of energy, is the energy used by the final consumer in the residential, commercial, agricultural, industrial and transportation sectors. Principal factors influencing energy use and related GHG emissions in the main sectors of the Canadian economy include the level of activity (e.g. production by industry or floor space of residential buildings); the weather; the structure or mix of activities that consume energy in a sector; the service level (e.g. penetration of auxiliary equipment such as computers, fax machines, photocopiers, etc. in commercial/institutional buildings); and the energy efficiency. These factors are not all targeted by domestic emissions reductions policies or measures, but they each influence the results of Canada's efforts to address climate change.

The industrial sector accounted for approximately 38% of total secondary energy use in Canada in 2004. The second largest energy-consuming sector, transportation, accounted for almost 28% of energy use.

Table 4.3.1.2 presents the effects that the principal factors had on secondary energy use in 2004 compared to that in 1990.

Secondary energy use in Canada increased by 23% between 1990 and 2004, and reached 8,543.3 petajoules (PJ). The rise in energy demand was driven primarily by the growth in economic activity across all end-use sectors, while increased energy efficiency was the primary mitigating factor. The other factors were of less importance.

Activity in the industrial sector rose by 40% during this period. In the residential portion of the buildings sector, activity (represented by a mix of households and floor space) rose by 26%. Likewise, the amount of commercial floor space in Canada grew by 24% between 1990 and 2004. In the transportation sector, there was a 31% increase in passenger-kilometres travelled and a 51% increase in tonne-kilometres of freight moved.

Changes in the structure of most sectors of the economy – the mix of activities that consume energy – increased energy use. These increases were mostly offset by a shift in the industrial sector towards industries that are less energy intensive.

Weather was another factor that impacted energy use in 2004. In terms of heating degree days, 2004 was 8% colder than 1990, so this contributed to the 36.5 PJ growth.

[14] This graph omits upstream energy consumed through producer consumption (approximately 1340.0 PJ in 2004) and non-energy use (1017.7 PJ). However, the majority of the energy used by the energy industries (e.g. natural gas in oil sands production) is purchased externally to the company and is thus covered under final demand.

Table 4.3.1.2: Factors Impacting Secondary Energy Use, 2004

Sectors	Energy Use (PJ) 1990	Energy Use (PJ) 2004	Energy Use (PJ) 2004 less 1990	Source of Change (PJ) – 1990 to 2004: Activity	Structure	Weather	Energy Efficiency	Other
Buildings								
Residential	1,289.4	1,420.8	131.4	331.0	46.0	25.6	-271.1	n.a.
Commercial/Institutional	867.0	1,171.2	304.2	218.6	3.3	11.0	-3.1	-1.0
Transportation								
Passenger	1,139.5	1,334.3	194.8	321.4	42.0	n.a.	-160.7	-7.8
Freight	685.1	1,035.2	350.1	348.6	155.5	n.a.	-154.0	n.a.
Off-Road	53.3	95.7	42.4	n.a.	n.a.	n.a.	n.a.	42.3
Industrial (including Forestry)	2,717.4	3,277.5	560.1	1,097.8	-223.9	n.a.	-313.9	n.a.
Agriculture	199.2	208.7	9.5	n.a.	n.a.	n.a.	n.a.	9.6
Total	**6,950.8**	**8,543.3**	**1,592.5**	**2317.3**	**22.8**	**36.5**	**-902.7**	**43.0**

n.a. = not available.

Included in the "Other" column are: agriculture and off-road transportation, (which are excluded from factorization analysis); non-commercial aviation within the passenger transportation sub-sector; and service level effect and street lighting within the commercial/institutional sub-sector.

"Service Level Effect", the service level of auxiliary equipment, represents another 75.5 PJ difference between 1990 and 2004 in the commercial/institutional sector but is not shown here.

Note that numbers may not add up to the total due to rounding.

The key conclusion from the factorization analysis is that energy efficiency played an important role in limiting the growth in secondary energy use and related GHG emissions. Figure 4.3.1.5 shows that if it were not for significant ongoing improvements in energy efficiency in all end-use sectors in Canada, secondary energy use may have increased by 36% between 1990 and 2004, instead of the observed 23%.[15] These energy savings of 902.7 PJ represent emissions avoided in the order of 53.6 Mt.

Figure 4.3.1.5: Secondary Energy Use, With and Without Energy Efficiency Improvements, 1990 to 2004 (Index: 1990 = 1.0)

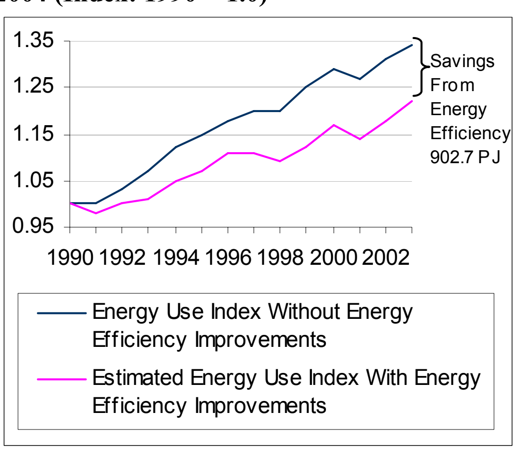
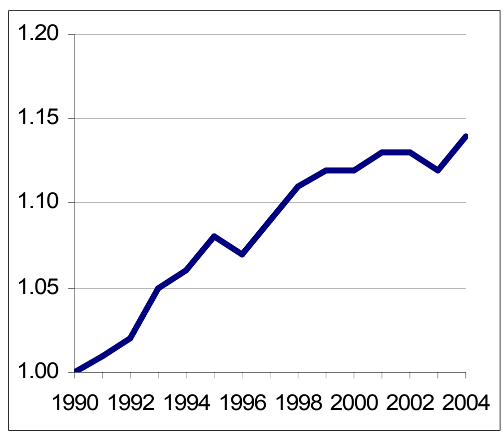


Figure 4.3.1.6 presents an Energy Efficiency Index, which provides an estimate of changes in energy efficiency since the base year of 1990. Canada's overall energy efficiency improved by 14% between 1990 and 2004.

Figure 4.3.1.6: OEE Energy Efficiency Index, 1990-2004 (Index: 1990 = 1.0)



Details on the policies and measures that contribute to reducing GHG emissions across the five sectors of the Canadian economy are provided throughout the remainder of this section.

[15] Source: NRCan, Energy Efficiency Trends in Canada 1990-2004.

4.3.1.2 Federal Cross-Sectoral Measures

The federal climate change strategy provided substantial support for GHG emissions reductions programs that cut across various sectors of the Canadian economy. Elements of these are included in the relevant sectors.

Aboriginal and Northern Community Action Program (ANCAP): ANCAP facilitates the engagement of Aboriginal peoples and Canadians in northern regions to undertake specific initiatives to address their energy needs, with a particular emphasis on supporting the approximately 130 remote Aboriginal and northern communities that rely on diesel generation. This initiative focuses on community energy planning and management; application of renewable energy and improved technology; enhancement of energy efficiency of housing, facilities and transportation; and capacity building, training and tools. The program has been allocated $53.7 million from 2001 to 2008, with $18.3 million spent by the end of 2004/05. ANCAP supported a number of workshops and provided both technical and financial support for the development of feasibility studies and business cases. Project partnerships, which typically include community leaders, utilities, provinces/territories, and private sector funding, are formed on a project-by-project basis. Regional representatives have been trained in energy efficiency and renewable energy technologies. By the end of March 2005, over 60 small to large projects had been generated, including three that have received contribution support.

Federal House in Order (FHIO): This initiative is the federal government's approach to tracking and reducing GHG emissions within its own operations. To show leadership and contribute to achieving Canada's overall goals, the 11 federal departments and agencies that account for 95% of all GoC GHG emissions have agreed to collectively reduce those emissions to 31% below 1990 levels by 2010. Funding of $94.2 million, from 2001/02 to 2005/06, has been designated for the various supporting programs within FHIO, of which over $47 million was spent by the end of 2005/06. The visibility of federal projects is highlighted through conference appearances, newsletters, case studies, signage and private sector involvement. Since 1990, the GoC has already achieved a 25% emissions reduction through building retrofits, better fleet management, strategic "green power" purchases and the downsizing of operations. FHIO is supported by three associated programs:

- The *Federal Buildings Initiative (FBI)* and the *Energy Technology Applications Group (ETAG)* are described in section 4.3.2 on buildings measures, while the *Federal Vehicles Initiative (FVI)* is described in section 4.3.3 on transportation measures.

Pilot Emission Removals, Reductions and Learnings (PERRL): This initiative provided Canadian companies, organizations and individuals with a modest financial incentive to take immediate action to reduce GHG emissions. Through PERRL, the GoC entered into agreements to purchase verified GHG emission reductions from qualified eligible projects in four strategically important sectors, on a fixed price per tonne basis. As a pilot project, it also helped both Canadian governments and private sector organizations learn about and better understand a number of important elements of emissions trading. PERRL was launched in October 2002 and allocated $15 million until the end of 2007.

Opportunities Envelope (OE): This initiative was conceived to provide financial support for cost-effective, GHG emission reduction projects or programs, from any sector of the economy, brought forward by provinces and territories. These proposals would address each jurisdiction's own climate change priorities while contributing to national climate change goals. Announced in the fall of 2003, it was originally a three-year, $160 million initiative, initially with a focus on smaller projects. By the spring of 2005, 29 submissions had been selected for support, representing a federal commitment of $54 million. These projects are expected to be completed in 2006/07.

Green Municipal Fund (GMF): Through grants and loans, the GMF stimulates the implementation of innovative environmental projects undertaken by Canadian municipalities and other public and private sector partners, with a strong focus of reducing GHG emissions; improving local air, water and soil quality; promoting renewable energy; and, brownfield remediation. The Fund has received a $550.0 million endowment from the GoC, which is managed at arms-length from the Government of Canada by the Centre for Sustainable Community Development at the Federation of Canadian Municipalities (FCM). Since its inception in 2000, 342 studies, field tests, pilots and projects, directed to date towards climate change activities, have been approved for funding of $219.6 million, leveraging over $1.3 billion of economic activity in communities across Canada. Of these files, $69.8 million had been dispersed by the end of March 2005. Existing GMF capacity-building activities include the Partners for Climate Protection (PCP) program, the Community Energy Mission, the Sustainable Communities Conference, the Availability and Choice Today (ACT) program and recognition of sustainable community leadership through the FCM-CH2M HILL Sustainable Community Awards. As well, a community assessment tool and sustainable communities workshops have been pilot tested. In addition, the Knowledge Management Unit (KMU) ensures that results and lessons learned are analyzed and shared with municipal governments.

Greenhouse Gas Verification Centre (The Centre): The Centre is an assistive program intended to help domestic climate change initiatives to better quantify their GHG emissions and emission reductions. The Centre has addressed this by building a database and resource centre of GHG-related literature and tools, developing quantification and verification protocols, providing technical support and initiating a process whereby private sector companies could become accredited to verify GHG emissions and emission reductions. The Centre was given a budget of $2.5 million over five years, beginning in 2001/2002. Training sessions are scheduled to run every four to six weeks in 2006/2007. During the verification process, companies or persons will evaluate and test the data and processes (data streams, documentation requirements, etc.) used by facilities. This process will establish a trail of evidence that can be used to support and confirm that reporters' assertions about their emissions and removals are accurate within a specified degree of certainty. The Centre's program is designed to address other GHGs in addition to CO_2, including methane (CH_4); nitrous oxide (N_20); sulphur hexafluoride (SF_6); hexafluorocarbons (HFC); and perfluorocarbons (PFC).

Other Federal Initiatives of Interest

Infrastructure and Communities: While there are no specific GHG emission reduction targets in place, the following three infrastructure programs have, over time, enhanced their focus on sustainability by increasing the emphasis on "green" infrastructure, which supports sustainability, encourages mitigation of GHG emissions and benefits the environment in a number of ways:

- *The Infrastructure Canada Program (ICP)* has a green project target of 50% and encourages investment in such categories as public transit, wastewater and water treatment and distribution, solid waste management, and energy efficiency. This program was introduced in 2000 and virtually all $2.05 billion in funding has been committed with close to 3,000 ICP projects announced.
- *The Canada Strategic Infrastructure Fund (CSIF)* supports projects of major federal and regional significance in areas that are vital to sustaining economic growth and enhancing the quality of life of Canadians, such as highway and rail infrastructure, local transportation infrastructure, tourism or urban development, water and sewage treatment infrastructure and northern infrastructure. The $4 billion set aside for this fund since 2001 helps in reducing production of GHGs and airborne pollutants by making investments conditional on the demonstration of a project's environmental benefit.
- *The Municipal Rural Infrastructure Fund (MRIF)* supports smaller scale municipal infrastructure projects in areas such as water, wastewater, municipal environmental energy improvements, solid waste infrastructure, public transit infrastructure, culture and recreation. This program was launched in 2004 with $1 billion in funding and has been structured to respond to the specific needs of Canada's smaller and First Nations communities. It set requirements for project funding with a national target of 60% for investment in green projects.

In Budget 2005, the GoC enhanced its commitment to sustainable development by allocating $5 billion to the Gas Tax Fund (GTF), a five-year initiative that provides support for environmentally sustainable municipal infrastructure projects such as public transit, water and wastewater systems, community energy systems, solid waste management, rehabilitation of roads and bridges, and capacity building. These investments help cities and communities improve the quality of the environment by contributing to cleaner air, cleaner water and reducing GHG emissions.

4.3.1.3 Provincial/Territorial Cross-Sectoral Measures

Numerous provincial and territorial climate change programs overlap different sectors and industries. Some of the leading cross-sectoral programs and measures are highlighted below.

The most common cross-sectoral measure is a general environmental fund that is aimed at either an extensive group of project proponents or a wide array of climate change topics. The government of *New Brunswick's Environmental Trust Fund* is used to co-fund any projects that contribute to provincial environmental objectives that include energy efficiency and climate change undertakings. Manitoba's *Sustainable Development Innovations Fund* provides funding for the development, implementation and promotion of environmental innovation and sustainable development projects delivered by local governments, industry, community and youth groups, Aboriginal organizations, and First Nation communities.

Canada's territories have been actively using broadly focused funds and organizations to promote innovation and action on a wide scope of climate change issues. The Yukon government has developed the *Community Development Fund*, a program that assists municipal and First Nations governments and community non-profit organizations to conduct projects that improve the quality of community life. Energy-related projects have included wind energy monitoring, solar power for a summer camp, an educational wind turbine for a school, and a wood-fired district energy system. The Government of the North West Territories provides funding for the *Arctic Energy Alliance*, a non-profit organization responsible for delivering a wide variety of programs to regional energy consumers in areas such as energy efficiency, energy technologies, climate change, public education and community energy planning.

Many cross-sectoral measures are designed to give municipalities and local communities the resources to run their own climate change programs. The Alberta government in conjunction with the federal government implements the *Infrastructure Canada-Alberta Program*, aimed at developing regional infrastructure with a focus on encouraging innovation and more efficient use of existing infrastructure, including a specific focus on "green" municipal infrastructure. The Saskatchewan Research Council implements the *Municipal Energy Upgrades* program, which encourages and assists municipalities in reducing their conventional energy use, by making them aware of the potential for saving money and reducing their conventional energy use through improved design of new facilities. British Columbia's *Local Government Grants Program* offers up to $10,000 per application for local government planning activities that support climate change action.

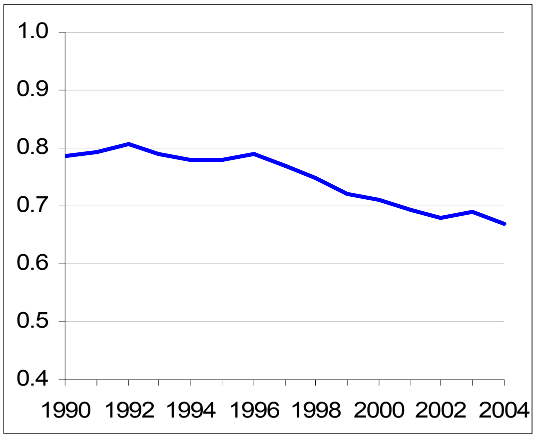
A few provinces have enacted air quality-related regulations that have clear benefits for climate change and affect a wide array of sectors. The Ontario government has introduced *Regulation 419/05, Air Pollution — Local Air Quality* new and updated air standards for 40 pollutants into the regulation to protect Ontario communities from the impacts of air pollution. The new standards are based on health and environmental impacts, and will be used to assess and manage local impacts from industries on surrounding neighbourhoods and communities. The Nova Scotia government has enacted the *Environment Act*, which includes Section 112 - Air Quality Regulations that outlines the new provincial emissions cap and emissions reduction planning requirements for large emitters.

4.3.1.4 Performance Indicators

Economy-Wide GHG Emissions

The GHG emissions intensity of the Canadian economy decreased by 15% between 1990 and 2004 (Figure 4.3.1.7). Between 1990 and 1996, Canadians emitted about 0.8 Mt CO_2 eq./ $billion of GDP, but then emissions intensity declined fairly steadily to less than 0.7 Mt CO_2 eq./ $billion of GDP by 2004, suggesting changes were occurring in the use of carbon within the Canadian economy.

Figure 4.3.1.7: Emission Intensity of the Canadian Economy (Mt CO_2 eq. / $billion of GDP), 1990-2004

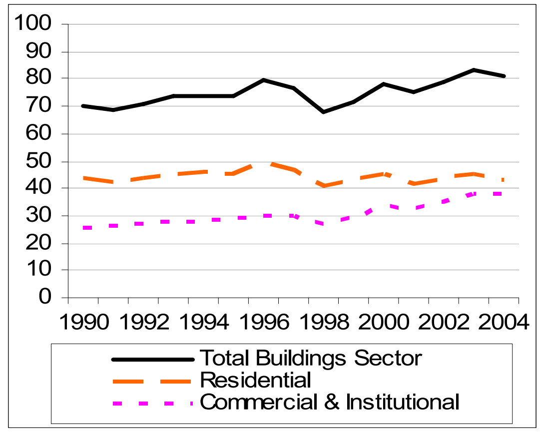


Thus, while GHG emissions across all sectors of the Canadian economy grew by 27% between 1990 and 2004, they grew at a much slower rate than the Canadian GDP. After recovering from mild/strong recession in the early 1990s, the Canadian economy has grown at a sustained rate. Over the 1990 to 2004 period, GDP (by expenditure in 1997 constant dollars) grew by 48%.

4.3.2 Buildings Sector

The buildings sector, a combination of residential dwellings, commercial and institutional buildings, produces GHG emissions primarily from the use of fossil fuels in space and water heating. In 2004, this sector accounted for 11% of Canada's total GHG emissions. Slightly more than half of the emissions came from the residential sub-sector (Figure 4.3.2.1). From 1990 to 2004, emissions from the buildings sector rose by 16%, the majority of the increase derived from the commercial/institutional sub-sector.

Figure 4.3.2.1: GHG Emissions from the Buildings Sectors (Mt CO_2 eq.), 1990-2004[16]



Electricity used in appliances, equipment, lighting and space cooling within buildings also contributes indirectly to GHG emissions. The emissions created in the generation of electricity are reported in Section 4.3.6, "Electricity Generation Sub-Sector", but the measures used to reduce electricity in buildings are presented in this section.

4.3.2.1 Buildings Sector Trends[17]

Residential Trends

Total energy use by the residential sub-sector rose by 10% or 131.4 petajoules (PJ), from 1990 to 2004. End-use analysis shows that the following factors have affected energy demand in this sub-sector:

- a 26% rise in activity (i.e. rise in total square footage of the built environment due to population growth and consumer preferences), resulting in a 331.0 PJ increase in energy demand;
- a colder winter and cooler summer in 2004 compared to 1990, resulting in a 25.6 PJ increase;
- changes in the structure (e.g. mix of end-uses); specifically, increases in the relative energy shares of water heating, lighting and

[16] Unless explicitly stated otherwise, all emissions estimates given in Mt represent emissions of GHGs in Mt CO_2 equivalent, or "Mt CO_2 eq.".

[17] The Trends data presented in each sector within Section 4.3 is taken from the *Energy Use Data Handbook* (2006). The Handbook uses different sectoral mappings than *Canada's Greenhouse Gas Inventory 1990-2004* (CGHGI), so its data is only used for end-use energy trends and energy/ emissions intensity performance indicators, while the CGHGI emissions estimates are used throughout the remainder of the chapter. Refer to Appendix B of the Handbook to review the differences between the two reports.

space cooling, resulting in a 46.0 PJ increase; and,
- energy efficiency gains in appliances, equipment and the thermal envelope of dwellings, resulting in a combined 271.1 PJ decrease.

Commercial/ Institutional Trends

Total energy use by the commercial and industrial sub-sector rose by 35%, or 304.2 PJ, from 1990 to 2004. End-use analysis shows that the following factors affected energy demand in this sub-sector:
- a 24% rise in activity (i.e. total square footage of built environment), resulting in a 218.6 PJ increase in energy demand;
- a colder winter and cooler summer in 2004 than 1990, resulting in a 11.0 PJ increase;
- structural changes in the sector (the mix of activity types), resulting in a 3.3 PJ increase;
- an increase in the service level of auxiliary equipment, or the penetration and usage rates of office equipment (e.g. computers, fax machines, and photocopiers), resulting in a 75.5 PJ increase; and,
- energy efficiency gains, resulting in a 3.0 PJ decrease.

4.3.2.2 Federal Measures

The GoC has had a long history of encouraging emissions reductions in the built environment, with the creation of the Efficiency and Alternative Energy Program in the early 1990s and the adoption of the *Energy Efficiency Act* of 1992.[18] In recent years, the federal government announced several initiatives aimed to augment its activities in this area, particularly under Action Plan 2000, Budget 2003, and Budget 2005. The federal strategy has been composed of four elements:

1. ***residential dwellings***: encouraging more energy efficient and less GHG-intensive houses in Canada;
2. ***commercial/institutional buildings***: encouraging more energy efficient and less GHG-intensive commercial and institutional buildings;
3. ***equipment***: encouraging the use of more energy efficient equipment and/or the use of alternative energy sources;
4. ***targeted clientele***: initiating specialized programs on energy efficiency and the use of alternative energy sources in:
   - aboriginal and northern communities;
   - municipalities; and
   - federal facilities.

With respect to the first two elements, federal initiatives can also be categorized between existing and new buildings.

Nearly 85% of the buildings that will exist in 2010 have already been built, thus most of the near-term GHG reduction potential in this sector lies in improving existing buildings. This can be accomplished through thermal envelope upgrades, retrofits to higher efficiency furnaces, boilers and water heaters, and fuel switching. Federal initiatives aimed at existing buildings take advantage of these near-term opportunities in order to help achieve broader goals such as retrofitting 20% of the housing stock to optimum levels by 2012.

It is generally less expensive to build a new energy efficient building than it is to retrofit an existing building to the same level of efficiency. Although new buildings will make up only 15% of the total building stock in 2010, their share will continue to grow. Therefore, the key to achieving lower-cost, long-term emissions reductions from buildings is to ensure that new construction is more efficient. Federal initiatives contribute to this broad goal by helping to augment the number of new buildings that are built to at least 25% better than the *Model National Energy Code for Buildings* (a reduction of more than 500 megajoules (MJ) of energy used per square metre per year.)

Residential Measures

EnerGuide for Houses (EGH) and Retrofits of Existing Houses (REH): This program aimed to increase the energy efficiency of existing housing through cost-sharing home energy evaluations that recommend energy-efficiency improvements and further provides incentives to encourage homeowners to undertake energy-efficiency retrofits in their homes. This program was terminated in 2006.

R2000 Standard (R-2000) and EnerGuide for New Houses (EGNH): This program undertakes to encourage the construction of healthy, energy-efficient and environmentally friendly new houses in Canada through a series of voluntary actions, including training, builder certification, energy performance labelling of

[18] A description of past activities and results can be found under the chapter on buildings in Natural Resources Canada's *Report to Parliament on the Administration and Enforcement of the Energy Efficiency Act*, first released for fiscal year 1992-93.

new houses, and recognition of premium energy performance of qualified houses. The average energy efficiency level (EGH ratings[19]) of EGNH program participants is now at 77, while the average rating of R-2000 is at 82, versus 73 for new conventional construction. As of 2001, $17 million was allocated to this initiative with $8 million spent by the end of March 2005. As a result, 4,975 industry professionals had been trained and 206 companies, including 46 tract builders, had signed on to EGNH labelling, with 2,600 houses EGNH or R-2000 rated. Participants are also committed to labelling a cumulative annual total of 11,000 houses commencing 2005.

Commercial/Institutional Measures

EnerGuide for Existing Buildings (EEB): Formally known as the *Energy Innovators Initiative, Commercial/Institutional Building Retrofits Initiative and Retrofits of Existing Commercial Buildings*. Collectively, these activities are now referred to as the *Existing Buildings Initiative (EBI)*. This initiative is designed to assist commercial businesses and public institutions to reduce energy consumption and increase energy efficiency through a variety of market transformation tools such as training, technical support, awards, case studies, benchmarking guides and technical sheets. It also provides incentives through contributions to retrofit planning activities and implementation projects. As of March 2005, $68.3 million of the $102.3 million earmarked for the period of 1998/99–2006/07 had been spent on the program. Since 1998, over 225,000 copies of the 70 publications have been distributed to Energy Innovators clients and more than 3,400 professionals have been trained on advanced energy efficiency techniques and practices. In addition, the program stimulated about 715 planning projects and 515 retrofit projects in approximately 6,000 buildings, which save an average of 20% in energy consumption each year.

Commercial Buildings Incentive Program (CBIP) and Improved Efficiency of New Commercial Buildings: This program accelerates the design and construction of new commercial and institutional buildings that are at least 25% more energy efficient than the current *Model National Energy Code for Buildings* (MNECB) through a variety of instruments, including financial incentives, training, and design tools and infrastructure. Funding of $91.7 million has been committed for the period 1998/99–2006/07, with $64.0 million spent by the end of fiscal year 2005/06. CBIP has provided incentives to 746 projects, involving 1,000 design professionals and averaging 35% better performance than the MNECB. There are over 5,000 registered users of CBIP’s simulation software and 3,000 participants have attended training workshops. CBIP projects accounted for 15% of new construction floor space in 2005/06. Since inception, program uptake has been increasing at a rate of approximately 30% per year (50% in last two years) with an anticipated 2,700 more buildings complying by 2012. Five provinces have adopted CBIP as the standard for their own buildings and more than 20 national and regional partners participate in the program.

Refrigeration Action Program for Buildings (RAPB): This program focuses on the deployment of innovative refrigeration technologies integrated with a building’s heating, ventilating and air-conditioning (HVAC) systems, in order to drastically reduce refrigerant losses, allow the recovery and upgrade of the heat rejected by the refrigeration system, and adapt the system’s operation to the Canadian climate. The RAPB performs capacity building, demonstration, information and training activities in partnership with key stakeholders, for Canadian supermarkets, ice rinks and curling rinks. It also undertakes research and development activities on refrigeration technological solutions. The RAPB, which was initiated in September 2003 with a March 2007 termination date, received $2.9 million in funding, of which $2.3 million was spent by the end of March 2005. As of the end of March 2005, five demonstration projects were completed and 14 others were under construction. The new system reduces by 80% to 90% the synthetic refrigerant charge, eliminates the need for space heating equipment, and is 20% to 50% more energy efficient, when compared to conventional systems. The program also delivered seminars and workshops in addition to producing and distributing various training and awareness materials.

[19] EGH rating is a standard measure of a home's energy performance on a scale of 0 to 100. A rating of 0 represents a home with major air leakage, no insulation and extremely high energy consumption. A rating of 100 represents a house that is airtight, well insulated and sufficiently ventilated and requires no purchased energy.

Equipment Measures

Energy Efficiency (EE) Standards and Regulations: This regulatory measure establishes the minimum energy performance standards for energy-using products, gradually eliminating the least energy efficient equipment from the Canadian market. It also provides for labelling of energy-using products and the collection of data on energy use. The initiative has been on-going since the enactment of the *Energy Efficiency Act* of 1992. Canada is a world leader in the use of energy efficiency standards. Regulations have now been established for more than 30 products that consume 80% of the energy used in the residential sector in Canada and 50% of the energy used in the commercial/institutional sector. Regulated products include major household appliances, water heaters, heating and air-conditioning equipment, automatic icemakers, dehumidifiers, dry-type transformers, electric motors of 1 to 200 horsepower and certain lighting products. As a result of Canada's minimum energy performance standards, it is estimated that aggregate annual energy savings in 2010 will be 178 PJ.

EnerGuide for Equipment Labelling: This program is a rating, labelling and information initiative to promote the production, purchase and use of energy-efficient major household electrical appliances and heating, ventilating and air-conditioning (HVAC) equipment. The EnerGuide label shows how much energy major appliances consume in a year of normal service and makes it easy to compare models of the same size and class. Regularly conducted surveys indicate that over 50% of Canadians are aware of the EnerGuide label.

Accelerated Standards Action Program (ASAP) and Enhanced Equipment Market Transformation (EEMT): This initiative encourages the supply and purchase of highly efficient energy using equipment through the promotion of endorsement labels, high performance procurement specifications, pilot incentive programs targeted at various levels in the product distribution chain and the deployment of more stringent energy efficiency standards in the future. The Energy Star program complements the EnerGuide program by going one step further and identifying specific products that meet or exceed premium levels of energy efficiency, those deemed to be "best-in-class", for consumers. ASAP/EEMT has been allocated $50.0 million in funding between 2001/02 and 2006/07, with $23.5 million having been spent by the end of March 2005. Partners, who contribute financially through cost sharing of incentives to consumers or organizations, include 11 provincial and territorial governments, all major Canadian electricity and gas utilities, non-government organizations, and environmental groups. Energy Star is recognized by 45% of Canadians as a mark of high efficiency. Only four years after its introduction, 60% of total equipment sales meet 2001 Energy Star levels and 100% of sales are projected to meet that level by 2010.

<u>NOTE:</u> All the equipment measures are now collectively referred to as the *Equipment Market Transformation (EMT)* program, which includes the Standards and Regulations, EnerGuide for Equipment Labelling, and ASAP and EEMT described above.

Renewable Energy Deployment Initiative (REDI): This initiative is designed to promote renewable energy systems for space heating and cooling and water heating within the business, industrial, and institutional sectors (including federal departments). REDI provides information and financial incentives to stimulate demand for systems, to create market awareness, and to develop industry infrastructure and capacity. The REDI financial incentive is equal to 25% of project cost for solar thermal systems and 15% of project cost for biomass combustion systems (up to 40% in northern and remote areas, which include one-third of aboriginal communities), to a maximum of $80,000. No incentive is provided for ground source heat pump systems, although a REDI partnership with the Canadian Geoexchange Coalition provides support to this industry indirectly. Overall, $59 million has been committed for the period April 1998 to March 2007, with $30.5 million spent in the first six years. REDI interacts with a variety of stakeholders, including those from all levels of government, the renewable energy industry, the private sector and NGOs. As of March 31, 2005, REDI had supported 471 green heating and cooling systems, and aims to install a total of 600 active solar thermal systems and high-efficiency/low emission biomass combustion systems, as well as 6,000 ground-source heat pump systems by March 2007.

Targeted Clientele Measures

Aboriginal and Northern Community Action Program (ANCAP): General information about ANCAP is provided in section 4.3.1 on cross-sectoral measures; however, it is worth noting here that an EGH pilot project has been implemented to improve EGH delivery capacity in First Nation, Inuit, and Northern Communities.

Federal House in Order (FHIO): General information about FHIO is provided in section 4.3.1 on cross-sectoral measures. Under the Federal Building Demonstration Projects, which showcased innovative emission reduction and renewable energy projects, some 60 federal buildings and housing projects were enhanced, with at least one project in each province and territory. Building related projects are supported by two associated programs:

- *The Federal Buildings Initiative (FBI)* assists federal organizations in implementing energy efficiency improvements in their facilities to reduce energy costs and GHG emissions, through public-private partnerships with energy management firms. This program has been funded mostly under departmental base funding and is now supported only through FHIO. The FBI provides an implementation model, supporting documents, information and advice to facilitate the development of projects. New projects averaged 18% in efficiency improvements. The FBI has fostered more than 80 projects, attracting $265 million in private sector investment, generating $38 million in annual energy cost savings and reducing GHG emissions by approximately 250 kt.
- *The Energy Technology Applications Group (ETAG),* formally known as the *Federal Industrial Boiler Program (FIBP),* provides technical and project management services related to energy reduction and sustainable development of facility heating, cooling and ventilating systems and overall energy consumption at federal departments and agencies. It is funded under departmental base funding and operates on a cost-recovery basis. Through projects implemented by this program, GHG emissions were reduced by an average of 4.7 kt per year, which amounted to energy savings of approximately 1,150 TJ in 2004/05.

Other measures related to electricity purchases and on-site generation contribute to the goal of reducing emissions from federal facilities; these measures are described in section 4.3.6, “Electricity Generation Sub-Sector”.

Opportunities Envelope (OE): General information about the OE is provided in section 4.3.1 on cross-sectoral measures. It supports initiatives put forward by provinces and territories. Sixteen of these initiatives, accounting for more than half of the total OE funding, are intended to improve the energy efficiency of buildings, equipment and appliances through the provision of financial incentives to end-users and regulatory amendments to provincial building codes. These will therefore contribute to reducing emissions beyond the built environment targets of existing federal programs.

Green Municipal Fund (GMF): General information about the GMF is provided in section 4.3.1 on cross-sectoral measures. Emission reductions in the buildings sector are expected from projects in energy-efficient building retrofits, renewable energy and community energy systems. Examples include Edmonton’s *CO2RE Home$avers Series* project and the *Greening the Infrastructure at Benny Farm – Chez-soi* project in the City of Montreal.

Other Infrastructure Programs: Emissions from energy consumption in the built environment can be significantly reduced through improved energy efficiencies. Effective modern infrastructure investments in the development of the built environment can lead to improvements in environmental sustainability. The GoC is strategically targeting its infrastructure-related investments to promote better environmental outcomes through various initiatives. General information about the infrastructure programs is provided in section 4.3.1 on cross-sectoral measures.

4.3.2.3 Provincial/Territorial Measures

Many of the Provincial/Territorial initiatives build on federal government measures to reduce GHG emissions in the building sector. Some of their leading programs and measures are highlighted below.

Most provinces/territories have programs that provide support, through the provision of information or planning services, to government departments, municipalities, and the private sector in order to increase energy efficiency and the use of renewable energy in institutional and/or commercial buildings. In Saskatchewan, the *Office of Energy Conservation* partnered with the *Saskatchewan Urban Municipalities Initiative* for a project that encourages the use of solar heating to reduce the natural gas consumption of outdoor swimming pools. Yukon has a program that promotes the installation of space heating systems that use an alternative fuel and the retrofit of outdated electrical systems in commercial buildings. British Columbia has created the *Green Buildings BC* program, which provides schools and hospitals with the resources needed to design buildings that reduce both the direct and indirect environmental consequences associated with its construction, occupancy, operation, maintenance and eventual decommissioning.

Provinces have recognized the importance of supporting building standards with incentive funding. Quebec has a program that provides financial support to encourage energy efficiency in institutional buildings, mainly in the health, social services and education sectors. *BC Hydro*, through its *Power Smart* program, works with numerous municipalities to help them identify cost-effective energy efficiency opportunities, and helps project proponents apply for incentive funding for technical, financial and training support. Alberta has developed standards and guidelines for the building of new schools, to ensure they meet high energy efficiency standards. To complement these standards, Alberta has established a $100 million interest-free *ME First!* loan program, which helps municipalities carry out energy efficiency projects in their buildings.

A number of provinces/territories provide energy efficiency and conservation information to homeowners, including Alberta (through *Energy Solutions Alberta*), Saskatchewan, Ontario, New Brunswick, Nova Scotia, Yukon and Northwest Territories (through the *Artic Energy Alliance*). Some also provide information and advice on home heating options, including renewable energy sources. Nova Scotia has developed an independent *Energy Advisory Service* to provide homeowners and the construction industry with a source of unbiased technical advice on energy related issues.

Provinces are increasingly offering financial incentives to promote residential energy refurbishment upgrades. Quebec, through *Hydro Quebec*, offers financial support for upgrading the energy efficiency of homes. *Saskatchewan Housing Corporation* offers an energy efficiency refurbishment grant of $1,500 per unit in an attempt to reduce energy consumption within the province's *Senior Social Housing* sector. A few jurisdictions (Manitoba, Yukon and Northwest Territories) provide homeowners with evaluations of the energy use of their homes. Prince Edward Island has created a $1.4 million energy assistance plan that includes direct assistance to low-income Islanders in the form of a home energy efficiency upgrade and low interest loans, as well as a provincial sales tax exemption on alternative heating systems such as wood stoves, pellet stoves, solar panels and geothermal units.

A few provinces have initiated programs to support the construction of new energy efficient homes. Both Manitoba and Quebec encourage consumers and builders of new houses to construct homes to a high standard of energy efficiency. British Columbia has a tax incentive program to encourage energy conservation and use of alternative energy in new residential buildings.

Provinces and Territories recognize the important role that innovative energy efficient equipment will play in reducing GHG emissions. British Columbia, Ontario and New Brunswick have *Energy Efficiency Acts*, and Nova Scotia has an *Energy-Efficient Appliances Act*, which set out minimum energy performance standards for energy devices (such as appliances and equipment). Both Quebec and New Brunswick have put into practice regulations that have eliminated the most energy inefficient appliances. Saskatchewan has created the *Communities of Tomorrow Project*, a research centre that specializes in building sustainable communities and is developing a house that uses new technology to achieve a 90% reduction in energy consumption and 50% reduction of water consumption, when compared to that of conventional homes.

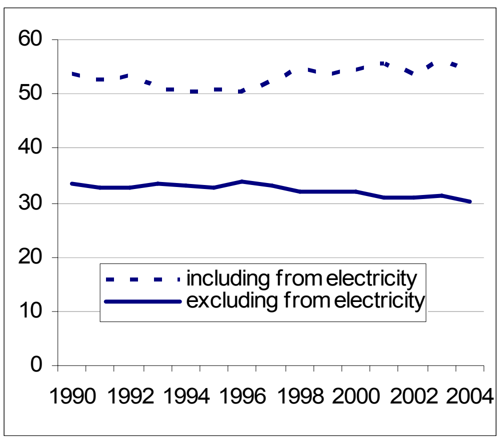
4.3.2.4 Performance Indicators

Residential Indicators

Since 1990, the energy intensity of the residential sub-sector, in the form of energy consumed per square metre of residential floor space, has been affected significantly by energy efficiency and energy mix (part of the energy mix effect of which is included in the energy efficiency effect.) End-use analysis shows that without energy efficiency improvements, energy use by the residential sub-sector would have risen by 31% between 1990 and 2004, instead of the observed 10%.

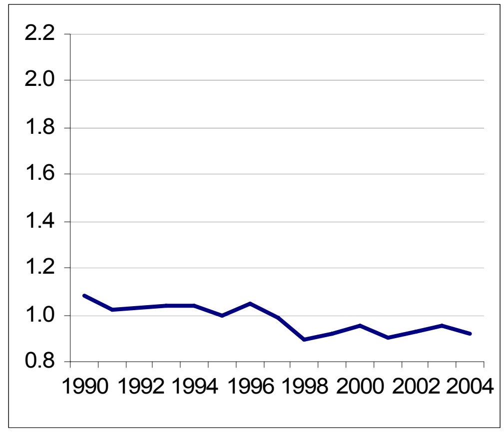
Between 1990 and 2004, the share of natural gas grew in the residential energy mix, displacing heating oil, which is a higher carbon fossil fuel. Natural gas now represents 46% of the total energy use in this sector, electricity being the second most important source at 38%. As a result, the carbon intensity of the energy consumed in this sector declined by 10%, or 3.3 tonnes of CO_2 per terajoule, between 1990 and 2004. If emissions from electricity generation are taken into account, the carbon intensity rose by 0.2% (Figure 4.3.2.2).

Figure 4.3.2.2: Carbon Intensity of the Residential Sub-sector (tonne/TJ), 1990-2004



Thus, improved energy efficiency, including a positive change in the energy mix, aided in achieving a 15% decrease in energy intensity per square metre of residential floor space between 1990 and 2004 (Figure 4.3.2.3).

Figure 4.3.2.3: Energy Intensity of the Residential Sub-sector (GJ/m^2), 1990-2004

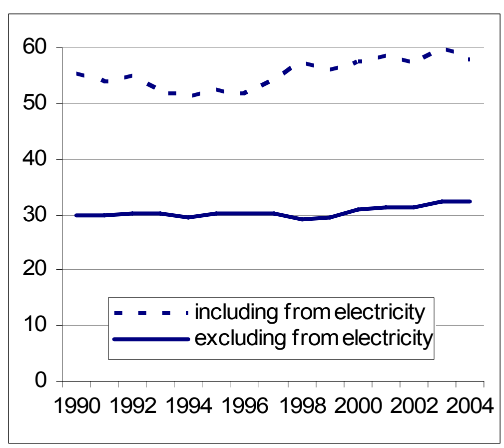


Commercial/ Institutional Indicators

Similarly to the residential sub-sector, the commercial/ institutional sub-sector energy intensity was affected by energy efficiency, including energy mix. A detrimental shift in the energy mix between 1990 and 2004 was partially offset by other energy efficiency gains.

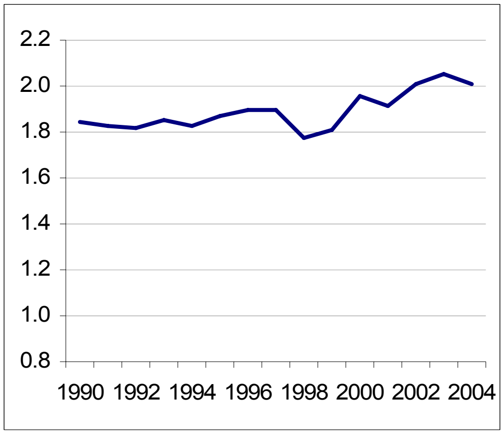
Electricity, the second most important energy source in the sub-sector after natural gas, declined from having 45% to 41% of the share of the energy mix during the analysis period, replaced by heavy fuel oil. As demonstrated, the carbon intensity of the sub-sector rose by 8% (Figure 4.3.2.4). If emissions from electricity generation are taken into account, the carbon intensity grew by 5%. The REDI initiative may counteract this trend over time by enhancing the uptake of renewable energy systems into businesses and institutions in the future.

Figure 4.3.2.4: Carbon Intensity of the Commercial/Institutional Sub-sector (tonne/TJ), 1990-2004



As a result of these changes in energy efficiency, the energy intensity per square metre of commercial and institutional floor space rose by 9% between 1990 and 2004 (Figure 4.3.2.5).

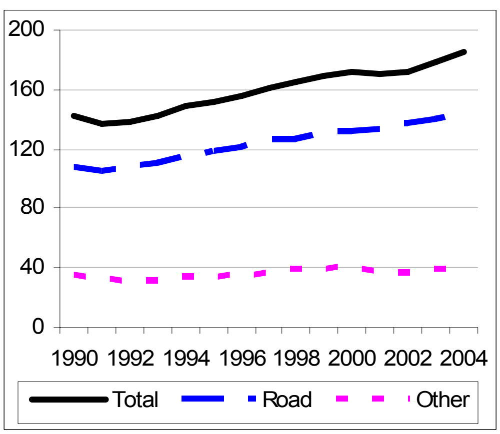
Figure 4.3.2.5: Energy Intensity of the Commercial/Institutional Sub-sector (GJ/m²), 1990-2004



4.3.3 Transportation Sector

The transportation sector was the second leading source of GHG emissions in Canada in 2004. The sector accounted for approximately 24% of Canada's greenhouse gas emissions that year.[20] Total emissions were up 30% from their 1990 levels (Figure 4.3.3.1).

Figure 4.3.3.1: GHG Emissions from the Transportation Sector (Mt CO_2 eq.), 1990-2004[21]

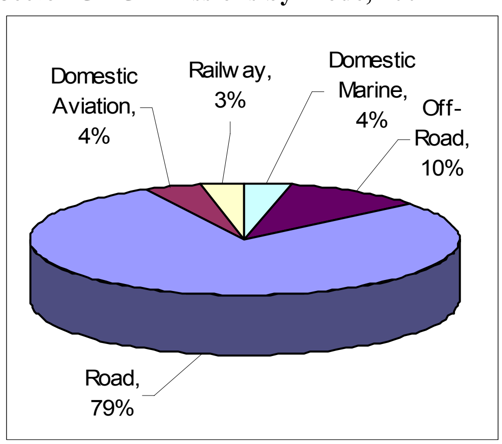


The transportation sector includes activities related to the transport of passengers and freight by four modes; road, rail, marine and air.[22] Vehicles and equipment, fuels and infrastructure used in the four modes interact within Canada's transportation system. The transportation sector also includes off-road equipment, such as industrial, forestry and agricultural machinery, snowmobiles and lawn mowers. GHG emissions from this sector result from the combustion of fossil fuels, especially refined petroleum products, which provide almost all of the energy used for transportation.

Canada is a nation with a challenging climate, a diverse and rugged terrain, and a population spread over a vast geographic expanse. Transportation contributes to the health, well-being and quality of life of all Canadians. It is a basic need, influencing daily choices, lifestyles and opportunities. Canadians value their ability to move freely and efficiently to access food, goods and services, friends and family, employment, and recreation. The Canadian economy depends upon reliable, reasonably priced transport services to meet its needs as a major trading nation. It requires, for efficiency and competitiveness, goods transportation services that are flexible and meet service requirements such as just-in-time delivery.

Road transportation was the mode that led in emissions, accounting for more than three-quarters of total transportation sector emissions (Figure 4.3.3.2). Road transportation also increased by 38.4 Mt between 1990 and 2004, accounting for 90% the sector's growth in emissions between 1990 and 2004.

Figure 4.3.3.2: Proportion of Transportation Sector GHG Emissions by Mode, 2004



Note: Totals may not add due to rounding.

[20] Some numbers may be different from those cited in the National Inventory Report due to rounding.
[21] The total may not add up for certain years due to rounding.

[22] The transportation emissions data used in this chapter excludes emissions resulting from oil and gas pipelines (covered under the Industrial sector), and the use of energy in the foreign aviation and marine sub-sectors.

It should be noted that, as a result of the high altitudes above the Earth's surface at which commercial aircraft emit GHGs, the aviation industry has a greater effect on climate change (through radiative forcing) than might be expected from its share of transportation sector emissions.

4.3.3.1 Transportation Sector Trends[23]

Many factors influence the transportation demand over time: the size of the population; its disposable income; the spatial design of urban areas; the technology that is embedded in current transportation infrastructure; vehicles; fuels; and the weather. Transportation demand is further influenced by economic factors such as the growth of national income; growth in commodity flow and trade; the cost of vehicles and equipment; the cost of operations; and the cost of fuels. Trends in the transportation sector have been divided into three sub-sectors for the purpose of this report: passenger, freight and off-road.

Between 1990 and 2004, energy consumption in the transportation sector grew by 31%. Without energy efficiency improvements, the growth in transportation related energy use and GHG emissions would have been higher.

Trends in Passenger Transportation

The passenger transportation sub-sector consumed slightly more than half (54%) of the energy used in the transportation sector, reaching 1334.3 PJ in 2004. Total energy use by passenger transportation grew moderately between 1990 and 2004, up 17%, or 194.8 PJ. End-use analysis shows that the following factors have affected energy demand in this sub-sector:

- a 31% rise in activity level, defined as the number of passenger-kilometres travelled,[24] resulting in a 321.3 PJ increase in energy use;
- changes in the mix of transportation modes, with a relative growth in light truck use over cars as well as a relative growth in air use over rail, which resulted in a 42.0 PJ increase in energy consumption; and,
- improvements in the overall energy efficiency, especially in light-duty road vehicles and air transportation, which resulted in a decrease of 160.7 PJ.

Of the rise in passenger transportation energy use, 99% was attributable to light trucks (e.g. minivans and sport utility vehicles) even though they only accounted for 31% of the private vehicle stock. Light trucks experienced a strong growth in activity, with an increase of 127% in passenger-kilometres travelled between 1990 and 2004. Air transportation also grew significantly, up 70%.

Trends in Freight Transportation

The freight transportation sub-sector consumed 42% of the energy use in the transportation sector, reaching 1035.2 PJ in 2004. The sub-sector's total energy use grew significantly between 1990 and 2004, up 51%, or 350.1 PJ. It was the fastest growing transportation sub-sector between 1990 and 2004, accounting for more than half (61%) of the change in transportation energy consumption. End-use analysis shows that the following factors have affected the energy demand during this period:

- a 51% rise in activity level, defined as the number of tonne-kilometres moved, which resulted in a 348.6 PJ increase in energy demand;[25]
- structural changes resulting from shifts in activity between transportation modes - specifically, an escalation in the share of freight moved by heavy trucks relative to other modes - which resulted in an increase of 155.4 PJ;
- improvements in energy efficiency, particularly more fuel efficient trucks and locomotives, which resulted in a decrease of 154.0 PJ.

The expansion of freight transportation activity was spurred by increased international trade resulting from free trade agreements, and by the deregulation of the trucking and rail industries. The growth in trade with the United States and customer requirements for just-in-time delivery led to an increase in the share of freight moved by heavy trucks, which are more energy intensive relative to other modes.

[23] The Trends data presented in this section is taken from the *Energy Use Data Handbook* (2006). The data differs from the CGHGI data in that does not include the energy/emissions associated with industrial and agriculture diesel and agriculture motor gasoline. It also includes emissions resulting from the use of energy in the foreign aviation and marine sub-sectors and includes end-use electricity-related emissions related to the transportation sector. Refer to Appendix B of the Handbook for a more detailed description of the differences.

[24] A passenger-kilometre (Pkm) is the transportation of one passenger over the distance of one kilometre.

[25] A tonne-kilometre (Tkm) is the transportation of one tonne over the distance of one kilometre.

Trends in Off-road

The off-road transportation sub-sector consumed 4% of the transportation energy use in 2004[26], but end-use analysis reveals that off-road energy use increased by 80% between 1990 and 2004.[27] In 2000, estimates indicated that there were approximately 12 million off-road vehicles and equipment in Canada, which operated over 1.4 billion hours per annum in total. On average, between 1990 and 2004, 70% of the off-road energy was consumed by diesel-powered machines in the agricultural, construction and mining sectors. However, that percentage has declined to 66% since 2002.

4.3.3.2 Federal Measures

Canada's policy approach toward reducing transportation GHG emissions requires close coordination among federal, provincial, and territorial governments. The approach includes infrastructure modernization and adaptation, urban planning upgrades for efficient and integrated transport systems, technology development, and activities with stakeholders to promote behavioural changes.

Several factors that influence transportation demand are exogenous to the Canadian emissions mitigation strategy, such as growth in population and disposable income. The strategy concentrates on those that can be addressed through existing transportation technologies, while balancing between cost-effective GHG reductions and serving the needs of individual Canadians and the economy. Targeted factors include:

- ***Choice of vehicle / equipment***
  Encouraging individual Canadians and transportation service providers to use energy efficient vehicles or equipment, as well as supporting the commercialization of lower carbon-fuelled vehicles, can reduce fossil fuel consumption and therefore emissions.
- ***Supply and use of alternative fuels***
  Increasing the availability and market acceptance of lower carbon alternative fuels can reduce GHG emissions from transportation. Examples of lower carbon alternatives include cellulosic and grain-based ethanol, hydrogen, hydroelectricity and bio-diesel – all of which have applications in passenger and freight transportation.
- ***Transportation system efficiency improvements***
  Improving the efficiency with which individual components of the transportation system are used, and modes within the system are integrated, can reduce energy demand. One aspect involves improving vehicle / equipment maintenance and operator practices (e.g. using energy efficient driving techniques). Another aspect involves facilitating the integration of personal vehicles with alternative, more energy-efficient modes and supporting the use of the most energy-efficient mode of transportation for a given freight service. A third aspect is applying an Intelligent Transportation Systems (ITS) strategy, which involves a broad range of technologies applied to make transportation systems safer, more efficient, more reliable and more environmentally friendly, without necessarily having to physically alter existing infrastructure. ITS can contribute to improvements in areas such as traffic management and congestion control. Effective transportation planning, technology and infrastructure are critical to system efficiency improvements.
- ***Reduction in transportation demand***
  GHG emissions can be reduced by managing the overall demand for transportation (expressed in Pkm and Tkm) operated over a given period. This requires developing passenger transportation alternatives and urban forms that reduce auto-dependency. In terms of freight transportation, it is critical to use effective price signals.

Federal measures that support the four targeted factors are presented under the following headings:

1. passenger transportation;
2. freight transportation;
3. off-road transportation;
4. alternative fuels; and,
5. targeted clientele.

The strategy combines multiple, mutually reinforcing initiatives that seek to influence at both the individual and the system level.

Passenger Transportation

Many of the federal initiatives are focused on Canada's urban transportation systems. About two-thirds of transportation emissions originate in our urban areas.

[26] Bear in mind that this Handbook data excludes industrial and agriculture transportation fuel. The difference explains in part why the CGHGI emissions data reported elsewhere in Section 4.3.3 suggests the off-road sub-sector has a much larger share of the transportation sector energy/emissions.
[27] Some numbers may differ from the Handbook due to rounding.

Urban Transportation Showcase Program (UTSP): This program encourages individuals to reduce the use of personal vehicles by demonstrating the advantages and convenience of integrating alternate, sustainable modes of transportation. A total of $40.0 million has been committed for the period 2001/2002 to 2006/2007, of which $7.2 million was spent by the end of 2004/2005. The federal government works in partnership with municipal and regional governments and authorities to showcase integrated transportation projects in urban areas. The UTSP engaged 48 municipalities in proposal development and invited 15 communities to submit detailed proposals for funding, resulting in eight projects being selected. It also developed 40 case studies on successful Canadian sustainable transportation projects and held over 40 seminars, workshops, and other public education and outreach events. The capacity to reduce GHG emissions is enhanced as a result of behavioural changes and the selection of more energy efficient land use/transportation planning strategies by municipalities. GHG emissions reductions strategies are also replicated in other jurisdictions.

Motor Vehicle Fuel Efficiency Initiative (MVFEI): This initiative aims to improve the fuel efficiency of motor vehicles in Canada. It has been designed to influence the supply and penetration of more fuel-efficient vehicles as well as the demand for, and use of, these vehicles by Canadians. MVFEI was allocated $16.0 million between 2001/2002 and 2005/2006, with $10.0 million of that spent by the end of 2004/2005. On April 5, 2005, the GoC signed an agreement with the Canadian automotive industry, under which the latter pledged to take actions to voluntarily reduce GHG emissions of new light duty vehicles in Canada so that by 2010, annual emissions reductions will reach 5.3 Mt. This will be achieved through technological improvements and by helping to change consumer behaviour. Entry-level, fuel-efficient vehicles now account for about 40% of total sales in Canada, compared to 30% a decade ago. The number of motorists performing regular vehicle maintenance has also increased from 37% in 1998 to 46% in 2005. MVFEI is supported by the following associated programs:

- *Advanced Technology Vehicles Program (ATVP)* evaluates advanced vehicles and technologies, to determine their role in meeting the MVFEI program objectives and to showcase these technologies and their benefits to Canadians. It also identifies regulatory barriers to the penetration of advanced technology vehicles into the Canadian market. By the end of 2004/2005, ATVP spent $2.7 million of the $4.0 million funded under MVFEI for the period 2001/2002 to 2005/2006. As of March 2005, 126 vehicles were acquired, 400 on-road evaluations completed, 900 instrumented track and laboratory tests conducted, and 144 public events were held reaching 7 million Canadians.
- *Marketing of Efficient Vehicles (MEV) and Personal Vehicles Initiative* promotes sustainable energy conservation behaviour by consumers to reduce fuel consumption through the purchase of fuel-efficient vehicles and the improvement of operating and maintenance practices. Specific activities to assist consumers include: 1) the EnerGuide for Vehicles (EGV) labelling system and the New Vehicle Ranking System (NVRS), launched in January 2006; 2) the CO_2 rating system; and, 3) targeted campaigns such as the Idle-Free Initiative, Auto$mart Fuel-Efficient Driving and Vehicle Maintenance Tips. Funding for this program comes from MVFEI and departmental base funding, in addition to the $5.5 million committed between 2003/2004 and 2006/2007, of which $1.2 million was spent by 2004/2005. Over 9 million Canadians have been reached in the annual campaigns. A 2005 survey highlighted that 79% of vehicles in dealership lots had EGV labels displayed compared to 64% in 1999. Since program implementation, over 100 municipalities and/or community groups have launched idle-free campaigns, 150,000 new drivers have been trained for fuel efficiency and some 300,000 Fuel Consumption Guides were distributed in 2004/2005 alone.

Moving On Sustainable Transportation (MOST) Program: This program supports small-scale projects that promote awareness of sustainable transportation issues and develop practical tools and approaches to encourage concrete action by Canadians. Although MOST was not designed specifically as a climate change program, it has the potential to mitigate GHG emissions through social marketing and capacity building in sustainable transportation. MOST will allocate approximately $3.5 million, between 1999/2000 and 2006/2007, to projects that promote the program's objectives. As of March 31 2005, 84 projects had been approved for a total of approximately $3.0 million in funding.

Freight Transportation

Freight Efficiency and Technology Initiative (FETI): FETI is designed to help transform Canada's freight transportation system by engaging the freight industry in efforts to reduce growth in their GHG emissions via technology uptake and innovative operational practices. This five year (2001/2002 to 2006/2007) $14.0 million initiative is split between the road fleet component, which has been allocated $6.15 million, and the multi-modal (air, rail and marine modes) component with the remaining $7.85 million in funding. Furthermore, FETI is delivered through the following three components:

- *The Freight Sustainability Demonstration Program (FSDP)* encourages the take up of technologies or best practices that can reduce GHG emissions from all freight modes. Funding of $4.7 million is dedicated to this program. To date, 34 projects are being implemented with an aggregated price tag of approximately $4.7 million.
- *Voluntary Performance Agreements* are being established between the federal government and industry associations within each freight mode to outline concrete initiatives for reducing GHG emissions. For example, an agreement was reached in November 2004 with the Air Transport Association of Canada that will encourage its members to improve their energy efficiency by an average of 1.1% a year, which will result in a collective GHG emissions reduction of 24% by 2012, when compared to 1990 levels.
- *Training and Awareness* to provide carriers in all freight transportation modes with a better understanding of the impact of transportation on climate change and improve their competitiveness through efficiency-enhancing technologies and best practices. This is done through a series of events such as conferences, workshops, and promotional material. For example, approximately 200,000 truck operators have been trained or retrained and are bringing about an average of 10% improvement in fuel use. Conferences and workshops on the environment and the emissions reduction have been hosted or funded for the aviation, rail and marine sector, reaching hundreds of participants from major stakeholders.

Commercial Transportation Energy Efficiency and Fuels Initiative (CTEEFI): This initiative, which focuses on increasing the market penetration of efficiency enhancing technologies in all modes of commercial and freight transportation, complements existing energy-efficiency efforts under FETI. Technical workshops, training programs, and publications on preventive maintenance, fuel management practices, and better informed modal choice are also part of this initiative. A total of $32.3 million has been allocated to CTEEFI from 2003/2004 to 2007/2008, which is delivered through the following components:

- *The Commercial Transportation Energy Efficiency Rebate Program* offers rebates to truck and bus operators to encourage the use of proven, off-the-shelf technologies that reduce idling. Approximately 150 trainers and 8,500 transit drivers have received training, sustaining a fuel consumption improvement of 10% on average. Technical workshops were delivered to more than 270 fleet participants across Canada. An estimated 5,900 additional cab heaters and 625 additional auxiliary power units were sold by the end of 2004/2005, reducing hours of unnecessary idling substantially. In addition, 127 factory made light duty natural gas vehicles (NGVs) and 105 conversion kits were purchased, reducing GHG by approximately 20% annually on fuel full life cycle basis.
- *The Freight Efficiency Program (FEP)* aims to reduce GHG emissions by Canadian companies and not-for-profit organizations in the rail, air and marine freight-transportation industries. It administers the Freight Incentives Program (FIP), provides funding for Marine-shore Power Pilots and delivers Awareness Programs for Shippers and Freight Forwarders. Of the $11.0 million earmarked for this program from 2003/2004 to 2007/2008, $5.0 million is directed to the FIP to help in the purchase and installation of tested technologies that cost-effectively reduce GHG emissions. Approximately $1.0 million was approved for allocation to three FIP projects by the end of 2004/2005. One of these projects resulted in a 53% reduction in the company's fuel consumption. To date, a total of 13 projects have been selected for incentives; a major feasibility study has been completed for three marine-shore power pilot projects; and, concept papers for the Shippers Awareness campaign have been developed.

Off-Road Transportation

Off-Road Vehicles and Equipment Initiative: This initiative examined ways to reduce GHG emissions from off-road vehicles and equipment. It did this by gathering and disseminating data; improving the GHG forecast and inventory for the off-road sector; as well as increasing awareness of consumers and industrial users of off-road machines. Funding of $1.1 million was committed for the period from 2003/2004 to 2005/2006. Information on the off-road sector has been gathered and disseminated to interested parties via a discussion paper and five supporting technical papers in 2004, followed by a multi-stakeholder workshop in Toronto. Information on off-road was further improved through the results of eight targeted studies that took place in 2005/2006. Over 150 parties participated in the initiative.

Off-Road Engine Emission Regulations: The *Off-Road Small Spark-Ignition Engine Emission Regulations* came into force on January 1, 2005 and established standards for spark-ignition engines rated up to 19 kW (25 hp). These are typically gasoline-fuelled engines found in lawn and garden machines (hedge trimmers, brush cutters, lawnmowers, garden tractors, snowblowers, etc.), in light-duty industrial machines (generator sets, welders, pressure washers, etc.), and in light-duty logging machines (chainsaws, log splitters, shredders, etc.). Although this regulation was designed to reduce the maximum allowable limits for pollutants that contribute to smog, the engine technology used to meet the regulation may also contribute toward reducing GHG emissions.

Alternative Fuels

Canadian Transportation Fuel Cell Alliance (CTFCA): The federal government is paving the way for the introduction of fuel cell vehicles. CTFCA aims to develop the necessary supporting framework for the fuelling infrastructure and to encourage the adoption of hydrogen vehicles through technological development; demonstration of production processes and delivery of hydrogen to fuel cell vehicles; and, financial incentives. This initiative is also helping to develop standards, training and testing procedures related to fuel cell and hydrogen technologies. Of the $33.0 million being invested for this initiative between 2001/2002 through to 2007/2008, $16.6 million was spent as of the end of March 2005. CTFCA relies heavily on the vision and energy of about 50 key partners, ranging from industry, municipalities, NGOs, federal and provincial governments, and universities. There are currently eight operational fuelling stations in Canada, with a goal of reaching 20 such stations by 2010. There are also four Ford Focus fuel cell passenger vehicles and a Purolator fuel cell delivery van being tested. In addition, dual fuel gasoline/hydrogen and diesel/hydrogen pick-up trucks are being developed and demonstrated. It is estimated that, by 2010, sales of light duty fuel cell vehicles will reach 7,000 vehicles and sales of fuel cell transit buses are projected to reach 100 units.

Natural Gas Vehicle Market Transformation: The objective of this program is to re-invigorate the NGV market, with a focus on light duty vehicles and large fuel-consuming commercial fleets, through vehicle grants, the establishment of revolving funds and promotion and awareness activities. The program is funded by $9.9 million from 2003/2004 to 2006/2007. A pilot project, conducted from April 1, 2005 to March 31, 2006, paid eligible beneficiaries up to $3,000 toward the capital cost of buying or leasing a new NGV, or for converting a gasoline vehicle to natural gas using an advanced natural-gas vehicle-conversion system installed by an approved conversion facility.

Future Fuels Initiative (FFI) and Ethanol Expansion Program (EEP): These programs aim to boost Canada's annual ethanol production and use and provide market information to consumers. FFI essentially renews the National Biomass Ethanol Program (NBEP), which helps overcome lender resistance to investing in ethanol plants, by providing up to $140 million in contingent loan guarantees. It also creates public awareness and analytical capacity. The EEP is providing $118.2 million in repayable contributions toward the construction financing of fuel ethanol production facilities. FFI received $3.0 million in funding from 2001/2002 to 2005/2006, while $100.0 million has been pledged for EEP from 2003/2004 to 2007/2008. It was also agreed that an additional $18.2 million in contributions would come from departmental funding. As of the end of March 2005, a total of $32.6 million had been spent. To date, 11 ethanol plant projects have been selected and allocated contributions, five of which have started construction. These plants are expected to produce over 1.2 billion litres of fuel ethanol per year by the end of 2007, which would raise domestic production to seven times what it was prior to the launch of the program.

Biodiesel Initiative: This initiative addresses technical and market barriers to the development of a sustainable Canadian biodiesel industry, in an effort to reduce GHG emissions from the transportation sector. As of the end of March 2005, $3.7 million of the $11.9 million set aside for this program, from 2003/2004 to 2006/2007, had been spent. The program has expanded knowledge-based and policy making capacity by developing a national fuel standard for low level blends, and work is ongoing for higher level blends. Five end-use demonstration projects in different transportation areas are currently underway and two Canadian pilot plants have now developed into commercial production. In addition, ongoing outreach is being done through workshops and media events.

Excise Tax Exemptions for Lower Carbon/ Renewable Fuels: The GoC encourages the development and marketing of alternative transportation fuels in part through the taxation system. It provides an exemption from the federal excise tax for lower carbon fossil fuels such as natural gas, propane and renewable fuels. Renewable fuels include ethanol, methanol and the biodiesel portions of blended fuels, when they have been produced from biomass or renewable feedstock. While not a program in the usual sense, this policy provides an incentive to producers.

Targeted Clientele

Federal House in Order (FHIO): General information about FHIO is provided in section 4.3.1 on cross-sectoral measures; however, the Federal Vehicles Initiative component is elaborated on here, as it is specifically expected to reduce emissions from federal fleets:

- *The Federal Vehicles Initiative (FVI)* focuses on good federal fleet management and environmental stewardship through reducing fleet size; improving efficiency and environmental impact of vehicle operations; and, increasing the use of alternative fuels and vehicles in meeting the requirements of the *Alternative Fuels Act*. Funding for FVI amounted to $5.5 million from 2001/02 to 2005/06, with $3.7 million spent by the end of March 2005. As of 2002/03, there had been a 31% reduction in GHG emissions by federal fleets in comparison to 1990/91 levels. The number of active vehicles using E-85 technology rose from 57 in 2000/01 to 269 currently, leading to a total of 15 federal bulk E85 refuelling facilities and one commercial site, now located in various regions in Canada.[28] An E85 fuel credit was issued to increase the penetration of E85 fuel across the federal fleet. As a result, 158,024 litres of E85 fuel was subsidized in fiscal 2003/04, increasing to 315,219 litres in 2004/05. In addition, 286 alternative fuel vehicles and 79 hybrid vehicles were purchased across the federal fleet in 2003/04. FVI also provided Green Defensive Driving Training to 4,461 federal fleet drivers between April 2003 and March 2005; delivered 31 Demonstration Projects in various locations across Canada in 2004/05; and, held workshops for fleet managers on an annual basis since 2000. The federal fleet uses its leadership position to challenge commercial and public fleets to similarly reduce their GHG emissions.

Green Municipal Funds (GMF): General information about GMF is provided in section 4.3.1 on cross-sectoral measures. Emission reductions in the transportation sector are expected from a number of projects in public transit, municipal fleets, integrated and alternative transportation systems, and transportation demand management. Examples include the *Alternative Fuels for City of Waterloo Fleet* project and the *Articulated Electric Hybrid Transit Buses for Winnipeg's BRT System* project.

Other Federal Initiatives of Interest

Two issues targeted by Canada's climate change strategy for the transportation sector are "transportation system efficiency" and "reduction in transportation demand". Investment in the development of effective transportation infrastructure is crucial in achieving these objectives. The GoC has committed to support environmentally sustainable municipal infrastructure projects through various initiatives. General information about the infrastructure programs is provided in section 4.3.1 on cross-sectoral measures.

On September 14, 2005, NRCan and the U.S. Environmental Protection Agency (EPA) signed an MOU to work jointly with North American freight and shipping industries to take voluntary actions to save fuel and reduce GHG emissions. The agreement brings together NRCan's *FleetSmart* program with the EPA's *SmartWay*

[28] E-85 is a blended fuel mixture of 85% ethanol and 15% unleaded gasoline based on volume.

Transport Partnership to cooperate and share information on research, development and projects to achieve these goals.

Canada has played a leadership role in developing effective approaches to reducing international emissions from international air travel and maritime transport through the International Civil Aviation Organization and the International Maritime Organization respectively. Canada intends to apply lessons learned from these international processes domestically.

A voluntary agreement has been agreed to with domestic airlines to improve their fuel efficiency by 1.1% per year. The airlines have provided Transport Canada with a list of measures they plan to apply to meet this target and have indicated that they are on track to meet or exceed the 1.1% annual efficiency improvement target. Canadian airlines have improved fleet fuel efficiency by over 30% from 1990 levels.

4.3.3.3 Provincial/Territorial Measures

Provinces and territories have important responsibilities regarding transportation activities within their boundaries. As a result, they have a wealth of policies and measures that affect GHG emissions from the transportation sector. This section contains an overview of these initiatives, with an emphasis on those specifically designed to reduce GHG emissions.

Numerous provinces have implemented varied educational campaigns to reduce unnecessary vehicle idling. Northwest Territories created a windshield decal program, handing out information pamphlets to idling motorists at heavily populated drop-off areas. Prince-Edward Island has a program that encourages communities to take the initiative to make their schools and workplaces idle free by providing literature and signs free of cost. More and more cities, municipalities, communities, school boards, businesses and others across Canada have also adopted their own anti-idling campaigns. Many parts of Canada even have enforceable laws, with fines ranging from $100 to nearly $400, to prevent excessive idle time.

Several provinces support innovative measures such as the *Car Heaven* program. Alberta, British Columbia and Ontario have partnered with *The Clean Air Foundation*, which founded this financial incentive program that encourages Canadians to get their old high-polluting cars off the road. The *Yukon Development Corporation* has partnered with the city of Whitehorse to implement the *Parking Lot Timer Project*. This project relies on temperature sensitive meters to regulate the electricity flow to car block heaters for cars parked in public lots.

Provinces and Territories continue to invest heavily in emissions reduction technologies in the transportation sector. The *Saskatchewan Research Council* recently unveiled the world's first modified pickup truck fuelled by a combination of hydrogen and conventional fossil fuels. Quebec has established the *Centre d'expérimentation des véhicules électriques du Québec (CEVEQ)*, a research facility that tests electric vehicles and is currently conducting a project focused on introducing these vehicles into commercial and institutional car fleets in Montreal.

In addition to the federal excise tax exemption for ethanol, six provinces also provide tax or other incentives for ethanol. Of these, Ontario, Manitoba and Saskatchewan have also announced provincial requirements for ethanol content in gasoline. British Columbia now provides a tax (PST) exemption of up to $5,000 to clean-running mid-sized buses. Ontario has allocated $520 million toward an *Ethanol Growth Fund* that will provide capital assistance for research and supplier operations.

Much like the federal government, a number of provinces and territories have taken steps to reduce emissions from their own fleets. An *Alberta Environment* pilot program is testing three hybrid compact passenger cars for its regional operations and is considering hybrid alternatives to replace its courier vans for the government's internal fleet. Saskatchewan has followed suit by purchasing 11 hybrid trucks to be used over the next three years by their provincial corporations. The Yukon government has tested propane vehicles and electric cars and will soon be experimenting with hybrid vehicles for their government fleet.

Many provinces have indicated that financing transportation infrastructure is a key priority in their strategy to reduce GHG emissions. Ontario is currently constructing a network of *High Occupancy Vehicle (HOV)* lanes on provincial highways designed to promote car-pooling and public transit. British Columbia plans to spend more than $200 million for eight highway accesses leading to border crossings, facilitating safe and efficient movement of goods and people, thereby reducing GHG that result from idling in traffic jams. Both Alberta and Ontario allocate a portion of their fuel tax revenues to municipal transit improvement programs. Montreal has recently completed the *Biobus* project, one of the largest pilot public transit projects in Canada. *Biobus* tested 155 buses that used biodiesel in real-life conditions on a mass transit scale.

Provinces have also recognized the need for commuter education programs that complement infrastructure investments. Resource Conservation Manitoba annually conducts the Winnipeg Commuter Challenge focused on educating Winnipeggers to the healthy lifestyle and GHG reduction benefits of green commuting. The Ecology Action Centre in Halifax, Nova Scotia has created a sustainable transportation program called *Trax*, which works directly with employers to help commuters switch to more sustainable modes. Since 2000, the Agence Métropolitaine de Transport (AMT) in Montreal has implemented the *Allégo* project featuring 5 Transportation Management Associations (TMA) in the metropolitan area. This project aims at developing and promoting alternative transportation choices to single occupancy vehicle at workplaces, universities and colleges through demand management measures.

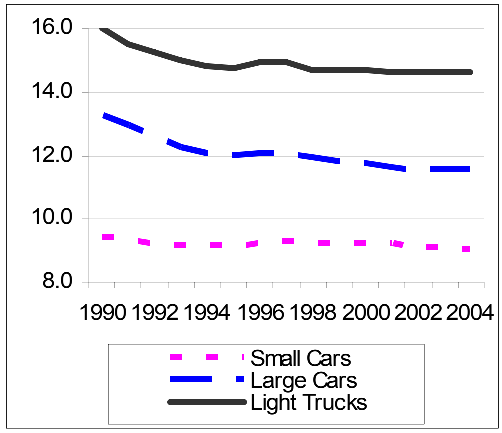
4.3.3.4 Performance Indicators

Passenger Transportation

There are several factors that affect the amount of emissions produced from passenger transportation. Evaluating the trends in the energy intensity of passenger transportation, vehicle energy efficiency and modal preferences provides perspective on a few of Canada's approaches to addressing its transportation sector emissions.

The energy intensity of passenger transportation, in the form of energy consumed per passenger-kilometre (Pkm), has been affected significantly by two factors since 1990; energy efficiency and modal preferences. First, the energy efficiency of new personal vehicles improved, particularly during the early 1990's. The improved fuel economy of the on-road vehicle stock is shown in Figure 4.3.3.3. Much of the public attention has focused on the demand for gasoline for personal vehicles, but road gasoline demand totalled 36.0 billion litres in 1980 and held roughly steady for almost 20 years, affected significantly by the improved fuel economy. If horsepower in car engines had stayed at 1990 levels, today's models would be about 33% more efficient.

Figure 4.3.3.3: On-Road Average Gasoline Consumption (L/100km), 1990-2004

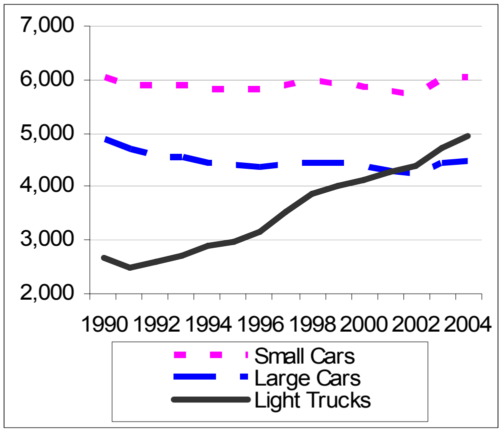


Energy efficiency also improved in three other main modes of passenger transportation; air, interurban buses and trains. Improved aviation efficiency, led by market conditions that required airlines to adopt more efficient routes and planes, meant that passenger air energy use only rose by 30% between 1990 and 2004, despite a 70% rise in the number of passenger-kilometres.

The second factor affecting energy intensity of passenger transportation offset some of the advances in energy efficiency. Between 1990 and 2004, consumers expressed a growing preference towards light trucks. The intensified market penetration of more powerful vehicles and the growth in energy consuming vehicle equipment (such as air conditioning) gradually eroded fuel economy gains. While the stock of large cars decreased by 8% and the stock of small cars increased by just 0.1%, the stock of light trucks increased by 85% between 1990 and 2004 (Figure 4.3.3.4). During this time there was a 14% increase in the light-duty vehicle fleet.

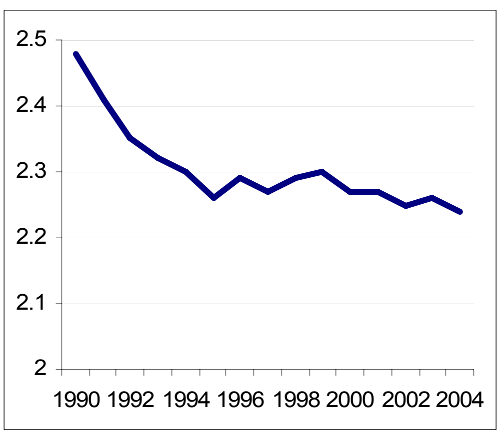
The rise in the stock of light trucks has had a detrimental effect on emission reduction strategies, as they are less fuel-efficient than cars and thus emit, on average, 40% more GHGs per kilometre. Emissions from light-duty gasoline trucks increased 101% between 1990 and 2004, while emissions from cars decreased more than 7%.

Figure 4.3.3.4: Stock of Passenger Vehicles (in 000s), 1990-2004



In addition, passenger transportation activity using interurban buses and trains declined (by 22% and 18%, respectively) over the analysis period. Reduced activity combined with improved energy efficiency diminished these modes' energy use over time, (29% decline in energy use by interurban buses and 46% by trains), but this reduction was replaced by more energy-intensive personal vehicle use. Thus, between 1990 and 2004, the energy intensity of passenger transportation declined by 10%, from 2.5 MJ per passenger-kilometre in 1990 to 2.2 MJ per passenger-kilometre in 2004 (Figure 4.3.3.5).

Figure 4.3.3.5: Energy Intensity of Passenger Transportation (MJ/Pkm), 1990-2004



Beyond the energy intensity of passenger transportation, emissions from this sector are also affected by how carbon-heavy the energy sources are. Gasoline (important in cars and light-duty trucks) was the fuel of choice during the period from 1990 to 2004, maintaining around 77% of the mix. Aviation fuel was the second most significant transportation energy source, at 17%, and diesel (for buses and trains) was a distant third at 5%. Given that virtually all of the energy used for passenger transportation was derived from fossil fuels, and that the top two fuel sources have similar emissions levels per unit of energy, the energy mix was not a determining factor in the growth of overall GHG emissions from passenger transportation.

Overall, the GHG intensity of passenger transportation, expressed in tonnes of GHG emitted per unit of energy used, declined slightly, from 71.2 tonnes CO_2 equivalent per TJ (million PJ) energy consumption in 1990 to 70.7 tonnes CO_2 equivalent per TJ energy consumption in 2004.

The gains in passenger vehicle energy efficiency have been offset by the mounting number of personal vehicles in use, the increased market share of vans and sport utility vehicles and the greater distances these vehicles are being driven. Progress has been insufficient in addressing the key drivers relating to transportation system efficiency and demand management. Also, a substantial shift away from conventional gasoline vehicles towards lower-carbon fuel vehicles has not yet been observed, as the measures to encourage such changes are relatively new.

Freight Transportation

The amount of GHG emissions produced from freight transportation is affected by the energy intensity of freight transportation, which is itself influenced by factors such as the energy efficiency of each transportation mode, the proportional use of each of the four modes of freight – trucks, air, rail, and marine, and the ease of inter-modal combinations; the emissions intensity, which is affected by the type of fuel used; and the level of freight transportation activity.

The energy intensity of freight transportation is measured by the energy consumed per tonne-kilometre (Tkm). In 1990, the energy intensity of freight transportation was about 1.3 MJ per tonne-kilometre. While it varied up and down somewhat during the 1990s, it had only decreased by 10.0 kJ in 2004 (Figure 4.3.3.6).

Figure 4.3.3.6: Energy Intensity of Freight Transportation (MJ/Tkm), 1990-2004

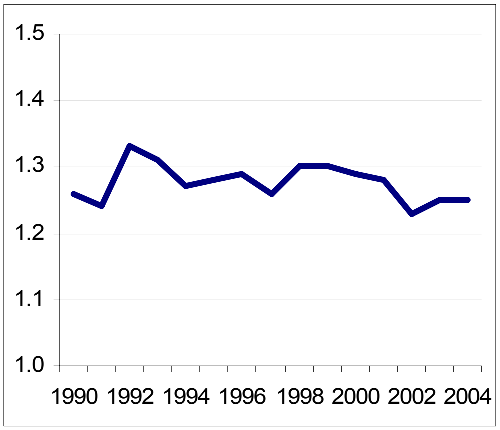
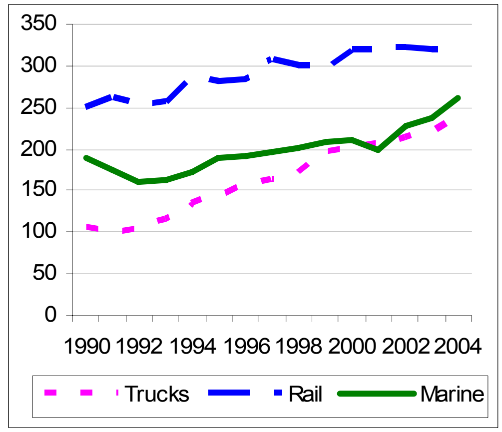


Figure 4.3.3.7: Freight Activity by Mode (billions Tkm), 1990-2004[29]



The freight sector in Canada employs four modes of transportation (i.e. trucks, air, rail, and marine) as well as inter-modal alternatives, which are a combination of two or more of these modes. The energy intensity of freight transportation is affected by both the energy efficiency of each mode and the modal share of the more energy-efficient freight modes. The energy intensity of freight transportation was reduced across all modes except air between 1990 and 2004 (Table 4.3.3.1). Improvements were especially marked in rail (34%), marine (22%) and heavy trucks (19%).

Table 4.3.3.1: Change in Energy Intensity of Freight Transportation by Mode (MJ/Tkm), 1990 & 2004

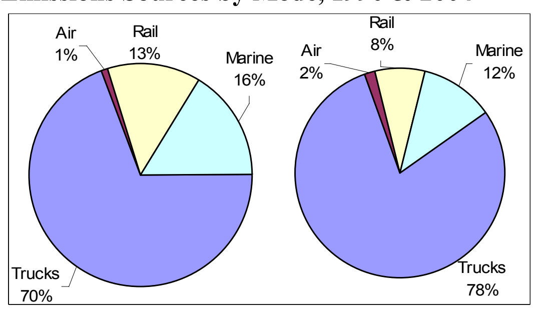
	1990	2004
Freight Trucks – average	4.6	3.6
Light Trucks	11.1	10.3
Medium Trucks	7.5	7.0
Heavy Trucks	3.2	2.6
Freight Air	4.2	5.0
Marine	0.6	0.4
Freight Rail	0.3	0.2

Note: truck average is weighted based on activity; freight movement by air is minimal.

While activity rose in all modes of freight transportation, the modal share of truck transportation activity expanded significantly between 1990 and 2004 (Figure 4.3.3.7). Almost half of the growth in tonne-kilometres between 1990 and 2004 was captured by truck transportation, which experienced a 131.3 billion Tkm increase.

Given that trucks are more energy intensive than rail and marine, their increasing modal share of freight transportation offset the energy efficiency improvements across all modes. The combined energy intensity and freight activity of each mode results in the modal distribution of emissions shown in Figure 4.3.3.8.

Figure 4.3.3.8: Proportion of Freight GHG Emissions Sources by Mode, 1990 & 2004[30]



With respect to the mix of energy sources, diesel made up the largest share, as it is used by large trucks and locomotives. Unlike motor gasoline demand, road diesel fuel consumption for trucks grew dramatically over the past two decades. Diesel's share of the freight energy mix grew from 60% in 1990 to 66% in 2004. Gasoline (for lighter trucks) and heavy fuel oil (for ships) provided most of the remaining energy used, and both saw their relative shares decline slightly. All three leading energy sources are petroleum-based, and have fairly similar GHG intensities (i.e. emissions levels per MJ), so the

[29] Air freight is not shown in Figure 4.3.3.7 because it was only 3001.0 million Tkm in 2004, a fraction of the other modes.
[30] Figure 4.3.3.8 uses OEE freight transportation emissions data.

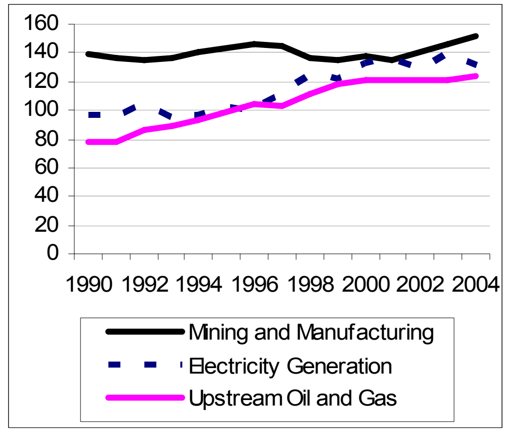
choice of energy sources was not a determining factor to explain the growth in overall GHG emissions from freight transportation between 1990 and 2004. Indeed, the overall GHG intensity of freight transportation declined only slightly during this period from 73.1 tonnes CO_2 equivalent per TJ (million PJ) of energy consumed to 72.8 tonnes CO_2 equivalent per TJ of energy consumed.

Analysis of the freight transportation sub-sector indicates that fuel efficiency improvements in the truck and rail transportation industries were off-set by increases in the demand for trucking services and reductions in the modal share of the more energy-efficient freight modes. This suggests that key drivers relating to freight system efficiency and effective price signals were not sufficiently influenced over this period. There was also no significant production and penetration of lower carbon fuels in the freight industry.

4.3.4 Industrial Sector

For the purpose of this document, the industrial sector is defined as comprising of: fossil fuel production; mining and manufacturing industries (including industrial processes); and, electricity generation.[31] The analysis of each sub-sector is presented following an overview of the industrial sector and a natural grouping of industrial cross-cutting programs and measures. Figure 4.3.4.1 presents the trends in GHG emissions from 1990 to 2004 for the three sub-sectors.

Figure 4.3.4.1: GHG Emissions from Industrial Activities (Mt CO_2 eq.), 1990 – 2004



The industrial sector, as defined above, generated 402.4 Mt CO_2 eq. emissions in 2004; accounting for 53% of the total GHG emissions in Canada. GHG emissions from the industrial sector rose by 29% (up 90.4 Mt) between 1990 and 2004, driven mainly by higher energy consumption. About half of the increase in emissions (44.9 Mt) occurred within the Upstream Oil and Gas subsector. Emissions from electricity generation rose significantly as well, up 35% (up 33.6 Mt). Combined mining and manufacturing emissions rose by 9% (up 11.9 Mt).

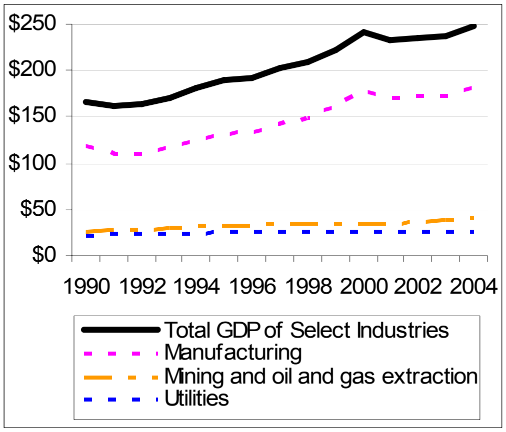
4.3.4.1 Trends in Industrial Output

The industrial sector experienced a significant growth in activity (i.e. a mix of GDP, gross output and production units) between 1990 and 2004.

Between 1995 and 2004, sectoral GDP increased in all years except 2001, when Canadian industry faced an economic downturn. The combined GDP of mining and oil and gas extraction, manufacturing, and utilities rose by 48% (Figure 4.3.4.2).

[31] Transportation-related pipeline emissions are included in this industrial sector analysis. Construction is not included, as its emissions are marginal and there are no federal programs directly related to it. For details on how the breakdown of industrial emissions data differs from Ch.3, see the three individual sub-sector analyses.

Figure 4.3.4.2: GDP ($1997 billions) by Selected Industries, 1990 – 2004



Structural changes in the industrial sector, specifically, a relative decrease in the activity share of energy intensive industries (e.g. pulp and paper, iron and steel, and lime) since 1997, helped the sector to offset increases in energy use due to activity. From 1995 to 2004, improvements in the energy efficiency of the sector have further limited the increase in energy use. Further discussions of specific factors influencing output in the industrial sector are mentioned in the *Upstream Oil and Gas, Mining and Manufacturing* and *Electricity Generation* subsections of this chapter.

4.3.4.2 Federal Measures Cross-Cutting the Industrial Sector

This section presents mitigation measures that are applied to several of the industry sub-sectors. Measures that address one of the three sub-sectors individually are presented in Section 4.3.5 to Section 4.3.7.

Action Plan 2000 on Climate Change (AP2000), starting in the fiscal year 2001/2002, involved a suite of practical, concrete industrial measures that were intended to strengthen partnerships among GoC and industries on improving energy efficiency. The following are descriptions of the AP2000 industrial cross-cutting measures:

Canadian Industry Program for Energy Conservation (CIPEC): CIPEC was created three decades ago as a voluntary partnership between government and business to champion industrial energy efficiency across Canada. Its mission is to promote action that reduces industrial energy use per unit of production, thereby improving economic performance while participating in meeting Canada's climate change objectives. CIPEC's multi-faceted approach focuses on technological innovation, behavioural changes, and shifting organizational culture to generate a sustainable market transformation. From its inception in 1975, CIPEC initially focussed on the mining and manufacturing sectors. The program was expanded in 2001 to reach across all industry sectors, and efforts were broadened to encourage achievement of even greater energy efficiency. It now comprises sectoral task forces that participate through their trade associations. Direct company involvement occurs through the Industrial Energy Innovators (IEI) component, through which more than 1,000 industrial plants have made a voluntary commitment to become more energy efficient. Over the years, CIPEC has been mostly supported through internal funding of NRCan. However, AP2000 provided a total of $23.5 million, between April 2001 and March 2006, to five sub-programs to operate under this umbrella organization. As of the end of March 2005, $17.0 million had been spent. According to a recent study, the increase in energy use among CIPEC participants was about half that of non-participants. An independent report also found that CIPEC's influence in Canada's industrial sector is on the rise and has helped Canadian industry reduce energy use by 13,500 terajoules, since 2001. CIPEC oversees the following AP2000 measures:

- The *Expansion of Canadian Industry Program for Energy Conservation (CIPEC)* builds upon the original CIPEC to reach more industrial companies in more sectors by developing new partnerships and new CIPEC Task Forces. The expansion received $2.5 million over five years to include the following sectors: oil and gas; electricity generation; forestry; and, construction. As a result, 12 new associations were recruited and five new task forces were created. CIPEC now encompasses 27 task forces led by 50 trade organizations representing more than 5,000 industrial firms that account for nearly 98% of Canada's secondary industrial energy consumption.
- The *Awareness Building* program aims to address barriers to the implementation of energy efficiency and emissions management programs, primarily within small and medium-sized enterprises (SMEs), by making them more aware of the benefits of reducing GHG emissions. This

program was allocated $2.5 million for five years. It provides organizations with tools such as the CIPEC web site, the highly popular *Dollars to $ense* energy management workshops, an employee awareness toolkit, the *Heads Up CIPEC* bi-weekly newsletter, and, the *Energy Managers Network* forum. Increased participation has averaged 12.5% per year, as measured by the number of facilities tracked in the program database. Participation in the workshops alone has grown by 600% since 2001. CIPEC also provides energy practitioners with forums through which to share information, best practices, experiences, and the latest technology developments including Task Force meetings, the Energy Managers Network, and the Energy 2003 and 2005 conferences.

- The *Emissions Benchmarking* program conducts sector benchmarking studies to enable companies to assess their energy efficiency and GHG emissions performance, relative to comparable operations, as a catalyst to initiating projects. It obtained $8.0 million from 2001/02 to 2005/06 and benchmarked 18 industrial sectors, covering 265 establishments, by the end of March 2005. It also developed “Best Practices” advisory and diagnostic tools such as a Process Integration pilot initiative.
- The *Energy Efficiency Audits* program is designed to work with IEI companies to co-fund on-site audits that pinpoint specific areas of energy waste, within their operations, and develop priorities to eliminate them. It was provided with $5.0 million for 5 years and had carried out 371 energy audits as of March 31, 2005. Based on a 2005 evaluation, 58% of recommended energy measures have been implemented.
- The *Improved Tracking and Reporting of Energy Efficiency and Emission Trends* works to upgrade statistics by expanding and better aligning existing industrial survey instruments so as to improve the scope and timeliness of industrial energy end use data. The program was funded with $5.5 million to phase in the upgrades and expansion over five years, starting 2001/02. In 2002/03, the Industrial Consumption of Energy (ICE) survey coverage grew from approximately 65% up to 95% of existing industrial industries. The information is used to help the federal government refine its focus on promising areas of activity for emissions reductions, and enables industry to set targets and establish action plans.

Industrial Building Incentive Program (IBIP): IBIP is designed as a Demonstration Program to improve energy efficiency and reduce GHG emissions, by fostering the integration of building and process design, in new industrial facilities. It extends the precepts of the CBIP to the industrial sector. The program modifies the expectations that owners have for their buildings and how designers think about addressing those expectations through a variety of instruments, including financial incentives, design assistance, development of design tools, promotion of integration design, professional training, information transfer, and partnerships. IBIP was approved in November 2001, with $3.0 million in funding until March 31, 2006 of which $2.0 million had been spent by the end of March 2005. IBIP had also supported 20 projects and the average performance of IBIP buildings was 55% better than the MNECB. In addition, there were over 3,800 registered users of the simulation software and more than 3,000 participants had attended IBIP/CBIP training workshops.

EnerGuide for Industry (EGI): Formally known as *Energy Rating Systems (for Industry)*, this program encourages industry decision-makers to use energy performance information and consider energy efficiency routinely when procuring or specifying energy using “off-the-shelf” industrial equipment. Building on the trusted EnerGuide name, it also identifies specific products used in the industrial sector for which standardized testing and rating schemes are needed and are appropriate. EGI received $2.5 million over five years, beginning in 2001, and $1.7 million of that was spent by the end of March 2005. The program develops Web-based fact sheets and case studies as well as delivering the *Canadian Motor Selection Tool (CanMOST)* software, which was launched in June 2004. With its database of over 43,000 motors, CanMOST analyses and compares the efficiency of three-phase electric motors so that equipment buyers can make the most energy-efficient and cost-effective choice when it comes to buying motors for their industrial application. The market for *National Electrical Manufacturers Association (NEMA)* premium motors has grown from 0 in 2001 to approximately 20% in 2005 and it is anticipated that they could account for 30% of all motor sales by 2010.

Renewable Energy Deployment Incentive (REDI) for Industry: The original REDI program is described under Section 4.3.2 on the Buildings Sector. Existing programs were expanded specifically within the industry sector, to provide incentives for increased use of technologies in the areas of biomass; active solar hot-water and air-heating systems; and, ground-source heating. Of the total funding earmarked for REDI, AP2000 provided $2.0 million over five years explicitly for this enhanced industry component.

Large Final Emitter (LFE) Initiative: Under AP2000, the federal government launched an initiative to discuss sector agreements / covenants on emissions reduction with provinces and territories, industry, and electric utilities. In 2003, these early efforts led to the creation of the LFE initiative, the purpose of which is to secure emission reductions from Canada's largest industrial emitters through a system that is market-based and in line with Canadian policy regarding Smart Regulations. LFEs cover almost 700 companies that produce goods in emissions-intensive sectors including primary energy production, electricity production, and selected areas of mining and manufacturing production.

The sectors from which LFEs originate make an important contribution to Canada's economic base, but they also contribute just under half of total Canadian GHG emissions. The Government intends to propose regulations to reduce air emissions from key industrial sectors including fossil-fuel fired electricity generation, upstream oil and gas, downstream petroleum, base metal smelters, iron and steel, cement, forest products, and chemicals production.

In addition to these programs there are several research-oriented technology development programs aimed at developing ways to reduce emissions from the industrial sector. These are covered in section 4.4 of this chapter on Technology and Innovation.

4.3.4.3 Provincial Measures

Many of the Provincial/Territorial initiatives build on federal government measures to reduce GHG emissions in the industry sector. Some of their leading programs and measures are highlighted below.

Regional governments have taken the initiative to create new regulations that encourage change towards renewable energy. Yukon has created the *Renewable Power Sales Incentive Program* that encourages the consumption of available surplus hydro electricity to displace fossil fuels used for space and water heating for industrial customers. The program guarantees a return on investment to customers who install the equipment necessary to purchase secondary power.

Most provinces provide services such as energy audits to support energy efficiency initiatives within their industrial sector. BC Hydro conducts their *Power Smart e.Review* program, a free service that provides a detailed, customized profile of an industrial facility's energy use to help identify opportunities to reduce energy and costs, and take the next steps to long-term savings. Manitoba Hydro has developed *Power Smart EnerTrend*, a Web-based energy-profiling tool developed specifically for large industrial and commercial operations. The energy profiles generated by EnerTrend illustrate how and when energy is being used – the important information needed to manage consumption, reduce peak demand and lower costs. SaskPower Energy Solutions guarantees their industrial customers savings through energy audits and energy performance contracting. The costs saved on energy consumption will pay back the cost of the contract, avoiding typical capital expenditure restrictions.

A few provinces have undertaken research projects that aid their industries in becoming more energy efficient. Alberta has undertaken an innovative pilot installation of a combined heating and power system in select greenhouses of local agricultural producers. Light industrial users interested in increasing their energy efficiency and reducing their GHG emissions will use results of this pilot to implement their own energy strategy.

4.3.4.4 Other Measures

GHG Registries: The registries provide a platform for reporting GHG emissions, removals, and reductions. They are designed to encourage organizations from all sectors of the economy to voluntarily develop and implement GHG reduction plans. The result of a partnership between industry, the GoC and all Provinces and Territories, the registries were formerly known as Canada's Climate Change *Voluntary Challenge & Registry Inc. (VCR Inc.)* and the *Bureau d'enregistrement des mesures volontaires sur les changements climatiques*

(ÉcoGESte) in Québec. VCR Inc. was set up in 1994 as a stand-alone, not-for-profit corporation and completed its transition from a government incubated program to a stand-alone private–public partnership in 1997. Effective January 1, 2005, the registries began operating as the new GHG Registries, through the Canadian Standards Association (CSA), and now charge for some services that were previously covered by VCR Inc.'s government-industry funding partnership. GHG Registries maintains two primary integrated registries that together have been designed to satisfy the registry needs of GHG management policy in Canada:

- the *Canadian GHG Challenge Registry* is an entity-based registry of voluntary GHG Emissions Reduction Action Plans; and,
- the *Canadian GHG Reductions Registry* is a project-based registry of GHG reductions projects and their annual registered emissions reductions (RERs).

The registries are linked together by sharing a central set of data files, ensuring that related data sets are consistent across the different functions. They contain the action plans and progress reports of over 1,200 organizations. In order to accommodate the varying approaches that may be taken to handle the measurement, reporting, and management of GHG emissions, the database structure is capable of documenting and recording transactions on an entity, facility, and/or project basis. These registries play a vital role by keeping track of emission reductions in Canada so that they are not double counted or traded more than once. They also provide some assurance to the seller and buyer as well as the regulators that claimed emission reductions are legitimate.

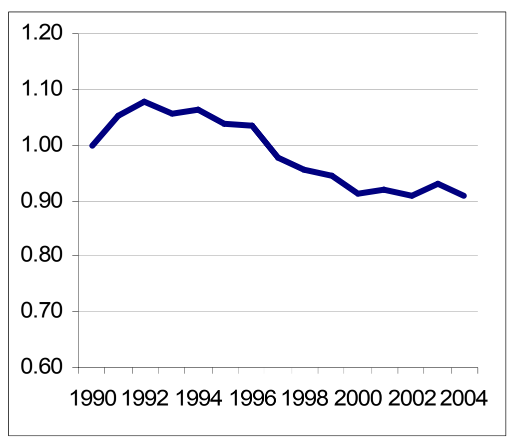
Environmental Supply Chain Management (ESCM) Pilot Project: Managed primarily by CSA Climate Change, GHG Registries, the ESCM pilot project focuses on GHG emissions and solid waste reductions along the manufacturing supply chain. It was set up to explore how supply chain management can be used to raise awareness of climate change and encourage activity to reduce GHG emissions among Canada's small and medium-sized enterprises (SMEs). AP2000 provided $1.0 million to this five-year pilot program that began in May 2001. Almost half of those funds were spent by the end of March 2005. SMEs collectively comprise 43.7% of the Canadian manufacturing industry GHG emissions, and as a result represent a significant opportunity to contribute towards national GHG emissions reductions. The diverse nature of SMEs and their limited resources make it difficult to raise their awareness of environmental issues as well as to provide them with the technical and financial tools they need to act. Designed to investigate the opportunities for SMEs to reduce their environmental impacts and fiscal costs associated with the activities in their supply chain, the project encourages SMEs to track, manage and reduce GHG emissions through changes in business/production processes and the use of new technologies.

4.3.4.5 Performance Indicators

Figure 4.3.4.3 presents the CIPEC Energy Intensity Index, which demonstrates the aggregate energy intensity trend of CIPEC industries.[32] The energy intensity indicator shown in Figure 4.3.4.3 is equal to the energy intensity (a measure of the energy consumed per unit of output) in a particular year divided by the energy intensity of the base year 1990.

Between 1990 and 2004, the aggregate energy intensity of the CIPEC industries improved by 9.1% (and by 12.1% between 1996 and 2004), as signified by the downward trend in Figure 4.3.4.3. Had energy intensity remained constant and not declined by 0.7% per year, GHG emissions would have been 29.5 Mt higher in 2004.

Figure 4.3.4.3: Aggregate CIPEC Industries' Energy Intensity Index (Index: 1990=1.0), 1990-2004



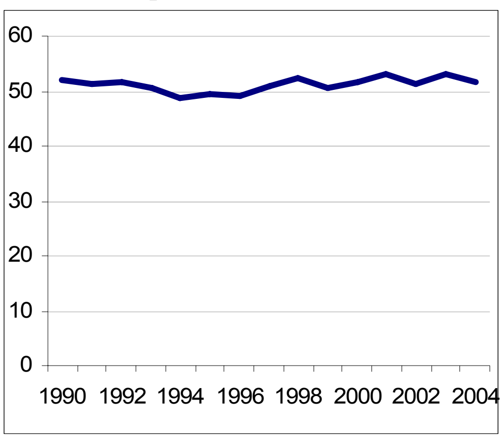
The energy intensity of specific components of CIPEC industries has been affected by structural

[32] CIPEC industries are mining, manufacturing, construction, upstream Oil and Gas and Electricity generation sectors, which are encompassed but not exclusively the sectors included in the industrial sector definition used for the report.

changes within the industries. By 2004, the Manufacturing, Mining and Construction component of CIPEC had decreased its energy intensity by an average of 2.0% per year, or 24.3%, since 1990. The Energy Producers component, however, experienced a 15.1% rise in energy intensity between 1990 and 2004 (with a slight (2.6%) recovery during the last four years of that period.) These trends within the components reflect shifts in activity to industries requiring either more or less energy, and are not simply measures of production efficiency.

The trend in industrial sector GHG emissions intensity (Figure 4.3.4.4) is different from that seen in energy intensity, primarily as a result of fuel switching and shifts in process emissions. The GHG emissions intensity of Canadian industry, when including forestry and construction, remained relatively constant between 1990 and 2004. The change in GHG intensity was small because fuel switching towards less GHG intensive fuels in the industrial sector was offset by a higher GHG intensity in electricity production.

Figure 4.3.4.4: GHG Emissions Intensity of Industry Including Electricity-Related Emissions (tonne CO_2 eq./TJ), 1990-2004[33]



When excluding electricity-related emissions, the emissions intensity declined by about 6% between 1990 and 2004. This was driven in part by a relative decline in the use of heavy fuel oil, coke and coke oven gas and an increase in the use of biomass (biomass requires more input energy to achieve the same amount of useful energy, but has fewer emissions per unit of energy.) GHG emissions from energy intensive industries (e.g. pulp and paper, smelting and refining, and iron and steel) decreased even though their energy use rose, as a result of changes in the type of fuel used. In addition, emissions from industrial chemical industries, with process emissions making up almost 71%, decreased by about 25% since 1990. Adipic acid production in particular decreased its process emissions by 71% during the analysis period due to the installation of emission abatement systems. The industrial chemical industries reduction in GHG intensity is further explained in the Mining and Manufacturing sub-sector section.

4.3.5 Upstream Oil and Gas Sub-Sector

The upstream oil and gas sub-sector is comprised of production of natural gas, conventional oil, and heavy oil and oil sands (including some bitumen upgraded to synthetic crude oil); pipeline transmission of oil and natural gas within Canada; and, fugitive emissions (releases of GHGs from the production, processing, transmission, and storage of fossil fuels.)[34] This sub-sector does not include petroleum refining activities as they are considered downstream; petroleum refining is covered within the mining and manufacturing sub-sector.[35]

GHG emissions from the upstream oil and gas industry represented 16% of total Canadian GHG emissions in 2004. Emissions grew by 57%, between 1990 and 2004, from 78.3 Mt to 123.2 Mt CO_2 eq.[36] This accounts for 28% of Canada's total growth in GHG emissions during the analysis period. The rise embodies many factors, but most significantly reflects the growth in oil production and, to a lesser extent, gas production. Between 1990 and 2004, crude oil, crude oil equivalents and marketable natural gas production increased by 65% in energy equivalent, with an attendant 56% increase in the upstream oil and gas economic activity.

[33] The industry data in Figure 4.3.4.4 includes all emissions from the manufacturing, mining, forestry and construction industries. It also includes emissions associated with the generation of electricity for use in these industries only.

[34] A portion of emissions from the upstream oil and gas sub-sector are accounted for in the mining and manufacturing sub-sector (under mining and petroleum refining) due to data limitations.

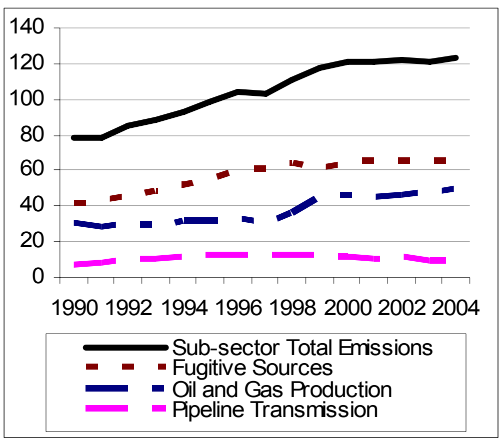
[35] End-use oil and gas emissions are specifically excluded from this sub-sector, since they pertain to domestic consumption rather than production.

[36] Due to data limitations, this data includes some downstream emissions related to the distribution of natural gas and excludes some upstream process emissions.

Between 1990 and 2004 there was a 192% rise in the net energy exported from Canada. By 2004, Canada exported over 61% (energy equivalent) of its gross crude oil and natural gas production. GHG emissions associated with net oil and gas exports[37] were 47.8 Mt in 2004, 123% higher than they were in 1990.

In 2004, fugitive emissions comprised 53% of total upstream oil and gas sub-sector emissions, alone constituting 9% of Canada's total GHG emissions. That same year, oil and gas production and pipeline transmission constituted 40% and 7% of the upstream oil and gas emissions, respectively (Figure 4.3.5.1).

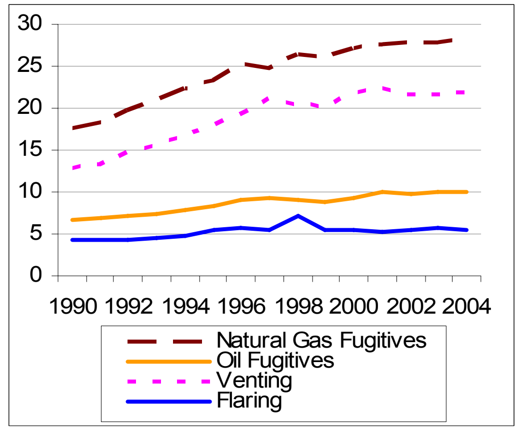
Figure 4.3.5.1: GHG Emissions from the Upstream Oil and Gas Sub-Sector (Mt CO_2 eq.), 1990 – 2004



Emissions related to oil and gas production grew by 64% between 1990 and 2004, while pipeline transmission emissions increased by 24%. Fugitive emissions rose 58% (increasing by 24.1 Mt to 65.5 Mt)[38], thus constituting 15% of the total growth of Canada's total GHG emissions during the analysis period.

The rise in fugitive emissions is primarily attributed to the growth in natural gas and heavy oil production, consequently amplifying traffic through the energy pipelines. During the analysis period, oil fugitives and natural gas fugitives rose by 49% and 60%, respectively. Emissions from venting and flaring increased by 72% and 23%, respectively (Figure 4.3.5.2).

Figure 4.3.5.2: Fugitive Emissions from Upstream Oil and Gas by Type (Mt CO_2 eq.), 1990 – 2004



4.3.5.1 Trends in Upstream Oil and Gas

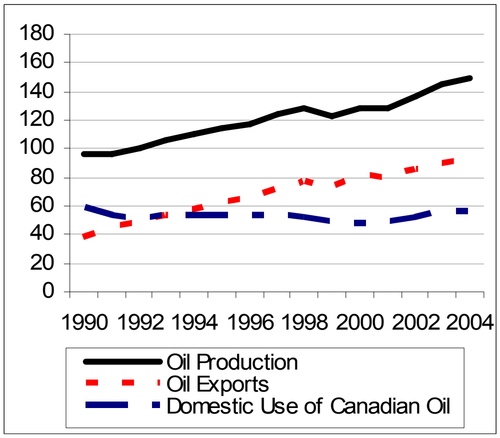
The upstream oil and gas sub-sector's rising GHG emissions result from two factors in particular; a rise in overall oil and gas production and a rise in the proportion of fuel that requires higher energy-intensity production. These factors combined lead to higher energy use and therefore GHG emissions.

Trends in Oil Production

Canada is the world's fourteenth largest crude oil producer (over 2% of the world's production) and eighth largest crude oil exporter. Oil production experienced a 54% growth between 1990 and 2004, from 96.7 million cubic metres to 149.4 million cubic metres (Figure 4.3.5.3). This growth essentially served the United States, with exports growing by 148%, while domestic uptake of Canadian crude oil declined by 6% during that period. Exports surpassed imports by 39.9 million cubic metres in 2004. Thus, unlike most developed countries, Canada, as a net exporter, incurred emissions not only to produce oil for its own requirements, but also to satisfy other countries' requirements.

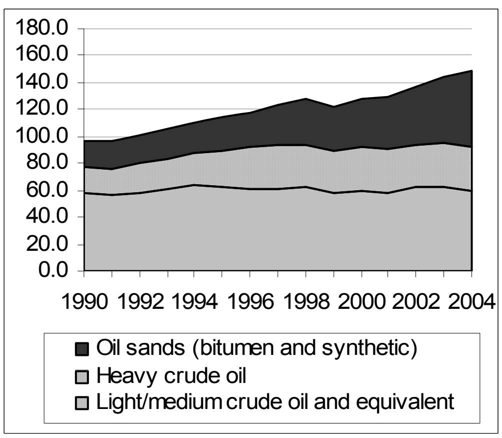
[37] Net export emissions are the Canadian emissions associated with extracting, processing, and transporting of exported fuel minus the Canadian emissions associated with transporting and processing imported fuels.
[38] This data includes a small amount of downstream emissions from natural gas distribution.

Figure 4.3.5.3: Canadian Oil Production and Disposition (million m³), 1990 – 2004[39]



Production rose across all types of crudes during the analysis period (Figure 4.3.5.4). The share of growth in oil production could be attributed to: light and medium crude oil and crude oil equivalent (2%), heavy crude oil (26%), oil sands (72%).[40]

Figure 4.3.5.4: Canadian Oil Production by Type (million m³), 1990 – 2004



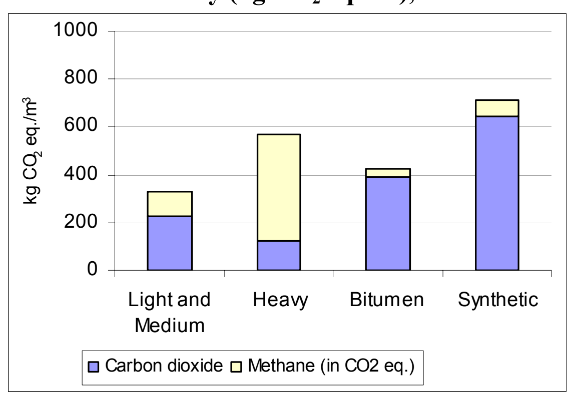
Conventional reserves in the western Canadian sedimentary basin are declining, and the production of light and medium crudes appears to be levelling off. Producers have been shifting their attention towards heavy oil and oil sands in order to increase supply. Heavy oil and oil sands accounted for 98% of the total growth in oil production between 1990 and 2004, shifting production towards crudes that are more GHG-intensive to produce. Heavy oil and oil sands combined made up at least 60% of all Canadian oil produced in 2004 (Table 4.3.5.1).

Table 4.3.5.1: Share of Canadian Oil Production by Type, 1990 & 2004

	Light/medium crudes and equivalent	Heavy crude oil	Oil sands (bitumen and synthetic)[41]
1990	61%	19%	21%
2004	40%	21%	39%

Figure 4.3.5.5 shows the differences in production emissions intensity between types of crudes produced in Alberta. Heavy oil production is a far less energy-intensive process than bitumen production (as reflected in its substantially lower CO_2 emissions.) However, heavy oil production is more emissions intensive than bitumen production because it emits a larger amount of CH_4, which is a stronger GHG than CO_2, through venting.

Figure 4.3.5.5: Alberta Crude Oil Production Emissions Intensity (kg CO_2 eq./m³), 2000[42]



Commercial oil sands production began in the late-1960s, but has accelerated significantly since the mid-1990s. When including oil sands resources, it has been estimated that Canada's oil reserves are second only to Saudi Arabia.[43]

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[39] Figure 4.3.5.3 data does not include domestic use of imported oil.
[40] In this chapter, crude bitumen and synthetic crude oil are grouped as "oil sands" because they are both classified as extra heavy oil (before upgrading) within the American Petroleum Institute gravity scale ranges (measuring weight per unit volume of hydrocarbon liquids). Crude oil equivalents (i.e. condensate and pentanes plus) comprise of relatively light hydrocarbons, so they are grouped with light and medium crude oil.

[41] Total oil sands production is actually higher than the proportion shown in Table 4.3.5.1, since some of the volume is lost before measurement through transformation of a portion of the bitumen into synthetic crude oil.
[42] Figure 4.3.5.5 data includes emissions from combustion, venting, flaring and other fugitives. Combustion and flaring primarily emit CO_2, while venting primarily emits CH_4, which is at least 21 times stronger than CO_2 as a GHG.
[43] Source: Radler (2002).

Currently there are three oil sands regions in northern Alberta (i.e. Athabasca, Cold Lake and Peace River). Some sites have on-site upgraders and there are two heavy oil upgraders in Lloydminster and Regina, Saskatchewan. Early commercial production at oil sands mines was initiated by the Great Canadian Oil Sands Company (now Suncor Energy Inc.) in 1967, then the consortium of Syncrude Canada Ltd. in 1978, and finally the Athabasca Oil Sands Project (Shell Canada, Chevron Canada Resources and Western Oil Sands) in 2003. Commercial *in situ* production commenced with Imperial Oil's Cold Lake Production Project in 1985, and was followed the next year by B.P. and Petro-Canada's Wolf Lake and Cold Lake operations, and Shell's Peace River Project.[44]

There are now several oil sands producers, including:

- Albian Sands Energy Inc.;
- Canadian Natural Resources Limited;
- EnCana Corporation;
- Husky Energy Inc.;
- Imperial Oil Resources Limited;
- Petro-Canada;
- Shell Canada Limited;
- Suncor Energy Inc.; and,
- Syncrude Canada Ltd.

As of December 31, 2003, there were 32 companies representing 59 projects approved under Alberta's Oil Sands Royalty Regulation.

The energy consumption and GHG emissions from oil sands production reflect the industry's growth strategy. Between 1990 and 2001, the last year for which there is sufficiently disaggregated data, non-conventional oil production more than doubled, but the total energy used to extract the non-conventional oil did not increase at the same rate. Rather, the energy use rose by 56% (to 207.3 PJ), reflecting energy efficiency improvements.[45]

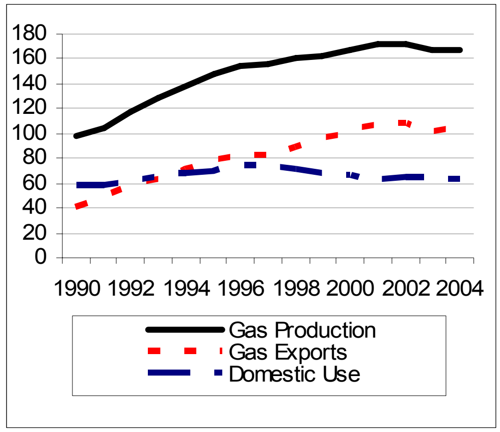
[44] There are two approaches to oil sands development: mining and *in situ*. The mining process excavates the oil sand and transports it to a cleaning facility to separate the bitumen from the sand. All operating oil sands mines are linked with upgraders that convert the bitumen to synthetic crude oil. The *in situ* approach removes crude bitumen from deep oil sand reservoirs by applying thermal energy that enables the heated bitumen to flow to the well bores. The crude bitumen can later be blended with lighter oil to become heavy oil or upgraded for conventional use.

[45] Source: NRCan (2005).

Trends in Natural Gas Production

Canada is the world's third-largest natural gas producer and second-largest gas exporter. Between 1990 and 2004, production of marketable natural gas increased by 70%, from 98.8 billion cubic metres to 167.5 billion cubic metres (Figure 4.3.5.6). Most of the growth in natural gas production served the export market; particularly the United States. Exports grew by 149% during that time and by 2004 consumed 63% of the total marketable production of natural gas. Imports were negligible.

Figure 4.3.5.6: Canadian Marketable Natural Gas Production and Disposition (billion m^3), 1990 – 2004



4.3.5.2 Federal Measures

The GoC has called upon the upstream oil and gas industry to continue to reduce the emissions intensity of production and distribution. Emissions intensity can be reduced through initiatives such as reducing the leakage of methane from natural gas pipelines and reducing the energy intensity of oil sands production. The industry has been encouraged to participate in the voluntary Canadian GHG Challenge Registry described under section 4.3.4 on the Industrial Sector.

AP2000 included two federal initiatives aimed at the oil and gas sector, namely: the expansion of CIPEC and the CO_2 Capture and Storage initiative.

Expansion of the Canadian Industry Program for Energy Conservation (CIPEC): CIPEC is an umbrella organization overseeing a partnership between government and private industry aimed at improving Canada's industrial energy efficiency. Although CIPEC was birthed in 1975, it was expanded in 2001 to reach beyond the manufacturing and mining sectors. It now comprises sectoral task forces – including upstream oil and gas – that participate through their trade associations. The development of an LFE system (as described in section 4.3.4.4), however, has somewhat dampened participation of the upstream oil and gas sector in the CIPEC program. Nonetheless, Through CIPEC, upstream oil and gas companies have implemented projects to reduce GHG emissions by millions of tonnes. General information about CIPEC is provided in section 4.3.4 on cross-cutting industrial measures.

CO_2 Capture and Storage (CO_2 C&S): This initiative aims to make the capture and underground storage of CO_2, produced from industrial activities, a viable option for reducing GHG emissions in Canada, by advancing deployment of commercial opportunities and facilitating the development of a CO_2 C&S market through financial incentives. CO_2 C&S involves capturing CO_2 from large point sources and storing it underground in geological formations. In addition, CO_2 can be used to enhance the recovery of oil and coal bed-methane. The initiative was allocated $25.0 million from 2001/02 with a March 31, 2006, termination date. As of the end of March 2005, $16.3 million had been spent primarily on five CO_2 based enhanced oil recovery pilot projects; funding of the *IEA Weyburn Storage and Monitoring* project[46]; establishing the CO_2 unit at Natural Resources Canada; and conducting foundation studies, including analysis of a fiscal framework and model, studies pertaining to CO_2 enhanced oil recovery and inventorying activity. The results of this work have led to a MOU to support the *IEA Weyburn Storage and Monitoring* project, the development of appropriate monitoring and verification protocols, and five signed contribution agreements.

Large Final Emitters (LFE) System: General information about the LFE System is provided in section 4.3.4 on cross-cutting industrial measures. Emission reductions in the upstream oil and gas sector are expected from LFEs by increasing energy efficiencies and encouraging greater reliance on renewable energy. For example, Talisman Energy Inc.'s 10-megawatt cogeneration facility, built in 2004, replaced boilers at their Edson, Alberta natural gas processing plant, substantially reducing fuel gas consumption and GHG emissions while producing more power.

4.3.5.3 Provincial/Territorial Measures

A few provinces and territories have developed measures to address GHG emissions resulting from the oil and gas sector. Some of the leading programs and measures are highlighted below. Since Alberta is central to oil and gas production in Canada, the focus of these programs and measures is on that province.

Innovative research and technology development has become a main strategy to achieve emissions reductions in the oil and gas sector. In 2004, Nova Scotia held an *Energy Research and Development Forum* that brought together more than 200 researchers, industry and government representatives to discuss oil and gas, renewable energy and climate change. The *Petroleum Technology Research Centre (PTRC)*, in Regina, Saskatchewan, is conducting a study, known as the *IEA GHG Weyburn* CO_2 *Monitoring and Storage Project*, examining technologies that monitor and evaluate the long-term reliability of CO_2 storage in underground geological formations.

Alberta has invested heavily in research on several enhanced oil recovery projects. It has allocated $27 million to its universities for research training projects in enhanced oil and gas recovery and emissions reductions related to oil sands production and upgrading. The *Alberta Energy Research Institute* is conducting a $30 million pilot project that injects vaporized solvents into heavy oil, with the aim to significantly reduce GHGs and water consumption as compared to processes applying steam-assisted gravity drainage technology. Alberta's Department of Energy has instituted an *Innovative Energy Technology Program (IETP)*, committing $200 million over 5 years. IETP provides royalty adjustments to pilot and demonstration projects that use innovative technologies to materially increase recoveries from existing reserves; and to encourage responsible development of oil, natural gas and oil sands reserves.

[46] The International Energy Agency (IEA), based in Paris, is an autonomous agency linked with the Organisation for Economic Co-operation and Development (OECD). The IEA is the energy forum for 26 Member countries that have agreed to share energy information, to coordinate their energy policies and to cooperate in the development of rational energy programs.

Nova Scotia has recently taken steps to increase the usage of natural gas as a less GHG emissions-intense fuel within the province. In 2003, it allocated $14 million from the *Gas Market Development Fund* to help individual Nova Scotians, small businesses and institutions use natural gas. Then in 2005 it approved a $7.6 million loan from the Fund to assist local distributors in extending the pipeline system and increasing its distribution network into nearby municipalities.

Alberta has taken steps to reduce fugitive emissions from venting and flaring. The *Alberta Energy and Utilities Board (EUB)*, in association with *Alberta's Clean Air Strategic Alliance* and industry members, produced an awareness-building publication, "Guide 60: Upstream Petroleum Industry Flaring Guide" in 1990 to promote the adoption of procedures that decrease flaring and venting of solution gas from conventional production. EUB reported that solution gas flaring for 2004 was 72.2% less than the 1996 flaring baseline, while solution gas venting was 49.4% less than the 2000 venting baseline year. The Alberta Department of Energy also implemented an *Otherwise Flared Solution Gas Royalty Waiver Program (OFSG)* in 1999. OFSG waives royalties on uneconomic solution gas and gas by-products that would have normally attracted a Crown royalty charge, in order to encourage the reduction of flared gas volumes in the province.

4.3.5.4 Other Measures

The *Canadian Association of Petroleum Producers (CAPP)* is the voice of the upstream oil and natural gas industry in Canada. Working closely with its members, governments, communities and stakeholders, CAPP analyzes key oil and gas issues and represents member interests nationally in 12 of Canada's 13 provinces and territories. At this time, Nunavut does not have oil and gas activity. CAPP is currently discussing climate change policy options with federal and provincial governments. Member companies are required to collect and report data related to GHG emissions as a part of *CAPP's Stewardship Initiative*.

Members of the upstream oil and gas industry, and oil sands in particular, have been undertaking their own programs to reduce energy consumption and thereby reduce GHG emissions. Upstream oil and gas companies representing 93% of upstream emissions voluntarily submit their plans to the *Canadian GHG Challenge Registry*. The introduction of new technologies in the mining and extraction stages is leading to significant energy efficiency gains. Plants are also introducing programs to recover waste heat and increase processing efficiency. Companies are purchasing domestic GHG offsets, funding Clean Development Mechanism projects with international partners, and engaging in feasibility studies regarding CO_2 capture.

The *Canadian Oilsands Network for Research and Development (CONRAD)*, described in section 4.4.6, supports responsible environmental activities and continued funding of research in upstream oil and gas emission reduction opportunities.

The *Oil Sands Environmental Coalition (OSEC)*, a coalition of public interest groups with interest in the Athabasca oil sands area, facilitates more efficient participation in the regulatory approval process for oil sands applications. OSEC believes that progressive companies need to develop internal capacity for evaluating and purchasing GHG emission offsets as part of their corporate GHG management plans. OSEC asserts that the onus is on companies to extend their emission reduction efforts beyond the Kyoto commitment period. The coalition calls for companies to provide comprehensive GHG management plans for new projects, including emission reduction targets and strategies for continuous improvements over the life of the project.

4.3.5.5 Performance Indicators

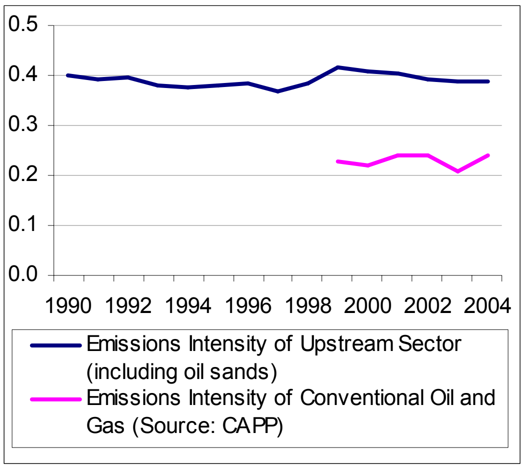
There is a need for improved, consistent benchmarking of Canada's oil and gas sector performance to allow for robust analysis. Performance indicators for the upstream oil and gas sub-sector are challenging to obtain; however, data collection has improved within the last few years. Some of the figures that follow present estimates designed to identify broad trends rather than exact numbers. CAPP is working with Natural Resources Canada's Office of Energy Efficiency (OEE) to develop indices and figures to assess how the industry is doing in terms of reducing energy intensity and GHG emissions and improving energy efficiency.

Sector-Wide

Canada's upstream oil and gas industry is reducing its GHG emissions intensity over time.

The industry's total GHG emissions per cubic meter of oil and gas output (including emissions from oil and gas production, pipelines and fugitives) declined by approximately 4% between 1990 and 2004 (Figure 4.3.5.7).

Figure 4.3.5.7: GHG Emissions Intensity of the Upstream Oil and Gas Sub-Sector, with and without Oil Sands (t CO_2 eq./m^3 conventional production equivalent), 1990 – 2004



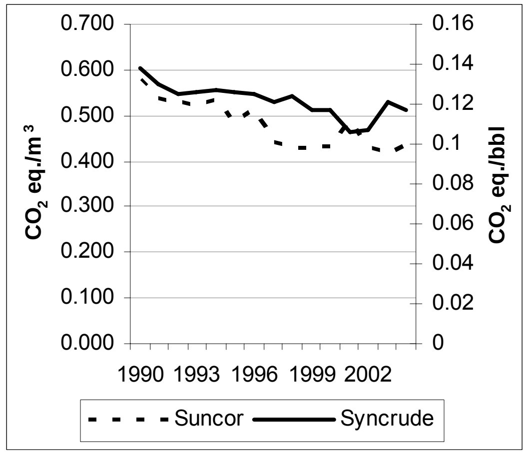
Data from CAPP shows that the GHG emissions intensity of conventional oil and gas production (i.e. excluding oil sands production) has experienced only minor fluctuations since 1999.[47] In 2004, it stood at 0.24 t CO_2 eq per cubic metre of production.

Oil Sands Production

Oil sands production energy intensity (energy used per unit of production) is much greater than conventional oil production due to the need to separate the oil from sand. Progress has been made by the industry in terms of energy efficiency improvements through the application of new extraction and upgrading technologies and management efforts, which in turn reduce energy intensity. By 2001 the energy intensity was 20% less than in 1990. However, even with the energy efficiency improvements, the processing still requires a tremendous amount of energy. The energy consumed per unit of oil sands production was 8.9 GJ/m^3 in 2001, such that for every 5 barrels of crude produced, the equivalent energy as provided in 1 barrel was consumed in production.[48]

The emissions intensity of oil sands production followed a similar trend as the energy intensity, since the fuel mix did not change significantly over the analysis period. Between 1990 and 1999, oil sands GHG emissions per unit of output were reduced by 22%, one of the best emissions reductions achievements in Canadian industry. Suncor and Syncrude's GHG emissions intensity data reflect this steady improvement (Figure 4.3.5.8).

Figure 4.3.5.8: Oil Sands GHG Emissions Intensity (t CO_2 eq./m^3), 1990 – 2004[49]

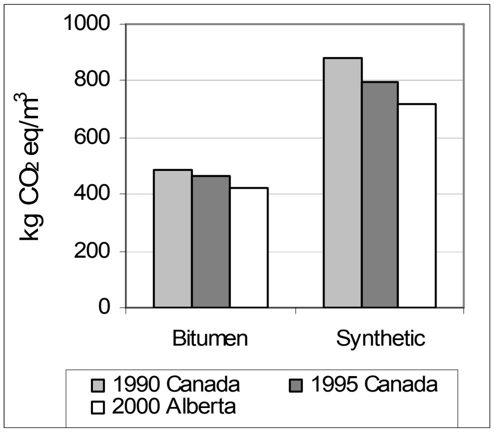


The oil sands industry predicts that the emissions intensity will continue to decrease in the future due to investment in new technologies (e.g.. Syncrude anticipates that through technology development it will improve by nearly 2% per year on average over more than two decades, resulting in a one-third reduction in CO_2 equivalent emissions per barrel during the period of 1988 to 2012.) Figure 4.3.5.9 presents an industry-wide estimate of oil sands production emissions intensity improvements.

[47] CAPP (2005).
[48] Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC) (2004).

[49] Suncor (2005) and Syncrude (2002, 2005).

Figure 4.3.5.9: Oil Sands Production Emissions Intensity (kg CO_2 eq./m^3), 1990, 1995 & 2000[50]



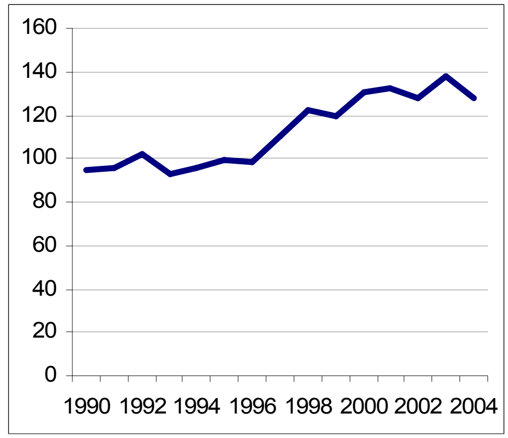
Reduction in GHG emissions intensity is a complicated issue that the industry is facing. Upstream oil and gas industry emissions are still rising because the rate of growth of oil and gas production (as shown in Figure 4.3.5.3 and Figure 4.3.5.6) has exceeded the improvements in emissions intensity. Improvements through research and technology development, such as those described in section 4.4, are expected to limit the growth in emissions over time.

4.3.6 Electricity Generation Sub-Sector

The electricity generation sub-sector involves the production of electricity from various energy sources. When electricity is produced by the combustion of fuel, such as coal, oil and natural gas, greenhouse gases are emitted. Converting other types of energy (including nuclear, hydraulic, wind, biomass, and solar) into electricity either produces no GHG emissions or, in the case of biomass, is considered part of the natural carbon cycle and therefore GHG-neutral. Seventy-five percent of power generated in Canada comes from non-emitting sources.

[50] Two sources of data were used in this table since no single source covers the range of years being assessed. The 1990 and 1995 nation-wide emissions data were compiled from NRCan (1997), the data for which was derived from Clearstone Engineering Ltd (1997). The 2000 Alberta data was compiled from NRCan in-house data.

Figure 4.3.6.1: GHG Emissions from Electricity Generation (Mt CO_2 eq.) , 1990 – 2004



Despite GHG-neutral sources providing a high proportion of electricity in Canada, electricity generation was responsible for approximately 17% (128.2 Mt) of Canada's total GHG emissions in 2004 and 21% of overall growth in GHG emissions from 1990 to 2004. GHG emissions from electricity generation grew by 35% during the analysis period (Figure 4.3.6.1).

Regions within Canada have very different allocations of energy resources; some are endowed with immense GHG-neutral hydraulic resources, while other provinces have abundant fossil fuel deposits.

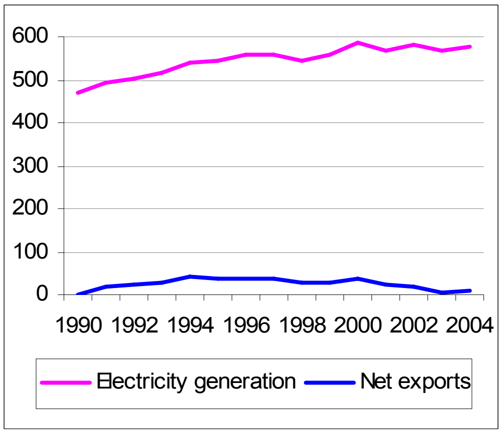
Management of energy resources such as power generation falls within the jurisdictions of individual provinces. Each province makes its decisions based on the availability and cost of development of resources within its boundaries, and the availability and cost of purchase of fuel or electricity from neighbouring jurisdictions.

The electric power grid in Canada developed largely as self-sufficient provincial grids. Over time, several provinces constructed both interprovincial and international interconnections. For geographic and economic reasons, the strongest transmission interconnections have been north-south, between provinces and adjacent American states. This has led to the establishment of integrated North American regional markets in which individual jurisdictions are mutually interdependent.

4.3.6.1 Trends in Electricity Generation

From 1990 to 2004, total electricity generation in Canada grew 24%; from 468 to 579 terawatt-hours (TWh) (Figure 4.3.6.2).This growth in generation occurred to satisfy domestic demand, which grew over 21% the same period.

Figure 4.3.6.2: Total Electricity Generation and Export (TWh) , 1990-2004



Of Canada's total electricity generation, electricity exports represent between 5 to 10% of production. At the same time, electricity imports have increased significantly since 1996, partly due to higher imports to Ontario following the lay-up of nuclear units.

Conventional Electricity Generation

Every conventional source of electricity in Canada experienced growth from 1990 to 2004, due to continued increases in electricity demand (Table 4.3.6.1). However, the shares of total generation of GHG-emitting electricity sources, including coal, oil and natural gas, increased while the shares of GHG-neutral electricity sources, including hydro and nuclear, decreased.

Table 4.3.6.1: Electricity Generation by Source (TWh), 1990 & 2004[51,52]

Source	1990	*share*	2004	*share*
GHG-neutral:				
hydro	293	*62.6%*	338	*58.4%*
nuclear	69	*14.7%*	85	*14.7%*
emerging renewables	4	*0.8%*	10	*1.7%*
Fossil-fuels:				
coal	78	*16.6%*	95	*16.4%*
oil	15	*3.2%*	19	*3.3%*
natural gas	10	*2.1%*	30	*5.2%*
other	0	*0.0%*	2	*0.3%*
Total	468	*100%*	579	*100%*

Hydroelectricity is the main source of electricity in Canada, representing 58% of supply in 2004. Provinces that produce large quantities of electricity from hydraulic energy include Quebec, British Columbia, Ontario, Newfoundland and Labrador, and Manitoba. Hydroelectricity production accounted for 80 to 85% of Canadian exports in recent years. Hydroelectric generation increased by 15% from 1990 to 2004, but its share of overall electricity generation decreased by four percentage points. This share decrease was a result of only moderate growth in hydroelectric capacity and lower than normal water levels in some regions in recent years.

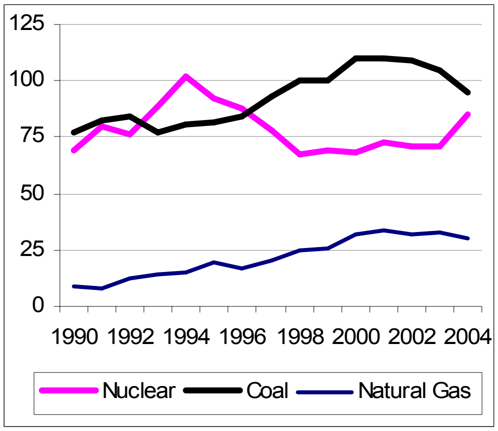
In 2004, 24 coal-fired power plants accounted for 16% of Canada's total generation. Five provinces (Alberta, Saskatchewan, Nova Scotia, Ontario and New Brunswick) produce 99% of all coal-fired electricity in Canada. Coal-fired electricity production increased by 24% from 1990 to 2004 (see Figure 4.3.6.3).

In 2004, nuclear power plants accounted for 15% of total generation in Canada. There are 20 units at three separate locations in Ontario and one unit each in Quebec and New Brunswick. Nuclear-based electricity generation increased by 24% from 1990 to 2004; however, nuclear's overall share of electricity generation

[51] Data on hydro includes both large and small hydro facilities; however, small hydro is generally considered an emerging renewable, and accounted for 13 TWh of the 2004 total.
[52] Emerging renewables data come from International Energy Agency's *Renewables information 2005*. All other data are from Statistics Canada catalogue no. 57-003-XIB.

remained relatively unchanged over the same period. Nuclear generation at eight units was suspended at various times during the analysis period (see Figure 4.3.6.3).

Figure 4.3.6.3: Nuclear, Natural Gas and Coal Electricity Generation (TWh), 1990 – 2004



Natural gas claimed a small but increasing share of total generation (5%) in Canada in 2004. The provinces of Alberta, Ontario, Saskatchewan, and British Columbia are the largest users of natural gas for electricity generation. In Canada, natural gas is used primarily as a peaking fuel. Because electricity production from natural gas-fired plants can be increased relatively easily and quickly when needed, they are more suited to meeting peak electric demand levels than other sources. Natural gas-fired electricity generation increased by 229% from 1990 to 2004, (see Figure 4.3.6.3); this considerable growth is partly attributable to the installation of almost 3,500 MW-equivalents of natural gas combined heat and power capacity during that period[53]. The share of overall electricity generation increased three percentage points over the same period.

In 2004, oil had a small share of overall electricity generation (3%) in Canada. Oil is occasionally used during periods of peak demand across Canada, and diesel is used in remote locations. As well, in New Brunswick, oil represents the largest share of electricity in the province's diversified electricity portfolio, at 41%. Oil-fired electricity generation has increased by 35% from 1990 to 2004; this increase resulted in a less than one-percentage-point decrease in oil's share of overall electricity generation.

Emerging Renewable Electricity Generation

While emerging renewables accounted for only a limited share of total generation in Canada (which is primarily due to the availability of large amounts of low-cost conventional electricity), some were among the fastest growing sources of electricity generation in the country. Canada produces electricity from the following emerging renewable sources: small hydroelectricity, biomass, wind energy, and tidal energy. Insofar as these forms of power generation displace existing or proposed fossil fuel-fired generation, they contribute to limiting GHG emissions.

The growth in emerging renewables has been influenced by supply-side initiatives and policies introduced in the late 1990s by federal and provincial/territorial governments and electric utilities.

The largest emerging renewable energy source is small hydroelectricity. Small hydroelectricity facilities with capacities lower than 50 MW totalled 13 TWh in 2004. Small hydro facilities can be found in almost every province and territory.

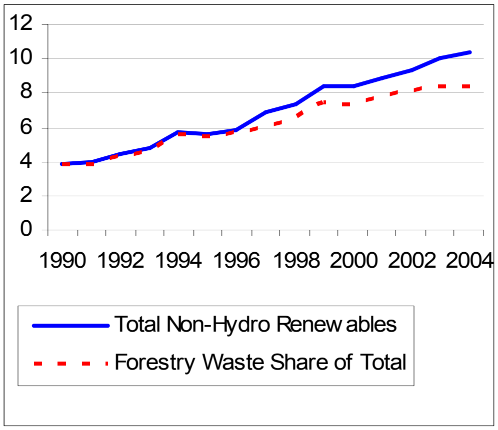
Wind power is the fastest-growing electricity source in Canada. In 10 years, wind energy capacity has grown from 20.0 MW to 683 MW by the end of 2005. Growth is expected to continue in the near future. Wind power facilities can be found in almost every province, and all provinces and territories plan to further develop their wind resources.

A major share of emerging renewable electricity in Canada is generated through the combustion of forest waste (e.g. wood chips, bark, and spent pulping liquor) by the forest products industry and some independent power producers. All provinces produce electricity from biomass to some degree, with the largest producers being those provinces with large forest products industries. Electricity from biomass has increased from less than 4.0 TWh in 1990 to over 8.0 TWh in 2004[54] (see Figure 4.3.6.4).

[53] Source: CIEEDAC 2004.

[54] Source: IEA 2005.

Figure 4.3.6.4: Non-Hydro Renewables Electricity Generation (TWh), 1990 – 2004



Note: the difference between the two lines results from the increasing share of wind power, solar power, landfill gas and other emerging renewables in electricity generation.

Tidal power is currently the least developed emerging renewable resource, totalling 20 MW in 2004. Canada has significant ocean resources and a number of costal provinces are exploring the possibility of developing these resources.

4.3.6.2 Federal Measures

The federal government's efforts to achieve emissions reductions in the electricity sector have been focused on three distinct areas: 1) encouraging and supporting demand-side management, 2) promoting emerging renewable sources of electricity and reducing barriers to interprovincial trade and transmission, and 3) research and development.

First, the federal government has encouraged and supported demand-side management (DSM). DSM programs aim to reduce residential, commercial and industrial demand through energy efficiency improvements. Measures focused on consumers are described in section 4.3.2 (Buildings Sector) and section 4.3.4 (Industrial Sector).

Second, the federal government has promoted emerging renewable sources of electricity and endeavoured to reduce barriers to interprovincial trade and transmission. Support for emerging renewable electricity sources could increase the share of GHG-neutral sources in the overall generation mix over time. Increasing interprovincial transmission capacity might facilitate a number of large-scale renewable projects where resources are of significant distance from large electricity load centres.

To this end, the federal government has undertaken the following initiatives.

Reducing Barriers to Interprovincial Trade and Transmission: These measures supported collaboration with provinces, territories, and other stakeholders to increase the availability of electricity from GHG-neutral sources. The initiative spent $1.1 million of an allocated $1.8 million to: 1) design and implement Canadian guidelines for the interconnection of small distributed power sources and proposals for changes to the Canadian Electrical Code; 2) assess and evaluate institutional and regulatory constraints to electricity trade and transmission, and explore policy and regulatory options to effectively improve knowledge and address the constraints; and, 3) develop information and approaches from which provinces could draw as they implement individual consumer information initiatives, consistent with their market structure, generation mix, and fuel options.

Wind Power Production Incentive (WPPI): This program was intended to increase the production of wind energy in Canada by encouraging participation from prospective producers in all regions to gain experience with wind power projects. The program, introduced in April 2002, received $329.9 million over 15 years to stimulate the installation of 1,000 MW of capacity by providing one cent per kilowatt-hour generated during the first 10 years of production. As of the end of December 2005, approximately $300 million had been committed to 21 projects with a total capacity of 920 MW.

On-site Generation at Federal Facilities: This program was aimed at promoting the adoption of electricity from emerging renewable energy sources for on-site electricity generation in federal buildings. It had two sub-objectives: to develop a sustainable market in federal facilities for reliable and cost-effective applications that are found essentially in off-grid locations; and, to create awareness of these systems among Canadians through installations in high-visibility buildings, mostly in on-grid locations. The program received $1.2 million from 2001 to 2005, resulting in a total of 17 projects (13 photovoltaic or PV; three wind; one micro-hydro) with federal departments and crown corporations for a total installed capacity of 857.5 KW, generating approximately 5.27 GWh/yr.

Government Purchases of Electricity from Renewable Resources (PERR): This initiative was intended to expand the emerging renewable energy industry in Canada by supporting promising technologies in the expectation that their total costs will come down as a result of the expanding market created by federal leadership. PERR contributed to the Federal House in Order mitigation objectives (described in section 4.3.1 covering cross-sectoral measures) by displacing existing electricity from high-carbon sources with new electricity from emerging renewable sources. The federal government committed to provide $70 million in funding over 10 years to this initiative, beginning in 2000. As of the end of March 2005, $11 million had been spent and $25.9 million in long-term financial commitments had been allocated to provincial governments.

Market Incentive Program (MIP): The MIP was designed to complement the PERR program. It was intended to encourage electricity marketers in competitive markets to offer customers the choice of purchasing electricity from emerging renewable energy sources. Of the $25 million committed to this program between 2001 and 2006, $0.4 million was spent by the end of December 2005, resulting in 130 GWh of new electricity production.

The GoC also has two significant tax measures that encourage business investments in electricity generation from emerging renewable sources:

- The *accelerated capital cost allowance (CCA)*, available on Class 43.1 and Class 43.2 assets, allows eligible production equipment to be written-off at a rate faster than its normally expected useful life. Class 43.1 provides an amortization rate of 30% on a declining balance basis while Class 43.2, which was introduced in 2006, provides a CCA rate of 50% for certain efficient and renewable energy production equipment acquired after February 22, 2005, and before 2012.
- The *Canadian Renewable and Conservation Expenses (CRCE)* allows for certain pre-project intangible costs to be 100% deductible in the year they are incurred. To further attract investors these expenditures can also be renounced to shareholders through a flow-through share agreement, provided the agreement is made before the expense is incurred.

The third area of focus under the federal approach has consisted of research and development efforts. This approach focused on the development of innovative long-term technology solutions designed to reduce GHG emitted through electricity generation. Programs and initiatives focused on advancing GHG reduction technologies through research and development are described in section 4.4 - *Technology and Innovation*.

4.3.6.3 Provincial/Territorial Measures

In recent years, provinces and territories have announced climate change plans that have included measures intended to facilitate GHG emission reductions from electricity generation consistent with their supply mix. This includes the promotion of emerging renewable technologies and research and development aimed at improving the conversion efficiencies of GHG-emitting technologies.

Most provincial and territorial governments have complemented these climate change initiatives with measures designed to promote the development of renewable energy[55]. Governments have used targets, incentives and competitive solicitation processes to encourage participation in the renewable energy industry. In addition, provincial and territorial governments have also begun R&D as well as promotional and awareness programs.

Some of the leading polices and programs are highlighted below.

In 2002, British Columbia set a target of 50 % of total new generation from renewable energy by 2012. In October 2005, British Columbia created a new participation rent policy for wind power projects located on Crown land, which offers financial incentives for capital investment in wind power production. Alberta has specified that 3.5 %, approximately 500 MW, of total electricity be met by renewables by 2008. In 2003, Alberta signed a $200 million green power contract, stipulating that 90% of the electricity used in provincial government operations will come from

[54] Renewable energy consists of large hydroelectricity as well as emerging renewable energy sources.

green power sources by 2005. In 2004, Saskatchewan enacted its Green Power Portfolio strategy, which declared that all new provincial electricity generation until 2010 would come from non-GHG emitting sources. Wind power has become the predominate source of new generation under this strategy, highlighted by a 150 MW wind development project that is under construction by SaskPower and will be operational by the beginning of 2006. In November 2005, Manitoba opened a competitive solicitation process for 1000 MW of wind energy to be built by 2014.

Ontario has established renewable energy targets of 5 % or 1,350 MW by 2007 and 10 % or 2,700 MW by 2010. Currently, the province has entered into agreements to purchase 1370 MW of renewable electricity, 1,300 MW of which will come from wind farms. Similarly, Quebec is seeking 3,000 MW of wind energy by 2013 through the solicitation process. The first solicitation for 990 MW has been awarded. A second for 2,000 MW will be awarded in 2007.

Prince Edward Island passed a *Renewable Energy Act* in 2004, requiring utilities to acquire at least 15% of electrical energy from renewable sources by 2010. Furthermore, this Act ensures the economic viability of community or wind cooperative systems by guaranteeing a selling price to the utility of up to 85% of the retail residential rate. In 2004, Nova Scotia passed an *Electricity Act* that requires resellers of electricity to ensure that a minimum portion of the supply comes from renewable resources. Regulations to be made under the act will state that by 2010, 5% of Nova Scotia's electricity supply must come from renewable resource generating capacity that was built after 2001. In 2005 Nova Scotia Power Inc. approved the commissioning of a wind farm of 30 MW. Contracts are signed for an additional 70 MW of wind energy. New Brunswick has set a guideline that 33% of provincial electricity consumption comes from renewable sources of energy by the year 2016. In conjunction with this guideline, the provincial government is currently developing 400 MW of new wind-powered generation.

The Northwest Territories has established a target that 10 % of the energy supplied to its communities, excluding industrial energy supply, will originate from renewable sources by 2010 and 25% by 2025.

In an attempt to accelerate the development of renewable and clean coal technologies, many provinces have also started research and development programs. Through the *Alberta Energy Research Institute*, the province of Alberta is conducting research and development of clean coal technologies for electricity generation. The nearly $13-million *Manitoba Research and Investment Fund* was created by the province of Manitoba to support research in alternative energy. Quebec has created the *Technical and Professional Energy-Efficiency Support Program* to provide financial and professional support to projects and activities that enable knowledge and know-how development of the energy efficiency and alternative energy industry in Quebec. Quebec has also created the *Energy Technologies Development Assistance Program* to contribute to energy resource diversification, and to support new technologies for which research costs cannot be covered entirely through private investment. Priority is given to research and development in hydrogen, biomass, and wind energy. In 2005, New Brunswick partnered with Nova Scotia to fund a study on the feasibility of tidal power off their coastlines, and to identify potential projects and demonstration sites. The *Northwest Territories Energy Corporation* examines the potential for large-scale hydroelectric development in the region. The *Yukon Development Corporation*, through the *Renewable Energy Resource Assessment* program, works to identify Yukon’s renewable energy resource potential on a comprehensive and systematic basis to assess the value for future supply.

Several provinces have taken measures to test the commercial feasibility of renewable energy through the development of pilot or demonstration projects. Ontario has started construction on a transportable bio-refinery plant to convert unused forest biomass into a renewable energy source that can be used to provide heat and electricity for northern communities. *SaskPower* and *SaskEnergy* have been investigating several distributed generation projects throughout the province, experimenting with flare gas, photovoltaics, natural gas, wood residue and animal manure. A small solar array is now part of the power source running the Alberta Legislature. Installation of this solar array is meant to help determine the regulatory/financial barriers that renewable and alternative energy generation projects face in relation to the power grid. The *Northwest Territories Energy Corporation* has several wind turbine projects under way to test the feasibility of using wind power to provide electricity to northern communities. The *Yukon Energy Corporation* is also testing two commercial wind turbines in an attempt to overcome technical barriers primarily associated with ice accumulation.

Provincial and territorial governments have also been active in developing promotional and awareness programs to encourage the commercialization of renewable energy. The *Northwest Territories Department of Resources, Wildlife and Economic Development* created a *Renewable Energy Technology Capital Assistance Program* to build public awareness of renewable energy systems and provide funding assistance to increase the number of systems installed. Ontario and Prince Edward Island have each launched an online wind atlas that allows users to identify prospective sites for future wind energy development. Manitoba has created several loan programs that supported the cultivation of a robust geothermal industry, which sees Manitoba leading the nation in the manufacturing of geothermal pumps and training more than half of Canada's geothermal installers.

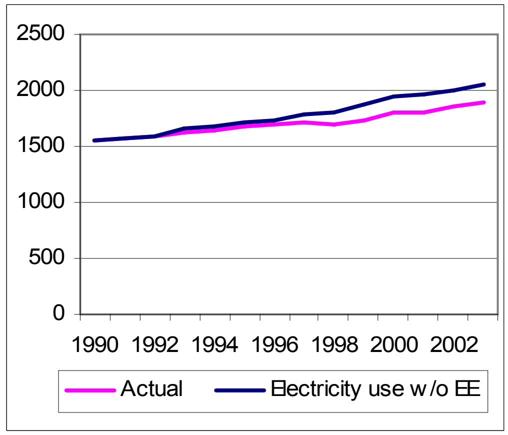
4.3.6.4 Performance Indicators

Between 1990 and 2004, GHG emissions from the electricity generation sector grew by 36% from 94.6 Mt to 128.8 Mt. This increase in emissions can be attributed to increased electricity generation (which was a result of increased demand), as well as the changes in the mix of generation sources. Two mitigating factors include energy efficiency and emissions intensity improvements.

Over the analysis period, total generation of electricity increased by 24% from 468 to 579 TWh (see Table 4.3.6.1). This increase in production was a result of increased demand. Demand for electricity increased over the period due to Canada's continued economic growth. Even if the generation mix had not shifted towards GHG-emitting sources, the production increase alone would have caused increased emissions.

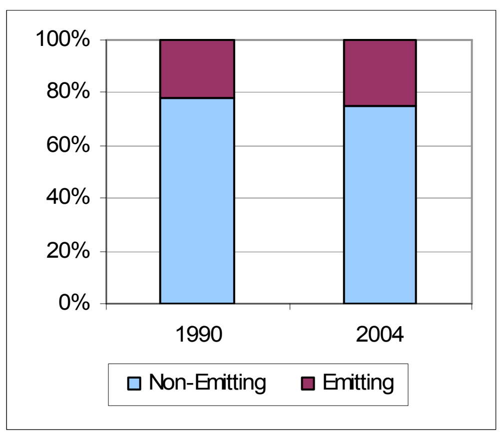
A second important factor affecting overall electricity demand is energy efficiency. Figure 4.3.6.5 demonstrates how demand-side energy efficiency measures have reduced demand growth over the analysis period. Had no energy efficiency measures been implemented, electricity demand would have been 8.5% higher, resulting in upward pressure on total electricity generation.

Figure 4.3.6.5: Electricity Demand, Actual and Without Energy Efficiency Improvements (PJ), 1990 – 2003



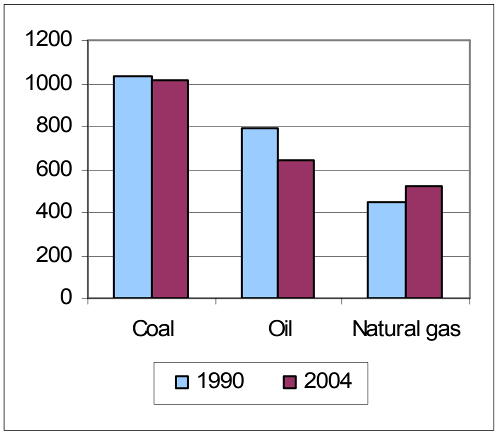
With regard to generation mix, the share of non-emitting sources declined from 78% to 74% between 1990 and 2004, while the share of emitting sources increased from 22% to 25% (see Figure 4.3.6.6). The impact of the shift towards using more fossil fuels in the generation mix was amplified by the increase in the use of coal, which has the highest emissions intensity of all fossil fuels.

Figure 4.3.6.6: Electricity Generation Mix by Source, 1990 & 2004



The growth in GHG emissions due to increased use of coal for electricity generation was partially muted by improvements in coal-fired technologies. This is shown by the emissions intensities of coal, oil and natural gas depicted in Figure 4.3.6.7.

Figure 4.3.6.7: Emissions Intensity of Fossil Fuels (t CO_2 eq./ GWh), 1990 & 2004



The emissions intensity of coal declined from 1030 t CO_2 eq. / GWh to 1010 t CO_2 eq. / GWh between 1990 and 2004. Emissions intensity of oil also declined but the muting effect was small as oil only accounted for 3% of the generation mix in 2004. The increase in the emissions intensity of natural gas partially negated the emissions intensity reductions of the other two fossil fuels.

When assessing whether mitigation efforts have been effective within the sub-sector, it is important to recognize that the effects of some of the efforts will be relatively limited in the near-term. For example, the adoption of new renewable technologies takes time, and although the sub-sector has made great strides since 1990, emerging renewables are still a relatively small share of the total electricity generation mix.

In the short term, replacing GHG-intensive fuels with those that are less intensive (i.e. replacing coal with natural gas) could reduce the emissions caused by electricity generation. Utilities and government authorities are continuing with efforts to reduce GHG emissions growth but substantial absolute reductions in emissions are only possible in the long term.

In the long run, demand for electricity can be expected to increase steadily as population grows and the economy expands. The efforts by governments and utilities in demand-side management could curb demand growth but are only one part of the equation to address GHG emissions.

A key element in reducing overall emissions from the sub-sector would be to shift the generation mix towards GHG-neutral sources. Emerging renewables are expected to provide an increasing but still relatively small contribution to emissions reduction. The installation of new hydroelectric stations, new and refurbished nuclear facilities, and clean coal power plants would provide significant emissions reductions for the sector. Plans have been put in place by provincial authorities to install new hydro capacity and to replace aging, subcritical coal-fired plants with new and/or refurbished nuclear facilities.

Finally, technological improvements in using fossil fuels are expected to lead to lower emissions intensity. The use of supercritical boilers instead of subcritical boilers in new coal-fired plants and the possible application of coal gasification with CO_2 sequestration would lower emissions from coal-fired electricity generation.

4.3.7 Mining and Manufacturing Industries

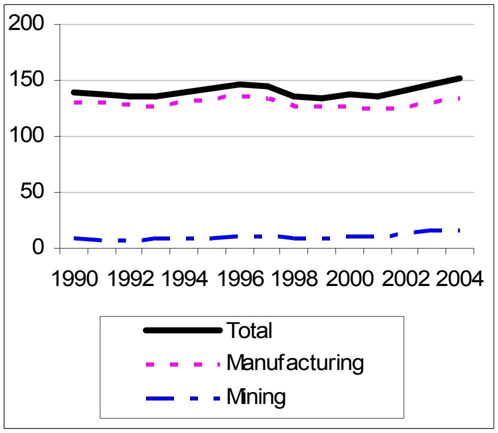
Mining industries include metal mining, non-metal mining and coal. Upstream oil and gas activities, usually considered as part of mining industries, are not discussed in this section as they are covered separately in section 4.3.5. Due to certain data limitations, however, emissions numbers presented for mining include some emissions related to the mining of oil sands.

Manufacturing industries include all industries involve in the processing of raw material into finished goods (including petroleum refining). Emissions from manufacturing industries result from the use of energy as well as emissions from industrial processes.[56] Due to data limitations, emissions numbers presented for manufacturing include emissions related to the upgrading of bitumen from oil sands.

[56] Construction is not included in this analysis, since it has a relatively small emissions output (1.4 Mt CO_2 eq. in 2003) and there are no emissions reductions programs specifically associated with it.

Together, mining and manufacturing industries as they are defined in this section contributed 20% (151.0 Mt) of total GHG emissions in Canada in 2004, down from a share of 23% in 1990. Emissions increased by only 9% between 1990 and 2004 (Figure 4.3.7.1).

Figure 4.3.7.1: GHG Emissions from Mining and Manufacturing (Mt CO_2 eq.), 1990-2004



Mining

Canada is one of the world's largest producers and exporters of more than 60 different minerals and metals. In 2004, Canada ranked:

- first in potash and uranium;
- second in nickel and magnesium;
- third in titanium concentrate, cobalt, aluminium, and platinum-group metals;
- fourth in gypsum, chrysotile (asbestos), zinc, and cadmium;
- fifth in molybdenum and salt; and
- sixth in lead, seventh in gold and silver, and eighth in copper.

In 2004, total exports for the mining and mineral processing industries, (including coal and excluding petroleum and natural gas), was $56.5 billion.[57] These exports represented approximately 13% of total Canadian exports.

The mining category contributed 2% (16.4 Mt) of Canada's total GHG emissions in 2004. Its emissions doubled during the analysis period, and a good proportion of the increase occurred in the recent years. The increase in emissions essentially reflects the recent growth in the mining of oil sands, as emissions from traditional mining activities have been relatively stable.

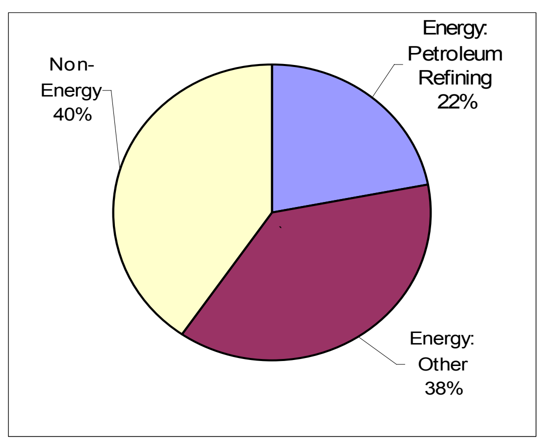
Manufacturing

Manufacturing contributed 18% (134.7 Mt) of Canada's total GHG emissions in 2004. Its share of total emissions diminished since 1990, as it experienced no significant change in emissions over that time.

Emissions in manufacturing industries result from the use of energy, essentially from the combustion of fossil fuels for process heat and for the space heating of plants and related buildings. Canada has many energy-intensive industries such as iron and steel, non-ferrous metals, chemicals, pulp, paper and print, and cement. The single largest emitting industry within manufacturing is the petroleum refining industry. Canada refines most of its requirements in refined petroleum products (e.g. gasoline). Refining is a downstream stage of the oil and gas industry, as opposed to the upstream aspects that are described in another section.

Emissions in manufacturing industries also result as different types of GHGs are produced as a direct by-product of non-energy related industrial activities, including production and use of minerals (i.e. cement, lime, limestone, soda ash), halocarbons and sulphur hexafluoride (SF_6), acid and metal production, and other undifferentiated production (e.g. lubricating oils and greases, waxes, etc.) Figure 4.3.7.2 shows the share of manufacturing emissions contributed from energy related activities and non-energy related activities in 2004.

Figure 4.3.7.2: Share of Manufacturing Emissions, 2004



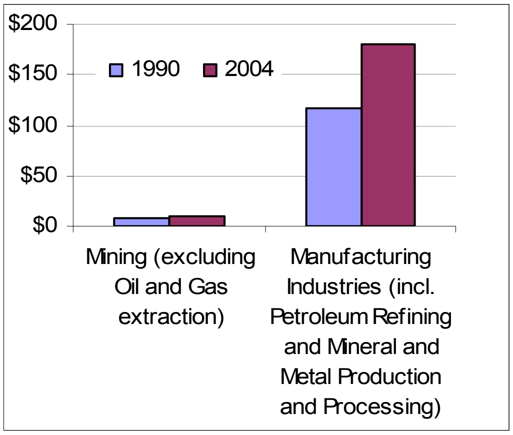
4.3.7.1 Trends in Mining and Manufacturing

Activity increased significantly in both mining and manufacturing industries during the review

[57] This data includes exports from the mining industry and the non-metallic mineral processing, primary metal processing and fabricated metal processing industries.

period, as reflected in the changes in GDP shown in Figure 4.3.7.3.

Figure 4.3.7.3: GDP of Mining[58] and Manufacturing (billion $1997 – GDP), 1990 & 2004



Mining

Mining experienced a 21% ($1.8 billion) growth in GDP between 1990 and 2004, (see Figure 4.3.7.3.) The largest increase occurred in the non-metallic mineral mining and quarrying industry sub-sector, with production more than doubling from $2.1 billion in 1990 to $4.7 billion in 2004.

The mining sector made energy efficiency gains that resulted in significant reductions in energy use during the analysed period. One factor that affects energy use in mining is the level of capacity utilization. Capacity utilization measures the extent to which an industry is using its existing production capacity. When production levels increase towards the potential maximum output of a facility, capacity utilization levels approach 100%. In general, the higher the capacity utilization, the more efficiently industry can use its resources.

In 1990, the mining capacity utilization rate was 88%, while by 2004 it had reached over 95% This means that the fixed component of energy use in mining facilities (e.g. lighting, equipment that consumes energy independent of production levels) was contributing to more output.

[58]Includes coal mining, metal ore mining and non-metallic mineral mining and quarrying.

Manufacturing

Manufacturing industries experienced a 54% ($63.2 billion) growth in sector GDP between 1990 and 2004. Despite this growth in activity, overall emissions from manufacturing did not increase. This was due in part to:

- structural changes in the manufacturing industry;
- a significant increase in the use of biomass waste for energy purposes in the pulp and paper industry; and,
- a sharp drop in non-energy process emissions from the production of adipic acid.

In terms of structural changes, manufacturing activity that consumes more than 6.0 MJ per dollar of GDP (e.g. pulp and paper and lime) represented 42% of industrial activity in 1990, but only 34% in 2004. The activity of many types of energy-intensive manufacturing was replaced by less energy-intensive manufacturing, such as computer, electrical and electronic products and machinery.

Emissions from petroleum refining rose by 29% between 1990 and 2004. The growth in emissions was influenced by a 30% rise in sector GDP and the growth in upgrading of bitumen from oil sands. Energy-related emissions from other manufacturing industries, however, declined by during the same period. A large portion of the decline resulted from a 4.3 Mt reduction in GHG emissions from the pulp, paper and saw mill industry, even though the industry saw a 20% growth in sector GDP.

The capacity utilization rate of manufacturing rose from 78% in 1990 to 85% in 2004. Within manufacturing, pulp and paper, primary metals and petroleum refining experienced a rise in capacity utilization, while chemicals experienced a reduction.

Non-energy related emissions, created through industrial processes, rose from 53.3 Mt to 54.3 Mt between 1990 and 2004. They made up 7% of total Canadian emissions in 2004, as opposed to 9% in 1990. The decline can be explained in part by significant emission diminutions in three areas: adipic acid production (-71%), magnesium production (-29), and aluminium production (-22%). Conversely, there were increases in process emissions associated with the production of ammonia (44%).

Adipic acid is mainly used in the production of nylon, but also inside lubricant components and gelling aid as a food additive. The sole adipic acid production facility in Canada (operated by Invista and formerly DuPont since 1990) installed an emission abatement system in 1997, which resulted in a 7.6 Mt (71%) reduction in process-related N_2O emissions over the 1990-2004 period despite being temporarily off-line in 2004. The decline in magnesium production emission, even while production rose by more than 212%, was due to the progressive replacement of SF_6, used as cover gas, (SF_6 is the most potent GHG the IPCC evaluated, with a global warming potential of 23,900 times that of CO_2 over a 100 year period.) Throughout the analysis period, as primary aluminium production increased by 66%, process emissions were reduced as a result of new technologies within existing plants and capacity additions.

4.3.7.2 Federal Measures

Under AP2000, the GoC set out to reduce emissions from the minerals and metals industries by enhancing processes and practices, through the following initiatives.

Enhanced Emission Reductions for Minerals and Metals: This aspect of the Minerals and Metals Program aims to reduce GHG emissions in the Canadian minerals and metals industries. This program is comprised of three initiatives announced in AP2000 programs. In 2001/02, the combined initiatives were allocated $6.6 million over five years, of which $5.1 million was spent by the end of March 2005. The initiatives are described below.

- The *Concrete Roads Program* was designed to raise awareness among decision makers (primarily provincial Ministries of Transport) of the fuel economy benefits of rigid (i.e. concrete) roads compared to asphalt roads. Although progress was achieved on some outcomes (e.g. adoption of lifecycle analysis; active networks and information exchange), a validation study undertaken at the request of the provincial stakeholders indicated that the reduction in rate of fuel consumption for concrete versus asphalt pavements was not large enough to produce significant GHG emission reductions. The resources and associated target of this initiative were redirected to the other initiatives.
- The *Supplementary Cementing Materials (SCM) Program* promoted increased use of SCMs to displace cement used for making concrete. The production of Portland cement, an essential constituent of concrete, leads to the release of significant amounts of CO_2 (producing one tonne of Portland cement generates about one tonne of CO_2) Reclaimed industrial by-products, such as fly ash, slag and silica fume - commonly called SCMs - can reduce the amount of cement needed to make concrete, and hence reduce the CO_2 generated in the cement manufacturing process. Approximately 10 to 12% of the cement used in concrete applications and mining is now replaced by SCMs, which accounts for 750,000 to 900,000 tonnes per year (tpy). The objective of the program is to increase the use of SCM by 500,000 tpy by 2012. The SCMs program was deemed quite successful in fulfilling most of the components' intended outputs. The impact of this program on GHG emissions reduction has not been measured yet, but according to the NRCan Minerals and Metals Sector's (MMS's) Canadian Mineral Yearbook, the proportion of SCMs used in concrete has increased by about 32% from 1999 to 2003. Although it is difficult to directly attribute recent increases in the use of SCMs to this program, the evidence indicates that the most significant increase appears to have occurred between 2001 and 2003, concurrently with this program.
- The *Studies and Monitoring for Greenhouse Gas Reduction Potential* examined areas where improved knowledge and understanding could enhance current programs, and potentially lead to new programs that would reduce GHG emissions, by gathering data and other information needed on potential approaches. Projects have shown potential for real reductions of GHG emissions in a pilot setting and results have been distributed to stakeholders. Work to date has identified several areas of significant potential reductions in GHG emissions, including the cogeneration of electricity from off gases (e.g. steel production); and replacing lime in mine effluent treatment with cement kiln dust.

Enhanced Recycling: This program aims to enhance Canada's potential to recycle more materials by developing new approaches and improving current recycling practices and policies. The scope of recyclables was originally primary metals such as aluminium and steel, as well as minerals, but it was subsequently extended to include other associated and valuable secondary resources. Program data show that the energy requirements of producing materials from primary ("new") feedstock far exceed those for recycling (producing the same materials from secondary resources). Of the $3.4 million pledged to this program for the five year period from 2001/02 to 2005/06, $2.9 million was spent by the end of March 2005. To date, the program has created a National Advisory Committee with stakeholders from all levels of government, industry associations and NGOs; conducted life-cycle analysis for a number of material and product-specific applications; recovered large scrap metal in the far north; supported a pilot to recover small residential metal scrap in a municipality; produced a "waste as a resource" manual for communities; and, developed a recycling website (www.recycle.nrcan.gc.ca), which continues to be populated with recycling data and information. The program has also raised awareness of many important issues among a broad group of stakeholders across Canada, through participation in various communications opportunities such as seminars and workshops. Since the start of the program, 35 projects have either been completed or are in progress. Additional benefits from increased recycling include reduced energy use, reduced greenhouse gas emissions, the recovery of valuable materials, and the reduction of discarded residuals.

Canadian Industry Program for Energy Conservation (CIPEC): CIPEC was established in 1975 as an industry-government partnership aimed at improving Canada's industrial energy efficiency in the mining, manufacturing and construction sectors. CIPEC has worked with the Mining Association of Canada (MAC) to co-fund a number of energy efficiency improvement initiatives for MAC members, using AP2000 monies. Specifically, two benchmarking studies were cost-shared with MAC members and led to the identification of $100 million in potential energy savings with an average payback of between 1 and 1.5 years at the sites where the audits first took place.

It was expanded in 2001 to reach more industrial companies in more sectors. Through CIPEC, the mining, manufacturing and construction industries have voluntarily improved their energy intensity by an average of 1.8% per year since 1990, with an accompanying 1.1% annual improvement in energy efficiency. General information about CIPEC is provided in section 4.3.4 on cross-cutting industrial measures.

4.3.7.3 Provincial/ Territorial Measures

Some of the provinces and territories have designed programs to reduce GHG emissions in the mining and manufacturing industries. A few of their leading programs and measures are highlighted below.

Most programs that are designed for the mining and manufacturing industries focus on energy efficiency. A few provinces and territories have created financial measures to entice these industries to become more efficient. Manitoba Hydro has started the *Power Smart Performance Optimization Program* that uses financial incentives to encourage the optimization of energy processes and motor driven systems including pumps, fans and air compressors. The Yukon government has implemented the *Energy Infrastructure Loans for Resource Development Projects*, an initiative designed to encourage the responsible and efficient use of energy in the development of resources in the Yukon. It assists the Yukon's resource development sector by deferring the high capital cost of building energy infrastructure.

Many jurisdictions provide services such as energy audits in an attempt to support demand side management initiatives. The Prince Edward Island government will conduct free energy audits for manufacturers and processors in their provinces. This service includes an analysis of the energy-consuming systems within the facility, a load inventory of all the equipment that consumes electrical energy, metering the facility for a minimum of 24 hours to obtain a load profile, and an analysis of potential energy conservation measures that will reduce the energy costs in the facility. Ontario Power Generation provides *Envision*, a free service that allows companies to aggregate and compare themselves to find efficiencies in how they can buy and use utilities. Envision provides accurate calculations of utility costs per item or unit of production, thereby allowing for accurate energy conservation planning.

A few provinces have also identified areas within mining and manufacturing that could benefit from further research and development. Such initiatives are described in section 4.4.

4.3.7.4 Other Measures

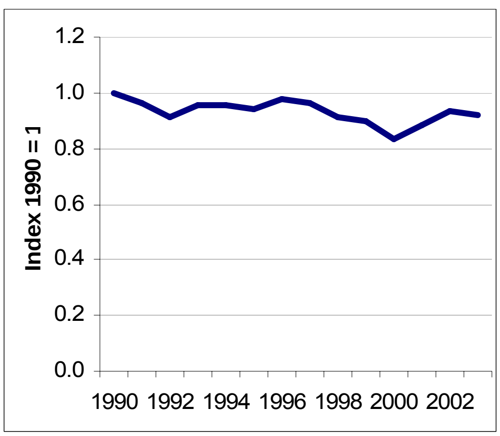
The Manitoba Division of Canadian Manufacturers and Exporters (CME) conducts the *Advanced Manufacturing Initiative (AMI)*. AMI promotes "Lean Manufacturing", which is all about building capacity with existing resources. It consists of the delivery of Lean Programs focused on the reduction and removal of waste from manufacturing processes, improvements in productivity and energy conservation.

4.3.7.5 Performance Indicators

Mining

Figure 4.3.7.4 shows an indicator of energy intensity for metal and non-metal mining.[59] It is a composite indicator that accounts for structural shift between metal and non-metal mining. Between 1990 and 2003, the energy intensity improved by 8%.

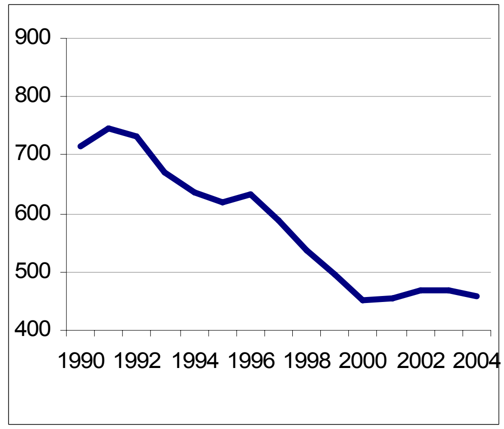
Figure 4.3.7.4: Energy Intensity Indicators for Aggregation of Metal and Non-Metal Mining, 1990-2003[60]



Manufacturing

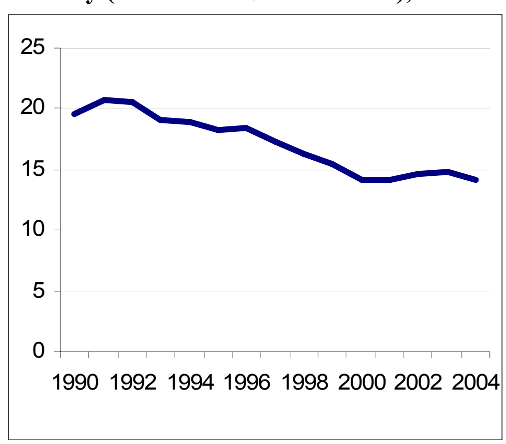
The aggregated manufacturing emissions intensity decreased by 36% between 1990 and 2004 (Figure 4.3.7.5). The emissions intensity was affected by the intensity of non-energy related process emissions, the carbon-intensity of the energy mix, and the energy intensity of the manufacturing processes.

Figure 4.3.7.5: Aggregated Manufacturing Emissions Intensity (tonne CO_2 eq./million $1997 – GDP), 1990 – 2004



With respect to the energy intensity of the manufacturing process, aggregated energy intensity improved by 28% between 1990 and 2004 (Figure 4.3.7.6). Growth in the share of less energy-intensive manufacturing industries was a contributing factor, as was the improvement in energy efficiency.

Figure 4.3.7.6: Aggregated Manufacturing Energy Intensity (MJ/million $1997 – GDP), 1990 – 2004



Improvements occurred in the high energy-intensive industries, specifically energy efficiencies were achieved in the petroleum refining, smelting and refining, and chemical industries. Only cement and iron and steel recorded slight energy-intensity increases, at 2% and 4% respectively (Figure 4.3.7.7).

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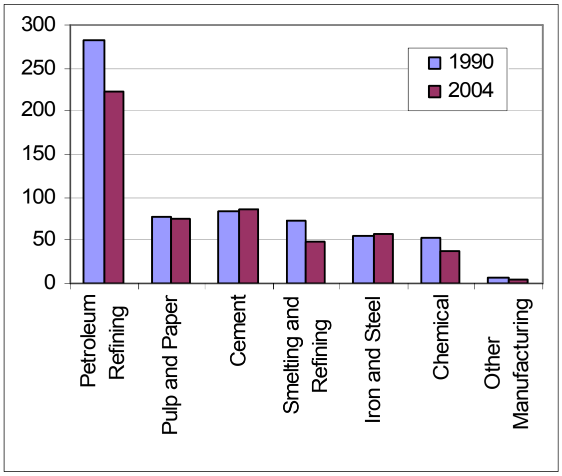
[59] Excluding quarries and sand pits, as well as oil and gas extraction.
[60] Source: CIEEDAC 2004.

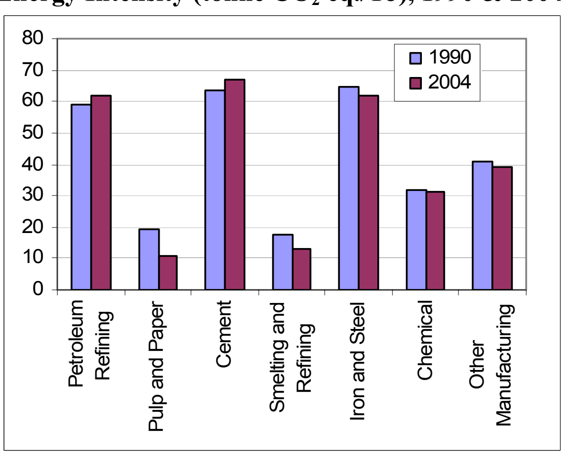
Figure 4.3.7.7: Manufacturing Energy Intensity (MJ/million $1997 – GDP), 1990 & 2004



Comparing the aggregated and non-aggregated results, the aggregated energy intensity figure is lower than those of most of the specific manufacturing industries' outlined in Figure 4.3.7.7 because the least intensive category, "Other Manufacturing", made up 84% of total manufacturing industry in GDP terms by 2004.

With respect to the carbon intensity of the energy mix, improvement occurred in all energy-intensive manufacturing industries with the exception of petroleum refining and cement, which each rose by 5% (Figure 4.3.7.8). Improvements also took place in "other manufacturing", which are predominantly composed of less-energy intensive industries.

Figure 4.3.7.8: Manufacturing GHG Emissions Energy Intensity (tonne CO_2 eq./TJ), 1990 & 2004



Pulp and paper made a significant improvement in emissions intensity, declining by 44% during the analysis period. The share of biomass (i.e. wood waste and pulping liquor) used in the industry's fuel mix increased, while shares of more carbon-intensive heavy fuel oil and natural gas declined. This fuel switching contributed to a slight rise in energy intensity during the same period.

4.3.8 Agriculture and Forestry Sectors

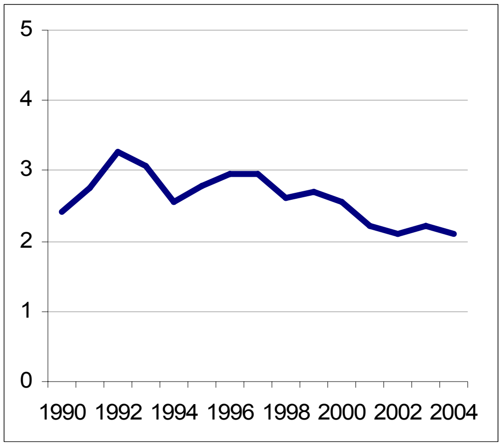
For the purpose of this chapter, the agriculture sector in Canada is composed of all types of farms, including livestock, field crops, grain, and oilseed farms. The forestry sector includes logging operations only in terms of their stationary combustion-related emissions, while the majority of the analysis is focussed on Canada's managed forest in terms of its sinks and sources.

Agriculture and forestry are two industries in the Canadian economy that provide opportunities for both emissions reductions and carbon sequestration. As biological systems, agriculture and forestry are both part of the GHG challenge and its solution. The analysis in this section is broken down into 1) energy sources and 2) non-energy sources and sinks. The forest non-energy GHG sources/sinks and removals of CO_2 from agricultural soils are not officially counted in Canada's national GHG total.

4.3.8.1 Energy-Related Trends

The stationary, combustion-related emissions from agriculture and forestry amounted to 2.1 Mt in 2004, a decrease of 13% since 1990 (Figure 4.3.8.1). The energy-related emissions included in the agriculture and forestry sector are limited to emissions from stationary fuel combustion. Mobile emissions associated with these industries (e.g. from farm diesel fuel oil and motor gasoline) are included as off-road or marine emissions under the Transportation sector. The exclusion of mobile emissions presents a major impediment to comparative analysis of trends in the emissions due to economic activity in the sector. Aggregate Gross Domestic Product numbers are presented below for reference only.

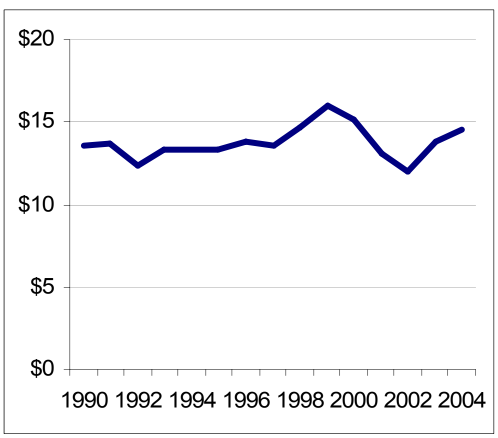
Figure 4.3.8.1: Stationary combustion-related emissions from agriculture and forestry (Mt), 1990 – 2004



Agriculture Trends

GDP in the primary agriculture sector was 6% higher in 2004 than 1990, at $14.5 billion (Figure 4.3.8.2). Production in the industry has fluctuated during the analysis period, reflecting weather as well as international trade issues.

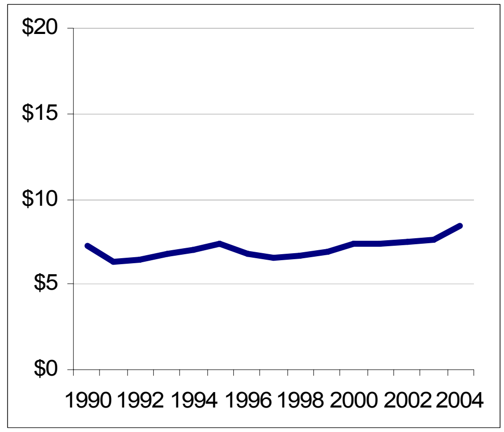
Figure 4.3.8.2: GDP of the Primary Agriculture Sector (billion $1997 - GDP), 1990 – 2004



Forestry Trends

Economic activity within the forestry sector experience growth during the analysis period, with the GDP rising 16% from $7.3 billion in 1990 to $8.4 billion in 2004 (Figure 4.3.8.3).

Figure 4.3.8.3: GDP of Forestry (billion $1997 - GDP), 1990-2004



4.3.8.2 Non-Energy Trends

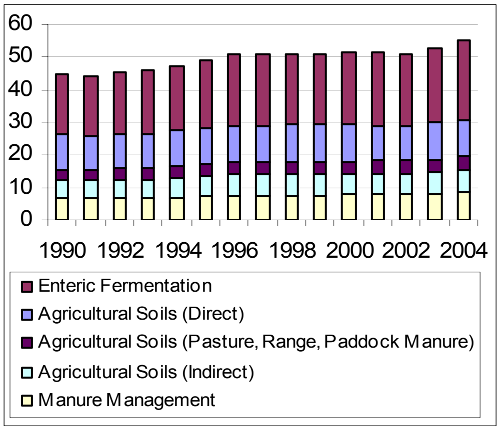
At present, agriculture contributes to Canadian emissions. Forest lands have generally contributed a sink though they can be highly variable and in years of large forest fires have contributed substantial emissions. The methodology through which these sectors' emissions are treated has changed in recent years.

Agriculture Non-Energy Trends

Canada's 247,000 farmers manage 68.0 million hectares of land and millions of livestock. Non-energy related GHG emissions from agriculture contributed 7% (about 54.9 Mt) of Canada's total GHG emissions in 2004, the vast majority of which were non-carbon dioxide emissions. Emissions result mainly from nutrient amendments (e.g. fertilizer application and livestock manure management), animal husbandry practices and land management activities. Agricultural sources generate three GHG gases: nitrous oxide (N_2O) associated with fertilizer and manure management, methane (CH_4) associated with enteric fermentation and manure management, and some carbon dioxide (CO_2).

Between 1990 and 2004, GHG emissions from the sector increased by 23%, or 10.1 Mt CO_2 eq. (Figure 4.3.8.4). The increase in emissions resulted mainly from the expansion of the beef cattle, swine, and poultry industry and the rise in synthetic nitrogen fertilizer consumption.

Figure 4.3.8.4: GHG Emissions from Agriculture Sector (Mt CO_2 eq.), 1990-2004



Enteric fermentation was the largest contributor to agricultural GHG emissions throughout the analysis period (Figure 4.3.8.4), with emissions rising 30% to 24.0 Mt by 2004. Total emissions from agricultural soils contributed the next largest amount, emitting 22.4 Mt. Specifically, direct emissions from agricultural soils rose 5% over the analysis period to 11.5 Mt. These originate from synthetic fertilizer, manure on cropland, crop residue, tillage, summer-fallow and cultivation of soils. The share of emissions from manure deposited on pasture, range and paddock land increased the most relative to what they were in 1990, with a 35% growth to 4.3 Mt in 2004. Indirect emissions from agricultural soils (i.e. volatilization and leaching of animal manure, synthetic fertilizer nitrogen and crop residue nitrogen) increased by 20% to 6.6 Mt by 2004. Emissions relating to manure management rose to 8.4 Mt, up 26% from 1990.

Agricultural land also has the potential to help Canada achieve emissions reductions through biological sequestration of carbon dioxide (soilcarbon sinks or storage of carbon in soil organic matter) in cropland. Land management practices can reduce emissions and remove carbon dioxide from the atmosphere and sequester it in soils as soil organic matter. These practices include conservation and reduced tillage, agroforestry, increased production of perennial crops and permanent cover, less use of fallow in crop rotations, grazing land management, and shelterbelt planting. . For carbon sequestration to continue, it is critical that cropland continue to be managed so that additions of carbon exceed loss of carbon from the soil; the carbon storage cannot be considered permanent. Improved management practices not only assist in carbon sequestration, but may also help to improve fertilizer and water use efficiency, generating economic gains for agricultural producers.

Forestry Non-Energy Trends

Including fresh water, Canada's total surface area is 998 million hectares (ha), of which 310 million ha (about 31% of the area) is forested. Forty percent (402 million ha) of the land has tree coverage, although not all of this land is considered to be forested. Areas such as treed wetlands (muskeg, bog, swamp) and land with scattered trees (treed rock, wooded prairie, etc.) are examples of treed land that is not considered forest (92 million ha). The Crown owns 92% of the treed land, with the remaining 8% being privately held. Most of Canada's treed land (93%) is publicly owned, with 77% under provincial jurisdiction and 16 % under federal purview.

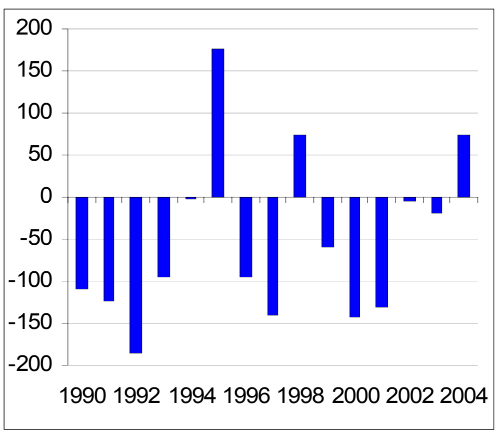
Canada's forests are extensive, dynamic carbon stocks. Forests can act as either sinks or sources for atmospheric carbon, depending on the disturbance regime. Photosynthesis is the process by which trees absorb carbon dioxide (CO_2) from the atmosphere, convert it to carbohydrates, of which carbon is an essential ingredient, and store it in their roots, leaves, branches and trunks. A vigorous and growing forest acts as a sink, storing carbon as it grows to maturity. When trees die as a result of old-age, disease, fire or insects, the stored carbon is released, and the forest may become a source. Forest fires also release non-CO_2 emissions (methane and nitrous oxide).

Forests are an integral component of the carbon cycle, which moves carbon (in the form of carbon dioxide, carbonates, organic compounds, etc.) between the atmosphere, oceans and terrestrial ecosystems through biochemical, physical, and geological processes. Trees incorporate atmospheric CO_2 within their tissue through the process of photosynthesis, and then redistribute it through the soil, biota and atmosphere through decay, respiration and consumption. The carbon flux within Canada's forests varies across ecosystems and on seasonal, annual, and multi-decadal time scales. The carbon budget of a forest, whether it is managed or unmanaged, is strongly influenced by age distribution, growth processes and disturbances caused by fire, insects, disease and harvesting.

Current estimates suggest that after having acted as a sink for atmospheric carbon for much of this century, Canada's total forest and other wooded land was a net source during the 1980s. However, what is relevant for considering human impact on forest emissions and removals is the area of the forest that is managed, not the total forest. As well, emissions and removals associated with deforestation (the permanent loss of forest) and afforestation (creation of new forest) must be considered to determine the overall emissions and removals associated with forests.

Figure 4.3.8.5 shows the changes in GHG removals and emissions from managed forest lands from 1990 to 2004, displaying the high interannual variability over the reporting period. In 2004, net emissions amounted to about 80.8 Mt. The changes in emissions reflect the difference between carbon uptake by tree growth, and emissions due to anthropogenic and natural disturbances, specifically forest management activities, wildfires, and insect infestations.

Figure 4.3.8.5: Trends of GHG removals and emissions from Forest Land (Mt CO_2 eq.), 1990 – 2004.[61]



The estimates in Figure 4.3.8.5 show that Canada's forests have generally acted as a net sink of GHG during the analysis period. Years 1995, 1998 and 2004 are exceptions in the analysis period, as they experienced substantial emissions due to extensive forest fires. The data used in Figure 4.3.8.5 has changed from previous national GHG inventory reports, reflecting better information and improved methodologies.

[61] Positive values are emissions while negative values represent removals.

It is important to note that these historical emissions and removals are not good predictors of future emissions/removals, since the net carbon balance of Canada's managed forest will be strongly affected by past and future natural disturbance rates. Future increases in insect and fire disturbances would increase the likelihood of the managed forest being a source, though actions could be taken to try to increase removals and reduce emissions.

It is also important to note that the net emissions/removals from forest-related activities are not included in the assigned national total for Canada under the Kyoto Protocol. Under Article 3.3 of the Kyoto Protocol, Canada must account for the GHG emissions and removals in the first commitment period (2008-2012) resulting from afforestation, reforestation and deforestation (ARD) activities since January 1, 1990. Under Article 3.4 of the Kyoto Protocol, Canada has the option to include the GHG emissions and removals associated with forest management in its first commitment period (CP1) accounting. The net emissions/removals in CP1 from ARD activities will be added or subtracted from our gross emissions. Similarly, the net emissions/removals during the commitment period from forest management, if Canada elects it, would be added or subtracted from our gross emissions.

4.3.8.3 Federal Measures

Agriculture Measures

The GoC, through its AP2000, set out to accelerate efforts to reduce agricultural emissions and explore environmental opportunities. Implementing beneficial management practices in the agriculture sector involves awareness building, outreach, research and demonstration.

The following is a description of measures that integrate GHG reductions and removals within the agriculture sector:

Greenhouse Gas Mitigation Program for Canadian Agriculture (GHGMP): This program involves identifying suites of best management practices (BMPs) to reduce GHG emissions; raising awareness, and involving producers in fostering the adoption of practices that reduce GHG emissions. It also quantifies and measures the impact of specific BMPs on GHG reductions, in order to improve existing practices. In order to achieve these objectives, the program measures are targeted at soil, nutrient and livestock management; and, increasing carbon sinks. AP2000 provided a total of $21.0 million to the three components of this initiative to cover the period from October 2001 through to March 2006. By the end of March 2005, approximately $15.0 million was spent and over 600 demonstration sites, throughout Canada's agricultural zones, have showcased BMPs to over 35,000 people. A further 200,000 people have been exposed to the program at agricultural conferences and industry meetings. The quantification of selected BMPs is facilitated by designated Agriculture and Agri-Food Canada (AAFC) scientists who have been paired with each of the partner industry groups. The Scientific Working Group of the GHGMP is working closely on the scientific and economic aspects of BMPs with the modellers in the companion AP2000 Model Farms Program (see section 4.4 *Technology and Innovation*). Suites of BMPs address each of the following three farm management areas:

- *Nutrient Management*, which was allocated $7.0 million, includes fertilizer formulation & application practices;
- *Livestock Management* was assigned $9.0 million for livestock feeding and manure handling practices; and,
- *Soil Management*, with $5.0 million in funding, covers soil management practices including carbon sink management.

Shelterbelt Enhancement Program (SEP): This program is contributing to the sequestration of carbon dioxide through the establishment of approximately 8,000 km of riparian buffer strips, consisting of wildlife, field, and farmyard shelterbelts on agricultural lands across the Prairies. It also raises awareness of the potential of shelterbelts to mitigate agricultural GHG emissions. Targeted at farmers, the SEP provides technical assistance as well as seedlings and plastic mulch for weed control, resulting in improved shelterbelt planting success at a lower cost to the participating landowners. The federal government, through AP2000, committed $4.0 million to this program over five years, beginning in 2001. By the end of March 2005, approximately $2.8 million had been spent and, 2,895 km of new shelterbelts had been planted as a result of the 1,332 applications that had been approved as of spring 2004. The targeted planting of approximately 8 million incremental shelterbelt trees and shrubs will also protect some 26,000 hectares of soils and crops, and water resources; enhance 6,400 hectares of wildlife habitat; and, provide energy savings by protecting farm buildings from wind and weather. Initial interest and uptake for this program has been strong, however recent demand has been impacted as a result of economic uncertainties in the agriculture sector.

These AP2000 programs were incorporated into Canada's *Agricultural Policy Framework (APF)* – a new strategic agriculture strategy announced in 2002. A combined federal-provincial-territorial initiative designed to support agriculture and agri-food, the APF has been allocated $5.2 billion over six years from the federal government and additional in kind funding from the provinces is expected to raise the total program budget to $8.0 billion. Though not directly designed as a climate change strategy, the environmental component of the APF has several programs that focus on improving environmental performance on farms, including reducing and removing GHGs. An example of such programs is *Greencover Canada*, a five-year, $110-million initiative that provides farmers with financial and technical assistance to convert environmentally sensitive land to perennial cover; manage agricultural land near water; and, plant trees and shrubs as a natural part of the agricultural landscape. Other APF agricultural measures, such as the Environmental Technology Assessment for Agriculture (ETAA) program, that focus on technical developments are covered in section 4.4 on technology and innovation.

The agriculture sector may also contribute to the replacement of fossil fuel by providing renewable biomass for bio-fuels and bio-products production (e.g. ethanol, bio-diesel), which are discussed under the transportation section of this chapter.

Forestry Measures

Through the following initiatives, the Canadian Forest Service (CFS) and its partners have examined policy options to encourage afforestation / reforestation activities to derive other long-term climate change mitigation, environmental and economic benefits in Canada.

Feasibility Assessment of Afforestation for Carbon Sequestration (FAACS): The main objectives of the FAACS initiative were to evaluate the feasibility of afforestation and undertake information collection and land assessment research on privately owned lands, as well as help establish Canada's carbon measurement and accounting infrastructure for reporting on afforestation. The initiative was completed in March 2005. This initial phase of afforestation analysis was essentially a preparatory measure intended to evaluate whether a large-scale national afforestation effort would be feasible and what it would involve. Work activities included the collection of information on past afforestation in Canada and the development of analytical models to estimate potential future afforestation. In partnership with provinces, industry and forestry associations, five afforestation pilots were established across Canada to test the responsiveness of landowners to a range of incentives to expand forest cover in Canada, resulting in several reports being produced. Development of an *Afforestation Feasibility Model* provided a national picture of where potential future afforestation would be economically feasible, given a range of financial incentives. A *Land Suitability Model* was developed for assessing species suitability, growth and yield. Finally, FAACS engaged in developing carbon accounting capacity, as described later in this section.

Forest 2020 Plantation Demonstration and Assessment Initiative (Forest 2020 PDA): Building upon the work of the FAACS initiative, the Forest 2020 PDA explored the use of fast-growing tree plantations to help achieve Canada's climate change and fibre production goals. It analysed investment potential and assessed options to attract private investment in future plantations, and demonstrated the potential of fast-growing tree plantations to help Canada reduce its GHG emissions and address climate change. This initiative was completed in March 2006. Working in partnership with provinces, forest industry, associations and rural landowners, the CFS established over 6,000 ha of fast-growing plantation demonstration sites on suitable private lands to test and improve our biological information and demonstrate the various benefits, both economic and environmental, from plantation forests. Research was devoted to examining the economics of these fast growing plantations and assessing options to attract investment, both internationally and domestically, into future Canadian plantations, by taking advantage of the combined benefits of wood fibre and potential values from carbon sequestration. To complement this research, the Forest 2020 PDA continued the FAACS research into cost-benefit modelling with the *Afforestation Feasibility Model* and into carbon measurement. Quantification protocols and guidelines were developed for assessing the plantation carbon sequestration and were tested by the Forest 2020 PDA participants.

The analysis on the economics and investment options for fast-growing hybrid poplar plantations indicated that while fast-growing forest plantations can provide a range of timber supply and carbon benefits, market mechanisms alone are generally not high enough to drive significant amounts of private investment across the country. However, in some specific parts of the country investment returns might be economic to some investors.

GHG Emissions Accounting

In addition to programs aimed at reducing emissions and removing GHGs from the atmosphere, the federal government initiated measures to help to better account for GHGs from the agricultural and forestry sectors.

Canadian Agricultural Monitoring, Accounting and Reporting System (CanAgMARS): CanAgMARS is a transparent and verifiable accounting system for estimating the amounts and uncertainties of soil carbon stock changes on agricultural land. Standard methodologies for measuring and modelling soil carbon and GHG emissions from agricultural land are key components of CanAGMARS and provide the basis for future GHG monitoring and verification programs in agriculture. A multi-disciplinary team of government and university scientists developed the comprehensive system that provided estimates of GHG emissions and removals from agricultural for the period 1990 – 2004, as reported in Canada's National Inventory Report of 2006. Methane and nitrous oxide emissions from enteric fermentation and methodologies for verification are reported consistently with CanAgMARS and will be incorporated into the system at a later stage.

National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS): Forest carbon accounting is the approach taken to quantify the amount of carbon sequestered in forest biomass and dead organic matter, and the changes in these carbon stocks over time. The *System* tracks any changes in carbon stocks and non-CO_2 emissions that result from forest management and land-use change (afforestation, reforestation, or deforestation) activities in Canada that have occurred since 1990. It incorporates information – such as forest inventories, temporary and permanent sample plots, statistics on fires and insects, and systems quantifying forest growth and yield – into a modelling framework designed to bring together the best available information and scientific understanding of the ecological processes involved in forest carbon cycling. The *System*, a national initiative involving CFS scientists from across the country includes the following key components:

- A new *National Forest Inventory (NFI)* provides information about the extent, state, and sustainable development of Canada's forest resources, to support policy and trade decisions, science initiatives and responses to regional, national and international inquiries. It also provides basic information needed for reporting on forest carbon. The *Canadian Forest Inventory Committee*, a group of forest inventory managers from federal, provincial and territorial governments, developed the NFI as a way to gather new and improved information on the state of the national forests for monitoring purposes. The NFI is a plot-based design consisting of permanent observational units located on a national grid. By collecting and reporting information to a set of uniform standards, it will allow for consistent reporting over time and across the country on the extent and state of Canada's landbase to establish a baseline of where the forest resources are and how they are changing over time. The first full set of plot measurements is scheduled to be completed by the end of 2006, and periodic remeasurement will occur thereafter. In addition to providing consistent estimates for traditional forest inventory attributes, the NFI will provide a framework for collecting additional data relevant to the reporting of progress towards sustainable development (e.g., socio-economic indicators), as well as data related to forest carbon, forest health (e.g., insect damage, disease infestation), biodiversity and forest productivity.
- A *Deforestation Monitoring* system uses remote sensing imagery, other records and ground-truthing to assess the extent of permanent losses in forest in Canada due to activities such as agriculture and urban expansion. The country is divided into 10 general strata based in part on expected intensity of deforestation and sampling of imagery is then undertaken. Higher sampling intensities are used for strata in which greater deforestation is expected, such as forest zones with intensive oil and gas development and the forest area at the northern border of the prairies.
- The *Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)* is a landscape-level forest carbon accounting framework that simulates carbon dynamics of above-ground and below-ground forest biomass and dead organic matter. It is being used to monitor past forest carbon stock changes and to predict future carbon stock changes through scenario and risk analysis. The framework incorporates forest inventory and growth and yield data, as well as statistics about natural disturbances (fire, insects), land-use change (afforestation, reforestation, deforestation) and forest-management activities (harvesting, slash burning, planting).
- The *National Afforestation Inventory (NAI)* Internet Reporting Tool, another forest carbon accounting tool that facilitates web-based reporting of afforestation, is integrated with the CBM-CFS3 to provide Carbon sequestration estimates for current afforestation activities and has been tested with the Forest 2020 PDA demonstration sites.

4.3.8.4 Provincial/Territorial Measures

Agriculture P/T Measures

Many of the provincial and territorial initiatives have created innovative programs to reduce GHG emissions in the agricultural sector. Some of their leading programs and measures are highlighted below.

Numerous provinces have awareness programs aimed at reducing the environmental impacts, including GHG emissions from farming practices. The Government of British Columbia, through the *BC Agricultural Council*, promotes best management practices to ensure that farmers and ranchers minimize environmental risk and maximize benefits. In Newfoundland, the *Canada – Newfoundland and Labrador Soil, Air and Water Quality Conservation and Enhancement Program* has been implemented to help minimize the impacts or risks to soil, air, water and biodiversity as a result of agricultural activity. The objectives of this program will help local agriculture adapt through improved use of agri-environmental risk assessment and planning, improved nutrient and pathogen management and improved land and water management.

A few provinces have provided financial incentives through research programs to promote innovative agricultural programs. The Saskatchewan Agriculture, Food and Rural Revitalization (SAFRR) department has ongoing programs to work with farmers, researchers and equipment innovators on soil conservation. Over the last 10 years, SAFRR has directed approximately $4.8 million in climate change research funding for 29 projects through the *Agricultural Development Fund* and the *Technology Adaptation Fund*. These soil conservation projects focus on reducing the loss and enhancing the productivity of valuable topsoil, while optimizing nutrient use. Manitoba has created the *Covering New Ground* initiative that provides funds to Manitoba producers and provincial commodity organizations to carry out sustainable agriculture demonstration or technology transfer projects throughout the province. Manitoba Hydro has also implemented the *Power Smart Heat Pad Program*, designed to help hog producers realize energy savings by using energy-efficient electric heat pads (displacing heat lamps) in their farrowing operations and increase market acceptance of the technology.

Alberta is conducting a research project that examines legal mechanisms for use with agricultural sinks. The project, led by the University of Calgary, will look at the contractual arrangements and market mechanisms that are needed for trading emissions offsets, as well as defining how buyers and sellers share the risk.

Forestry P/T Measures

The forestry sector plays a major role in the Canadian economy and actions in the sector could be aimed at increasing carbon sinks and reducing carbon sources while also serving the broader need of society for forest products, bioenergy and forest environmental services. Some of the leading provincial and territorial programs and measures in the forestry sector are highlighted below.

Better forest management and an increased focus on planning have been key topics in many of the provinces climate change strategies. British Columbia's *Crown Land Use Planning Enhancement Program* has been established to implement, monitor and evaluate land use plans and to assess the overall effectiveness of plans, as part of the cycle of continuous forest management improvement. The objectives of Ontario's *Large Scale Forest Carbon Project* are to generate forest carbon budgets at the regional level and determine how implementing Ontario's forest management plans will affect the forest carbon balance.

Saskatchewan has aggressively supported forest development projects in an attempt to increase the province's carbon sink potential. Saskpower's *Shand Greenhouse Pilot Program for Mini Nurseries* is a pilot program that assists in the development of 10 new mini-nursery sites in the province. Saskatchewan's *GHG Emission Reduction Trading pilot project* has allocated $6.0 million over five years in a project that establishes the equivalent of more than 500,000 ha of forest carbon reserves and the planting of approximately five million seedlings in northern forests.

Provinces are investing in science and technology to address the environmental concerns of forest management. Prince Edward Island is currently evaluating the feasibility of biomass-fuelled generating system to determine their suitability for economical power generation. Specifically, the potential of forest biomass fuel will be considered as part of upcoming public consultation on a new forest policy for the province. British Columbia's *FIA Forest Science Program* funds forest science initiatives that address the critical knowledge and information needed to enable science-based sustainable management of British Columbia's forest resources. The program focuses on applied research in the areas of sustainable forest management and improving timber growth, and achieving more effective use of forest science results through extension.

A couple of provinces have turned to genetics to increase the sustainability of their forests. British Columbia's *Tree Improvement Program* focuses on improving the public forest asset base by supporting the development and availability of genetically well-adapted, high quality reforestation material from natural sources and through the conservation of our forest gene resources. Alberta's *Standards for Tree Improvement*, enables the forest industry to plant genetically improved stock on Crown land.

A few governments have developed education programs or policy programs to publicize the importance of sustainable forest management. Manitoba Hydro's *Forest Enhancement Program* supports tree planting projects and forest education projects that improve the public's understanding of the role and importance of trees, forests and sustainable forest management in communities and forest-covered areas of Manitoba. Nova Scotia released the *Code of Forest Practice*, to provide direction to forest landowners and operators on forest management practices that lead to sustainable forests and forest use. It establishes key principles and provides technical references to assist in making operational forest management decisions.

4.3.8.5 Annex: Explanation of Methodology

Agriculture

In GHG inventory reporting as of year 2005, emissions and removals of CO_2 from agricultural soils are reported under Land Use, Land Use Change and Forestry (LULUCF), not under the agricultural sector.

Forestry

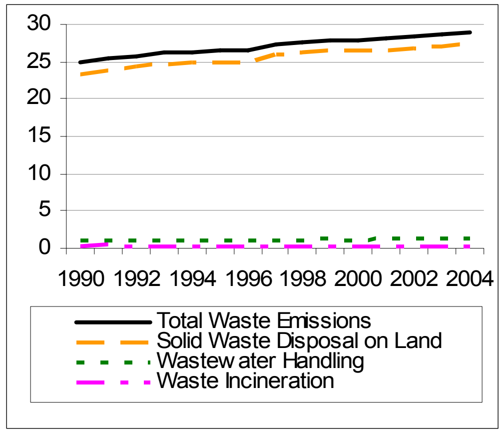
Canada's system for estimating and reporting GHG emissions and removals for the forestry sector is in a transition phase.[62] Key methodological changes between the 2003 and 2004 GHG inventory include the modelling of all forest ecosystem carbon pools, higher spatial resolution of input data, the long-term monitoring of forest ecosystem dynamics and disturbance regimes, and inclusion of insect disturbances. Previous and current approaches are radically different, so their components are not always comparable.

Details about the new GHG reporting format, keeping with the IPCC guidelines, are provided in Canada's *National Inventory Report - Greenhouse Gas Sources and Sinks in Canada, 1990-2004*.

4.3.9 Waste Sector

The waste sector includes emissions resulting from the treatment and disposal of waste, with sources including municipal solid waste and wood waste landfills, domestic wastewater treatment and waste incineration.[63] In 2004, the waste sector accounted for about 28.9 Mt CO_2 equivalent (4%) of Canada's GHG emissions. Landfills contributed 25% of Canada's total methane (CH_4) emissions. From 1990 to 2004, total emissions from the waste sector rose by approximately 4.0 Mt (16%) (Figure 4.3.9.1).

Figure 4.3.9.1: GHG Emissions from the Waste Sector (Mt CO_2 eq.), 1990-2004



Waste sector GHGs are emitted primarily as a result of solid waste disposal on land, i.e., municipal solid waste (MSW) and wastewater landfills (95%), but also wastewater handling (4%) and waste incineration (1%). Solid waste disposal emissions, at approximately 27.4 Mt in 2004, grew by 17% between 1990 and 2004. The chief contribution was CH_4 contained in landfill gas (LFG) from municipal solid waste and wood waste landfills. CH_4 is emitted through the decomposition of biomass in the waste.

GHG emissions from wastewater handling rose by 14% to 1.2 Mt between 1990 and 2004. Wastewater treatment generates CH_4 and nitrous oxide (N_2O) emissions.

GHG emissions from waste incineration decreased by 37% to 0.3 Mt during the analysis period. Waste incineration generates CO_2, CH_4 and N_2O emissions.

[62] The information that is reported in this overview is based on estimates reported in *Canada's Greenhouse Gas Inventory 1990-2003* and *National Inventory Report 1990-2004* submission to the United Nations Framework Convention on Climate Change (UNFCCC).

[63] When waste consists of biomass, the CO_2 produced from burning or aerobic decomposition is not accounted for in the Waste Sector, as it is deemed a sustainable cycle (carbon in CO_2 will be sequestered when the biomass regenerates). In theory, emissions of CO_2 are accounted for as part of the LULUCF Sector; however, waste that decomposes anaerobically produces methane (CH_4), which is not used photosynthetically and therefore does not sequester carbon in biomass. The production and release of unburned CH_4 from waste are therefore accounted for in GHG inventories.

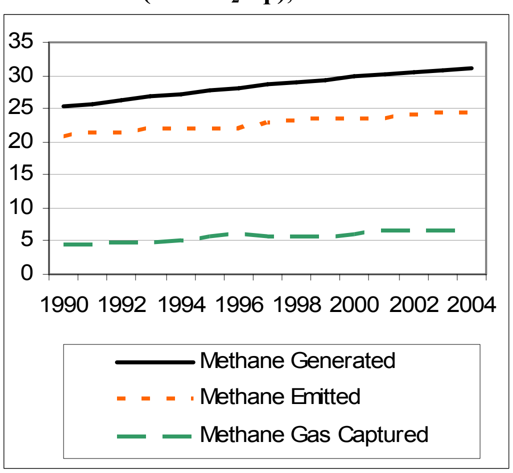
4.3.9.1 Trends in the Waste Sector

The amount of MSW generated in Canada in 2002 was 971 kg per person. The percentage of disposed waste contributed by various sectors of the economy was distributed as follows: 40% residential; 49% institutional, commercial & industrial; and 12% construction & demolition.[64]

LFG is a potentially harmful emission from MSW, the CH_4 component of which can be converted into a reliable energy source. In addition to GHG reductions, the capture and use of LFG provides co-benefits of limiting odours, controlling damage to vegetation, reducing owner liability, risk from explosions, fires and asphyxiation, and smog while providing a potential source of revenue and profit. Furthermore, the combustion of landfill gas destroys volatile organic compounds, reducing smog formation.

The portion of methane gas that was captured over the amount generated increased from 17% (4.4 Mt CO_2 eq.) to 21% (6.5 Mt CO_2 eq.) between 1990 and 2004 (Figure 4.3.9.2). It is estimated that the LFG sector has the potential to reduce emissions by an additional 8.0 to 10.0 Mt CO_2 equivalent per year through landfill gas capture and flaring from approximately 100 landfills.

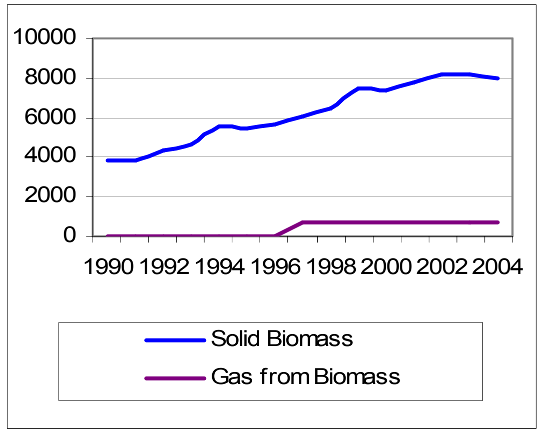
Figure 4.3.9.2: MSW Gas Generated, Captured and Emitted (Mt CO_2 eq.), 1990-2004[65]



[64] Source: Statistics Canada (2002).
[65] Wood waste landfills methane contribution is not included in these figures. Methane Gas Captured includes a portion of methane that is emitted to the atmosphere as a result of passing through the flare's burner uncombusted. Emissions from the combustion of methane gas captured and utilized are accounted for in the energy sector rather than the waste sector, and are thus not included in Figure 4.3.9.2.

In addition to LFG transformation to energy, solid biomass waste such as wood waste can also be converted to electricity. The amount of electricity generated from solid biomass waste in Canada has more than doubled between 1990 and 2004 to 7,938 GWh, while that generated from gas biomass waste has increased by more than 30-fold to 731 GWh in 2004 (Figure 4.3.9.3).

Figure 4.3.9.3: Gross Electricity Generation from Solid and Gas Biomass Waste (GWh), 1990, 1995, 2000-2003[66]



4.3.9.2 Federal Measures

The responsibility for MSW management in Canada is shared among the federal, provincial/territorial and municipal governments. MSW collection, diversion and disposal operations are the responsibility of municipal governments, while the provinces and territories are responsible for approvals, licensing and monitoring of MSW operations. The federal government is engaged in MSW management issues related to competitiveness and environmental sustainability, toxic substances, federal lands and resources, interprovincial and international transport, federal assistance programs, and climate change.

The GoC advances the LFG sector through such activities as conducting LFG-related research, purchasing GHG emission reductions from LFG projects, preparing technical bulletins on LFG projects, producing a guidance document for LFG development, supporting the Landfill Gas Industry Alliance, conducting a bi-annual LFG inventory, and developing a quantification protocol for GHG emission reductions from the LFG combustion.

[66] Source: IEA (2005).

Pilot purchasing of emissions reductions was done under the *Pilot Emission Removals, Reductions and Learnings* initiative. Several LFG projects benefited from support under the *Green Municipal Fund*. These initiatives are described under section 4.3.1 *Cross-Sectoral Measures*.

Canada joined the *Methane to Markets Partnership* in July 2005. The *Methane to Markets Partnership* is an international initiative that advances cost-effective, near-term methane recovery and use as a clean energy source. The goal of the Partnership is to reduce global methane emissions in order to enhance economic growth, strengthen energy security, improve air quality, improve industrial safety, and reduce emissions of greenhouse gases. The Partnership's success is built upon the commitment and collaborative efforts of partners and project network members. These parties support the goals of the Partnership by:

- Identifying promising ideas and sites for project development
- Assessing the technical and economic feasibility of projects
- Facilitating exchange of best-management practices and lessons learned
- Supporting technology transfer and demonstration
- Identifying and addressing legal, regulatory, and market issues
- Raising awareness that methane is a commodity with a practical and profitable use rather than a nuisance and safety hazard

As a member of this eighteen-country initiative, Canada has an opportunity to share its experiences implementing methane emissions reducing technologies and practices with other countries; assisting others to reduce climate-changing emissions; generating GHG emissions reduction credits; and creating new markets for Canadian products and expertise. Through co-operation between developed and developing nations, the Methane to Markets Partnership has significant potential to reduce global greenhouse gas emissions.

The *National Office of Pollution Prevention* (NOPP) within Environment Canada is the lead for the management of toxic substances, implementation of federal pollution prevention policy and legislation, and the development of new concepts and policy instruments that facilitate the transition to pollution prevention in Canada. NOPP's mission is to promote, through regulatory and voluntary initiatives, the shift to a preventive approach to environmental protection throughout Canadian society, and to contribute science, knowledge, leadership and innovation to the prevention and resolution of pollution problems.

NOPP provides recommendations on management of specific toxic substances that lead to regulations, guidelines, standards, codes of practice, voluntary agreements and other non-regulatory initiatives that result in clean air and water for Canadians. NOPP is responsible for development and implementation of these instruments, and for reporting on results. NOPP keeps abreast of emerging concepts and approaches to environmental protection nationally and internationally, evaluates their application, and where warranted, promotes the use within Canada. NOPP administers the *Waste Prevention Program*, which focuses on the sustainable management of solid non-hazardous waste by developing, implementing and coordinating national programs that foster waste prevention and sustainable waste management. Specifically, NOPP works with governments, municipalities and the private sector to identify and promote opportunities for landfill gas capture and utilization which can result in the reduction in environmental impacts, energy consumption and the optimization of energy recovery.

4.3.9.3 Provincial/ Territorial Measures

Provincial governments have developed legislation and regulations that govern both public and private waste management operations in Canada. In Canada, municipal governments own and operate landfills. They often contract the operations out to the private sector. Provincial and territorial governments have the jurisdiction to issue approval landfill certificates and licenses as well as monitor MSW management operations.

A 2003 inventory identified a total of 44 LFG recovery systems located within five Canadian provinces; 15 in British Columbia, one in Alberta, 17 in Ontario, 12 in Quebec and one in Nova Scotia. In total, 6.5 Mt CO_2 eq was captured. From this total, 55% of the captured methane was utilized at 16 sites and the remaining 45% was flared at 28 sites. Of the 16 utilization facilities, nine LFG systems generated a total of 80 MW of electricity and seven facilities utilized the LFG for heating applications ranging from heating buildings and greenhouses to providing fuel for a gypsum manufacturing plant, a steel refinery, and a recycling plant.[67]

In 1998, the Ontario government set out landfill standards, which require the collection and burning (or utilization) of methane at all new or expanding municipal waste facilities (larger than three million cubic metres). In Quebec, a few specific landfills have been required to install a landfill gas management system since 1993 as part of the site-specific permit under the impact assessment procedure. The *projet de règlement sur l'élimination des matières résiduelles* (PREMR) was published for comments in October 2000 with the intent of replacing the 1978 *Solid Waste Regulation*, which does not contain any specific requirements for the collection and combustion of landfill gas. If enacted as proposed, this regulation would require the capture and combustion of landfill gas for new and expanding large landfill sites (greater than 1.5 million cubic metres capacity, or the receipt of 50 000 tonnes/year or more of solid waste).

Some other leading provincial and territorial climate change programs and measures in the waste sector are highlighted below. All these programs reduce waste related methane emissions through waste diversion, recycling or modern waste management programs.

Several provinces have developed specialized funding programs to support waste management within their provinces. The Manitoba government established the *Waste Reduction and Pollution Prevention Fund* (WRAPP) to support improved waste reduction and pollution prevention practices in the province. This fund supports projects focusing on waste reduction, pollution prevention and innovative integrated waste management practices. The *Newfoundland and Labrador Waste Management Trust Fund* has benefited more than 300 community and environmental groups, municipalities, and schools, and has funded dumpsite closures, waste management studies, school recycling initiatives, and environmental education and recycling. Alberta's *Waste Management Assistance Program* provides technical and financial assistance to groups of municipalities to address their waste management needs. Assistance covers regional waste management planning studies and up to 75% of capital and engineering costs associated with the design and construction of regional waste management systems.

A few provinces have created knowledge dissemination programs to encourage better waste management programs within the private sector. The Saskatchewan government has partnered with Saskatchewan Waste Reduction Council to maintain a resource centre on waste reduction and other environmental issues. It has information on a wide range of topics and responds to information requests from businesses, municipalities and community groups about recycling and waste reduction. Nova Scotia has implemented the country's most aggressive solid waste-resource management strategy. It has conducted *Extended Producer Responsibility* (EPR) Workshops that provided participants with an opportunity to discuss EPR program design, to learn of emerging approaches and technologies, and to help in the planning of EPR programs in their area of responsibility. Ontario's *Pollution Prevention Pledge Program* publicly acknowledges facilities that develop and achieve pollution prevention goals that exceed existing government standards.

Some provinces have developed comprehensive acts or separate governing entities that guide or implement all of their waste management programs. British Columbia has enacted the *Environmental Management Act* that provides a more flexible authorization framework, increases enforcement options and uses modern environmental management tools to protect human health and the quality of water, land and air in the province. *Island Waste Management Corporation* (IWMC) is the provincial Crown Corporation that administers and provides solid waste management services throughout Prince Edward Island. IWMC operates and maintains the Waste Watch Program; a three-stream source separation based waste management system that is Island-wide. New Brunswick developed the *Waste Reduction and Diversion – An Action Plan* for New Brunswick, a comprehensive waste reduction plan that includes; Legislated Waste Diversion, Standards, Green Procurement Policy for Government, Public Education Campaigns and Industry Stewardship Programs.

[67] Source: Environment Canada (2005).

Canada's territories have also been actively implementing waste management programs. Yukon has established the *Recycling Club*, a program that helps children establish community recycling depot and programs and allows participants to win prizes in return for their effort. NWT has developed a *Beverage Container Program* where aluminum, tin/bi-metal cans; plastic, glass bottles; milk jugs and juice boxes are collected and recycled.

4.3.9.4 Other Measures

The *Landfill Gas Industry Alliance* promotes the recognition of LFG as a renewable energy resource, publicizes the related benefits, and builds broad-based support for its development. The Alliance acts as a forum for individuals and organizations to exchange information and advocate for policies and programs that support the LFG industry in Canada.

Wood waste landfills are privately owned and operated by forest industries, such as saw mills and pulp and paper mills. Some industries have shown increasing interest in waste-to-energy projects that produce steam and/or electricity by combusting these wastes.

4.3.9.5 Performance Indicators

The increase in the CH_4 generation rate from MSW landfills is directly dependent upon the population growth and the waste generation rate and is mitigated by the landfill gas capture rate. It is expected that as larger and more "state of the art" landfills are constructed, where gas collection systems will be required, a greater portion of landfill gas will be captured in the future, resulting in a greater reduction of emissions from this sector.

Per capita emissions from the waste sector increased 0.5% from 1990 to 2004, due primarily to the increasing emissions from landfills. Waste emissions growth surpassed population growth between 1990 and 2004 in part because material landfilled in the preceding 30 to 50 years continued to decompose and contribute to overall LFG production. Section 3 .4.5. provides a graph of the growth in per capita GHG emissions from the waste sector over the analysis period.

4.4 REVIEW OF MEASURES IN TECHNOLOGY AND INNOVATION

4.4.1 Introduction

The previous section described measures put in place in Canada to mitigate greenhouse gas emissions using existing technologies and processes. Development of new mitigation solutions through technology and innovation (T&I) constitutes the second most important set of measures to address climate change. T&I activities focus on the development of innovative long term solutions that would allow the reduction of GHG emissions while the economy continues to grow. The approach requires participation by federal, provincial and territorial governments, academia and industry.

4.4.2 Technology and Innovation Policy

Federal, provincial and territorial governments have recognized and strongly endorsed innovation and new technology as the key to addressing the economic and environmental challenges Canada faces going into the 21st century. To act on this commitment, the Energy Technology Working Group (ETWG) has been created with the following mandate:

- review energy research, development and demonstration (RD&D) programs across the country and identify strengths and weaknesses;
- identify technology priority areas for cooperative, focussed efforts;
- develop options to enhance collaboration amongst governments, industry, research institutions and other key partners; and,
- develop bilateral and multilateral agreements that result in implementation of collaborative programs or projects.

Several climate change-related measures have been identified, such as bioprocesses in industrial applications, hydrogen production for use in transportation, and advanced end-use efficiency buildings and communities projects.

4.4.3 Research Focus Areas

While T&I activities span a wide range of subject areas, there are currently five key research areas governments are focusing on:

- clean fossil fuels;
- advanced end-use efficiency;
- decentralized energy production;

- biotechnology; and,
- the hydrogen economy.

These research areas have been identified as having considerable potential in the Canadian context.

Clean Fossil Fuels

Both the World Energy Council and the International Energy Agency (IEA) predict that fossil fuels will remain the primary source of energy for the next 20 years. While requirements for burning fossil fuels increase with the wealth generation around the world, production moves toward heavier crude oils in all producing countries, which leads refineries to invest in upgrades that reduce efficiencies. In Canada, bitumen from the Oil Sands and heavy oil from the Western Canadian Sedimentary Basin (WCSB), Alberta and Saskatchewan will increasingly replace conventional oil supplies, while natural gas will be derived from unconventional sources in increasing proportion. Coal reserves are widespread in the WCSB and generate much electricity in the eastern and western parts of the country, while imports of coal from the Eastern United States fuel about 30% of the power generated in Ontario, Canada's largest province.

Canada has vast reserves of all types of fossil fuels; they can be accessed inexpensively and constitute an efficient method of generating energy. Since energy is derived from the burning of hydrocarbons, both CO and CO_2 are emitted in the production and use of the fuels. In addition, fossil fuels can emit a large number of pollutants (e.g. NO_x, SO_x, H_2S, Hg, particulates) that can be captured by a variety of methods. One method for "managing carbon" is the interest in CO_2 Capture and Storage by governments, industry and research institutions. An example of a planned international demonstration project is the *IEA Weyburn CO_2 Monitoring and Storage* project, in Weyburn Saskatchewan. The overall intent of the work in cleaner fossil fuels is to make the production of energy less energy intensive and less polluting.

Funding by the Program of Energy Research and Development (PERD), since the early 1970s, has supported R&D for the sustainable development of Canada's bitumen and heavy oil resources and its unconventional fuel products, and on the production, combustion, and transportation of conventional fossil fuels, while the funds provided by the federal Budget 2003 have placed more emphasis on the mitigation of GHG effects during the production and transportation of unconventional fuels. As well, PERD has contributed to gathering of information needed for regulating fossil fuel production and remediation of contaminated sites.

Advanced End-Use Efficiency

Canada has an extreme continental climate on most of its land mass, hot in summers and cold in winter; it is full of natural resources that need to be processed before they can be used; and it is a large country with the majority of the population concentrated in a few, widely spaced urban centres and a small minority in extremely remote communities. Since the energy for buildings, industry, and transportation mainly derives from fossil fuels, increasing the efficiency of energy end use will contribute to the reduction of total GHG emissions.

Historically, Canada has been an innovator in the design of buildings, both residential and commercial, and the Federal laboratories within Natural Resources Canada (NRCan) and the National Research Council of Canada (NRC) have led the way in developing construction methods, testing, codes and standards. There have been many programs within NRCan, Industry Canada, and other departments concentrating on industrial energy end-use and NRCan, NRC, and Transport Canada have been prominent in research and development (R&D), Demonstration and Deployment within the field of transportation. For instance, regulation for new vehicles at the federal level is done by the Canadian Motor Safety Vehicle Standard (Transport Canada) and the Canadian Environmental Protection Act (Environment Canada). However, provincial government departments and laboratories have considerable regulatory influence on all three end-use sectors, such as in licensing and operating vehicles. Municipalities, through their influence on infrastructure, including building and planning by-laws, are also a major player in determining end-use efficiencies.

At the federal level, the Advanced End Use Efficiency technology area has been divided into three program areas: Buildings and Community Energy Technology, Industry, and Transportation. The building, industrial and transportation sectors are economically important, have a very large number of participants of all sizes, and are capital intensive. They are regulated internationally, nationally, provincially, and municipally. All three sectors are highly segregated with huge numbers of individual players, both private and public, who work and make decisions independently. The intent is to maintain a supply of technologies and tools to ensure that all of the sectors can become more efficient with the slow but constant overturn of capital stock.

Decentralized Energy Production

Canadian electrical generation facilities and the distribution grid comprise a massive and aging system. Historically, these systems have been designed around a few, large electrical generating plants utilizing nuclear, hydro, and fossil fuels and were connected by a large grid of transmission lines delivering power to consumers.

Decentralised energy production (DEP) refers to highly efficient fossil fuel power plants and wind farms up to 25 MW capacity, and power plants from other sources of less than 1 MW capacity. Small power plants would primarily serve local customers but could be connected to the larger grid. The technologies involved include all of the renewable generation sources such as solar, wind, tide and current, low-head hydro, and biofuels, as well as grid integration issues, and combined heat and power systems. At this time, emphasis in Canada is on low-head hydro, wind and biofuels.

The intent of T&I activities is to help address institutional and technical barriers to DEP, and facilitate the use of DEP for new electrical generating capacity, thereby replacing fossil fuel plants. Providing new capacity, replacing old capacity, and the widespread use of grid integration could result in large GHG reductions, to the extent that this new or replaced capacity is from sustainable or renewable primary energy sources and related technologies. Much work is already being done elsewhere and international consortia already exist. The adaptation of international technology to Canadian circumstances is important, especially in the areas of intellectual services; communications and control software; and, the use of DEP in remote and northern communities, where the result will be a less costly and more reliable power supply.

Bioenergy Supply and Use

Canada has abundant sources of biomass in the form of forest and agricultural residues, and industrial and municipal organic wastes, which are all potential sources of renewable energy and/or fuel, materials, chemicals, and other products. Bioenergy, including the combustion of biofuels (e.g. ethanol, biodiesel, biologically-derived methane (CH_4)) is treated as CO_2 neutral, since the CO_2 emissions are balanced by the CO_2 sequestered during sustainable feedstock production. Landfill gas capture, anaerobic digestion of livestock manure, and the use of gasification and pyrolysis systems can provide further GHG reductions. In the case of landfills and manure treatment, there is a double benefit in that the gas generated from biomass can be used to replace fossil fuels, thereby creating an offset. Capturing and utilizing CH4, which has 21 times the global warming potential of CO_2, can substantially limit GHG emissions being released into the atmosphere.

Improved combustion technologies and electrical generating cycles will allow the conversion of sawmill residues, spent pulping liquor, and other biomass feedstocks into combined heat and power through a variety of different sized systems located, for example, at a large pulp mill, a single plywood operation, a mixed farm or small community. Large and medium municipal landfill sites and farms with livestock manure treatment can have gas collection systems and could make a substantial contribution to distributed energy by 2025.

There is a lot of government interest in the use of biofuels such as ethanol and biodiesel to displace conventional fuels. Advances in biotechnology will allow us to develop larger capacity production facilities for alternative biofuels and realize environmental co-benefits such as less surface and groundwater contamination, reduced odour, and fewer particulate emissions to the atmosphere.

In addition to bioenergy and biofuels, biomass can be converted into a variety of value-added intermediate and specialty chemicals and materials. R&D is needed to provide technical solutions to generate bio-based products. For example, recent advances in genomics are leading to new enzymes for biocatalysis in industrial applications. Co-production of bio-based chemicals, together with biofuels and bioenergy, may lead to the development of entirely new secondary industries. It may be that, in the future, the bio-refinery will be as common as the petrochemical refinery is today.

Hydrogen Economy

The hydrogen economy is a vision for an economy driven by hydrogen as an energy carrier and chemical feedstock. Since the oxidation of hydrogen produces only heat energy and water, it has the potential for very low GHG emissions and improved air quality. Due to the abundance of hydrogen containing materials in nature, hydrogen can reduce our dependence on fossil fuels. Currently, the principal source of hydrogen is from fossil fuels or reformed natural gas. To reduce emissions, however, the focus must be on producing hydrogen from sustainable or renewable energy sources.

Building the hydrogen economy is achieved through national partnerships involving federal, provincial and municipal governments; industry; research institutions; universities; and, NGOs. International collaborations such as the International Partnership for the Hydrogen Economy (IPHE) also play an important role. The federal government has a 20-year history of partnership with industry in the development of hydrogen and fuel cell technologies. Federal investments to date total over $200 million in research, development and deployment activities. These partnerships extend beyond hydrogen and fuel technology firms to include Canada's automotive and energy sectors, both significant stakeholders in the transition to the hydrogen economy.

Hydrogen and fuel cell technologies are one of the most promising future power alternatives to the internal combustion engine and other conventional power supply technologies. As such, they represent a tremendous opportunity for Canada from improving the quality of the air we breathe to reducing GHG emissions. Canada is a recognized world leader in the research, development, and deployment of hydrogen and fuel cell products and systems including proton exchange membrane and solid oxide fuel cells, parts supply, systems integration, balance of plant, hydrogen fuelling systems and fuel storage. Although still in the early stages of its commercial development, the fuel cell industry is already generating significant economic benefits to Canada. By 2003, over 2,600 people were directly employed by the Canadian industry, which is comprised of 17 fuel cell developers, and over 140 companies involved in parts and systems supply, fuelling infrastructure and service providers. That year, revenues reached $188 million, and industry R&D expenditures totalled $290 million.

The development of a hydrogen-based economy faces significant commercialization challenges. As identified in the 2003 Canadian Fuel Cell Commercialization Roadmap, overarching challenges include: stimulating early market demand, improving product quality while reducing cost, accessing capital, and creating a supporting infrastructure. T&I programs lay the foundation for a long-term strategic framework for building the hydrogen economy in Canada.

4.4.4 Federal Measures

Program of Energy Research and Development (PERD)

Since 1974, NRCan has fulfilled its non-nuclear energy S&T mandate mainly through PERD. This initiative was the original federal energy S&T program that funded work done interdepartmentally by federal departments and agencies in support of the GoC's energy priorities. This A-Base program directly supports 40% of all non-nuclear energy S&T conducted in Canada by the federal and provincial governments, and is concerned with all aspects of energy supply and use. PERD's current annual budget is approximately $58 million.

NRCan provides PERD funds directly to 12 partner departments and agencies who work closely with other government, academic, and private organizations. PERD is influenced by international activities through NRCan's participation in IEA agreements, bilateral MOUs with the U.S. Department of Energy and expert input to the PERD strategic planning and project development processes.

Action Plan 2000 (AP2000)

The T&I component of AP2000 is delivered through two measures of the plan: the *Climate Change Technology Development and Innovation Initiative Program (CCTDIIP)*, and the *International Initiative for Technology Development (IITD)*.

CCTDIIP's objectives are to accelerate the development of cost-effective GHG mitigation technologies; build the intellectual foundation for long-term technological advances; build alliances and partnerships to help plan and advance R&D; demonstrate federal leadership towards sustainable development; and, contribute to meeting Canada's international commitments for GHG reductions. Funding of $20 million was allocated to this program.

IITD's objectives are to identify and develop technology transfer projects; facilitate the expansion of market opportunities for climate change technologies for Canadian companies; provide a sound analytical base for future international technology marketing activities; and, encourage and build effective partnerships with other nations to help reduce GHG emissions through the Clean Development Mechanism and Joint Implementation (CDM and JI) projects. IITD funding totalled $9.75 million.

In addition to these two measures, AP2000 also included $5 million in funding for the *Model Farm* program. Model Farm objectives are to develop a method for estimating net GHG emissions from whole farms, estimate current emissions and evaluate mitigation practices. The Model Farm program draws on findings from soil, nutrient, and livestock studies and evaluates net GHGs from combined elements of current and proposed farming systems. In particular, the initiative looks at the GHG budgets from whole farming systems, and integrates economic analysis into identifying suites of practices that best reduces overall net emissions.

Funding from AP2000 has been used to support the Environmental Co-Generation from Agricultural and Municipal Wastes (ECoAMu) program, which aims at mitigating GHG emissions from agriculture and improving production efficiency and resource conservation through the development of energy co-generation and biofuel production technologies.

The Technology and Innovation Research and Development (T&I R&D) Initiative

With $115 million of federal funding, the T&I R&D Initiative is part of the Climate Change Plan for Canada implementation announced on August 12, 2003. It is the R&D component of a broader T&I effort whose objective is to "advance promising GHG technologies through R&D, demonstration and early adoption initiatives to achieve long-term GHG reductions and strengthen Canada's technology capacity". The T&I R&D Initiative is managed by the Office of Energy Research and Development (OERD) within NRCan, who also manages PERD.

Nine programs (Expert Groups) have been set up under five technology areas and have developed short, medium, and long term strategic plans for the next 25 years. These five technology areas and their associated programs are listed below:

1) Cleaner fossil fuels:
   - Bitumen and heavy oil,
   - Unconventional gas supply,
   - Clean coal,
   - CO_2 capture and storage.
2) Advanced end-use efficiency:
   - Buildings and communities energy technology,
   - Industry and the transportation.
3) Distributed energy production:
   - Distributed energy production program.
4) Biotechnology:
   - Biotechnology program.
5) Hydrogen economy:
   - Hydrogen economy program.

An additional sixth category, "Cross-Cutting Programs" has been introduced to cover projects in multiple technical areas or projects, which do not make a close fit under the other technology areas. Environmental assessment of technologies, accelerating deployment and first user concept are some examples of some cross-cutting issues. Also in this last category, a program titled Technology to market tends to push innovation toward commercialisation and is described separately below.

The Technology to Market Program (T2M)

NRCan's OERD set aside $2 million from the T&I R&D Initiative for the T2M program, the main purpose of which is to help make viable technologies emerging from the T&I R&D Initiative available to Canadian consumers quickly and effectively.

This pilot program has been set in place to improve the commercialization process from federal R&D onward. $1.3 million of the funds have been earmarked for market studies that will provide a rigorous analysis of domestic market potential and expected barriers to uptake or technology transfer. This will allow for better strategic planning and prioritization of T&I R&D funding. It will also provide essential information for effective continuation along the commercialization process; evaluation of whether technologies are ready for hand-off to demonstration and deployment programs of

Technology Early Action Measures (TEAM) or Sustainable Technology Development Canada (STDC), or directly to industry. The information gathered will also be used for feedback to policy and the R&D community to improve strategic planning in both areas.

The remaining $0.7 million have been set aside to create a market studies support structure for both the R&D community and the T&I R&D Initiative. Researchers will be provided with a resource kit consisting of market assessment tools, standardized GHG estimation methods and dissemination strategy support.

Technology Early Action Measures (TEAM)

TEAM is an interdepartmental program that offers support to late stage development and first time demonstration projects to reduce GHG emissions nationally and internationally, while sustaining economic and social development. The program's approach is built on incremental financing and extensive networking to bring together government, industry, community and international partners to encourage additional investment in innovative technologies. Since 1998, TEAM has been allocated funding of $147 million and has financed 111 demonstration projects with a total value of over $1 billion. Increasing emphasis will be placed on the evolving role of TEAM as a coordinator and integrator of diverse partners and new funding agencies into successful technology demonstrations. TEAM's key strengths include:

- in-house skill set for value added investment advice for project development and delivery;
- world leader in measurement and reporting for technology and GHG impacts;
- unique and flexible delivery window, which allows partnering of federal programs that would not normally occur otherwise;
- refocusing of federal technology programs towards climate change objectives;
- credibility to private companies who have received TEAM support;
- capability to undertake both domestic and international projects; and,
- transparency in proposal review and program delivery.

An independent review of TEAM confirmed its ability to reduce GHGs while contributing to the development of new companies, the expansion of existing companies, and an increased international Canadian profile. TEAM's emphasis on accountability led to the *System of Measurement and Reporting for Technologies (SMART)*, a methodology for validating GHG and technology performance claims. SMART is also the basis for emerging international ISO standards on climate change projects and will lead to enhanced private sector credibility in future carbon markets. TEAM works with venture funds and other financial institutions to develop technology-based investment tools focused on new technology opportunities.

Sustainable Development Technology Canada (SDTC)

SDTC was established by the GoC in 2001 and commenced operation in November of that year. SDTC's mission is to act as the primary catalyst in building a sustainable development technology infrastructure in Canada. There are many links in the innovation chain between research and commercialization. Two of the most critical – but traditionally under-supported – are development and demonstration.

SDTC is a not-for-profit foundation that finances and supports the development and demonstration of clean technologies that provide solutions to issues of climate change, clean air, water quality and soil, and deliver economic, environmental and health benefits to Canadians. SDTC works closely with an ever-growing network of stakeholders and partners to build the capacity of Canadian clean-technology entrepreneurs, helping them form strategic relationships, formalize their business plans, and build a critical mass of sustainable development capability in Canada. Every project involves representatives from the entire supply chain: researchers, product developers, manufacturers, distributors, retailers and end customers.

The Foundation draws from an investment fund of $550 million. To date, SDTC has completed six funding rounds and allocated a total of $126 million to 60 projects. That amount has been leveraged with an additional $354 million in funding from other project partners for a total project value of $480 million. SDTC-funded projects are active in all major Canadian economic sectors, including energy exploration and production, power generation, energy utilization, transportation, agriculture, forestry, mining, and waste management.

Programs in the Hydrogen Economy: Co-Led by NRCan and Industry Canada

The Hydrogen and Fuel Cell Committee (H2FCC) is co-chaired by Industry Canada's

Energy and Environmental Industries Branch, and NRCan. H2FCC is the focal point for the coordination of all federal efforts on hydrogen economy related activities. It acts as an advisory body by informing the development of program strategies and work plans. The programming addresses different issues of the Hydrogen Economy at different points in the Innovation Spectrum. The programs are focussed on two main elements: the *Innovation Excellence Initiative* supports R&D in order to accelerate development and demonstration of hydrogen products and applications, and the *Early Adopters Initiative* encourages the market adoption in Canada of these products and applications.

- *The Innovation Excellence Initiative*

The Innovation Excellence Initiative is aimed at researching, developing and demonstrating hydrogen and fuel cell technologies. A suite of programs across the innovation spectrum supports the sector's transition to the hydrogen economy as the technology progresses from basic R&D through to demonstration. Investments are targeted to public- and private-sector research, development and proof-of-concept demonstration efforts in hydrogen and fuel cell technologies. Innovation Excellence serves the hydrogen and fuel cell sector, offering assistance to both industry and academia, and encouraging partnerships and collaborative efforts among stakeholders. Activities respond to the strategic needs identified in the Canadian Fuel Cell Commercialization Roadmap: fuel cell membranes and catalysts, hydrogen production, distribution and storage technologies, and automotive-related hydrogen and fuel cell technologies.

Innovation Excellence programs are delivered through two responsibility centres, funded at $10 million each. The Energy and Environmental Industries Branch manages its part on behalf of the Industry Canada Portfolio. The Hydrogen Economy Experts Group, funded at $7 million, is managed by NRCan through the T&I R&D Initiative. The remaining $3 million is made available to TEAM for demonstration activities.

- *The Early Adopters Initiative*

The Early Adopters Initiative is aimed at addressing the urgent need to accelerate the market adoption of hydrogen and hydrogen compatible technologies and attract world-class talent and investment to Canada. From a total of $60 million in new funding under this initiative, $50 million is allocated for the *Hydrogen Early Adopters Program (h2EA)* managed by Technology Partnerships Canada (TPC). The remaining $10 million will be made available to NRCan's *Canadian Transportation Fuel Cell Alliance (CTFCA)*, commencing in 2006, to strengthen and extend its ability to support the commercialization of hydrogen and fuel cell technologies. The CTFCA was originally established in 2001 under AP2000 to demonstrate and evaluate viable fuelling routes for hydrogen fuel cell vehicles and to develop the necessary supporting framework for the fuelling infrastructure. Progress to date by CTFCA is reported in section 4.3 of this chapter.

CANMET Energy Technology Centre (CETC)

The CETC is Canada's premier energy S&T organization. As part of NRCan Energy Technologies and Programs Sector, its mission is to work in partnership with industry and all major stakeholders in the Canadian energy and S&T sectors to develop and deploy energy efficient, alternative energy and advanced hydrocarbon technologies.

CETC's expertise includes alternative transportation fuels and technologies; hydrogen and fuel cells; renewable energies (bioenergy, solar, small hydro, ocean, wind); catalytic and membrane process technologies; clean fossil fuel technology and clean power generation; CO_2 capture and storage; energy-efficiency for houses, buildings and communities, and high temperature processes for the steel industry; and, oil sands technologies.

CETC is also a world leader in advanced software tools. For example, since 1996, NRCan has worked with a number of key international partners, including the United Nations Environment Programme (UNEP), the National Aeronautics & Space Administration (NASA), and the World Bank, to develop the highly successful RETScreen International Clean Energy Project Analysis Software tool.

RETScreen is used worldwide to evaluate the energy production, life-cycle costs and GHG emission reductions for various types of energy projects. The RETScreen software, available free-of-charge, is now being used by more than 88,000 people in 216 countries and is growing by more than 450 new users every week. It is estimated that RETScreen has saved stakeholders $600 million since its launch in 1996 and it is projected to save worldwide users approximately $8 billion by 2012. To further promote the dissemination and use of the tool, NRCan has recently developed a multilingual version of the software. Available in 21 key languages covering roughly two thirds of the world's population, such as Chinese, Spanish, Hindi, German, Russian, etc., this upgrade allows users to produce a report in any language and translate it with a simple click of the mouse.

The Clean Energy Portal

The Clean Energy Portal contains a well-maintained directory of over 600 Canadian technology providers and is another key resource, supported by CETC, that is having a significant impact on international awareness of Canada's clean energy capabilities. The portal is further described in Chapter 7, *Financial Resources and Transfer of Technology*.

There are a number of other federal measures that were not introduced specifically to address climate change; however, they contain significant components that are relevant to climate change related technology and innovation. An example of such a measure is the *Environmental Technology Assessment for Agriculture (ETAA)* program. ETAA aims to assess innovative environmental technologies that maintain and enhance the health of natural resources associated with agricultural production, and provide information on these technologies for the benefit and use of stakeholders. ETAA is a $10 million, five year (2003 to 2008) initiative that invests in assessments of environmental technologies through demonstration and research projects with farmers, scientists and industry. The five main technology areas are animal wastes and manure, animal production, crop nutrients, pest management, and renewable energy.

4.4.5 Provincial/Territorial Measures

In Canada, provinces are responsible for managing resources, including fossil fuel; agricultural and forest biota; and, renewable energies like wind. Their R&D activities tend to focus on upstream energy flow, its delivery to markets, and its efficient use in housing and industry. Provinces are also responsible for universities in their jurisdiction, so that they tend to focus university R&D to issues relevant to provincial mandates. Examples of provincial emphasis are detailed below.

Provincial fossil fuel R&D focuses on enhancing resource recovery for oil and gas. Tools examined to do so include process simulation and control – for instance of steam-assisted gravity drainage for heavy oils; modelling; new sensors and advanced materials; multiphase flow technologies; and, computational fluid dynamics or injection of carbon dioxide to displace oil in strata. Oil sands R&D in Alberta concentrates on increasing the efficiency in the production of synthetic crude by improving the upgrading process, reducing the number of steps in the system from mining to processing to upgrading, using nanomaterials to improve recovery and enhancing catalysis in the various processes. In the harsh Canadian offshore environment, compressed natural gas (CNG) transport could unlock stranded natural gas resources and is being examined by Newfoundland.

Coal R&D concentrates on gasification for eventual feed into integrated gas combined cycles (IGCC) turbines, on some improved combustion technologies and on capture and sequestration of CO_2 from large point sources, mainly flue gases from electricity generating power plants. Focus is on cleaner fossil fuel use, including control of GHG emissions.
Pipeline R&D examines interaction with permafrost, geotechnical stability of buried ones, stress corrosion problems and computational fluid dynamics for productivity enhancements.

Water and waste water management in the upstream fossil fuel sector is a major preoccupation of provinces and territories and this situation will become more acute as the massive development of oil sands and coal bed methane accelerates.

Most provinces and some territories consider the production of renewable resources as either an addition to fossil fuels or an alternative to fossil fuel. Biomass is strong on the agenda, because production of biofuels would constitute a value-added product for farmers and wood producers. Other green technologies under investigation include steam production from geothermal sources in Yukon and British Columbia, small wave energy converters in Newfoundland and recovery of natural gas from municipal waste streams in many provinces.

Canada has many waterways and interest is increasing for harnessing more limited flow rates in streams and secondary rivers through small hydroelectric plants. Technologies are at the demonstration stage and some are at the deployment stage.

Wind energy has now successfully passed the level of demonstration in Canada and is now into the deployment stage. For example, Prince-Edward Island's government supports the national wind test site and is in the process of deploying wind farms in various parts of the island. Québec, Ontario and Alberta have initiated programs for the deployment of wind farms.

Distributed generation, the possibility for home owners to generate their electricity from small generators, sometimes fuel cell based, is a major preoccupation for provinces that will need to integrate surpluses that may be generated outside of peak hours. Provinces own most power generation facilities, so this new environment will need special care for harmonious integration. New Brunswick is developing a virtual distributed generation network simulator to simulate various hypotheses and define how such a network can maintain stability and responsiveness to needs. End-use energy efficiency is also an area where provinces tend to intervene. All buildings are a primary concern for saving energy, considering the continental climate of Canada with very hot summers and very cold winters. The goal in this area is to develop, as mentioned previously, self-sustaining, energy-wise buildings by 2030. Most provinces have programs aiming at progressive improvements, including support for R&D that can help achieve the goal.

Some funding also supports system analysis for industrial processes, demand-side management developments and a holistic approach to energy systems. In transportation, intelligent electronic signage and traffic lights are being progressively developed and tested on major arteries of main cities. Once established, these technologies will be propagated to smaller cities.

Canada has strengths in fuel cells and hydrogen production, but efforts are ongoing to improve the efficiency of both elements. Programs exist to analyse various aspects of the issue, like the hydrogen highway in British Columbia, catalysis and nanomaterials in Alberta, and the fuel cell innovation program in Ontario.

4.4.6 Other Measures

University R&D is mostly devoted to activities that contribute to the advancement of knowledge. This endeavour leads to activities that bear on multiple sectors at the same time. For instance, computational fluid dynamics can be used for flows in upstream oil and gas and in industrial activities like combustion to improve process efficiency. Process control is another area where universities tend to make a difference, some findings being transferred to industry soon after confirmation. Similar conclusions concerning combustion processes can lead to transfer in both conventional fuel systems and systems using alternative fuels.

Universities and research groups in producing provinces contribute to the water management file, cleanup of waste waters as well as reduction of water use in the production of energy. Steam-assisted gravity drainage is being further developed in Saskatchewan and Alberta universities at the laboratory scale. Multiphase flow technologies and new, specific sensors are areas of research related to upstream fossil fuel and delivery of energy products.

Another area where universities invest significant efforts is carbon studies for capture and modelling of storage of CO_2 as well as for uptake of carbon by biota and oceans. Work encompasses GHG reduction technologies, risk models related to changes in climate, and economic models of the impact of climate change on various sectors, including energy.

The Canadian Oil sands Network for Research and Development (CONRAD): CONRAD is a network of companies, universities and government agencies organized to facilitate collaborative research in science and technology for Alberta Oil Sands. This initiative supports responsible environmental activities and continued funding of research in upstream oil and gas emission reduction opportunities.

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CHAPTER 5 EMISSIONS PROJECTIONS TO 2020

5.1 INTRODUCTION

The primary objective of the greenhouse gas (GHG) emissions projection of this national communication is to give an indication of future trends in GHG emissions and removals for Canada. These trends take into consideration the national policies and measures that have been implemented. This section compares previously submitted projections with the current ones and provides explanations for the differences.

Chapter 5 presents Canada's projected GHG emissions for the period 2005 to 2020. The recently released document entitled *Canada's Energy Outlook: The Reference Case 2006* (the Outlook) has been used in the preparation of this chapter. Similar documents have been used in the past to support the earlier projections reported in the Second and Third National Reports on Climate Change.

Canada's GHG emissions have continuously increased since 1990, from 599 megatonnes (Mt) of carbon dioxide equivalent (CO_2 eq.) to 758 Mt in 2004, a growth of 1.7% annually. The Outlook projects total GHG emissions to increase by about 1.5% annually between 2004 and 2010, reaching 828 Mt by 2010. Emissions should increase at a slower pace thereafter (0.8% annually between 2010 and 2020), reaching 897 Mt by 2020.

Approximately 85% of Canada's GHG emissions are associated with energy production, distribution and consumption. About 60% of these emissions are attributable to the consumption of fossil fuels (combustion and non-energy use of hydrocarbons) by the end-use sectors, while the remaining 40% is associated with the energy production and distribution sectors (electricity, refining and upstream oil and gas sectors). Natural Resources Canada (NRCan) prepared the energy related emissions statistics, which were developed in consultation with other federal departments and provincial and territorial governments.

The other 15% of Canada's GHG emissions are from non-energy sources, such as agriculture and waste. They were estimated by Environment Canada and Agriculture and Agri-Food Canada (AAFC). GHG emissions in this report refer to the total amount of Canada's emissions, with adjustments made for each GHG to be expressed in terms of CO_2 eq.

A critical element incorporated into the projection is the anticipated effect of past and present federal, provincial and territorial policies. The Outlook incorporates the impacts of initiatives for which spending authority was approved as of May 2006. The impacts of these programs, other than those embodied in consumer behaviour, are assumed to cease when the approved funding terminates. The Government of Canada's (GoC's) policies and measures implemented during the period 2001 to 2005 are described in Chapter 4.[68]

In addition, The Outlook includes the *Memorandum of Understanding between the Government of Canada and the Canadian Automotive Industry Respecting Automobile Greenhouse Gas Emissions*, signed in April 2005.

The remainder of this chapter provides information on the emission projections and is organized into the following sections:

- Projection process
    - the modelling approach, the assumptions, the policy setting
- Current emissions projection
    - overview of sectoral, national and provincial projections
- Comparison with earlier submissions
    - revisions of methodologies
    - changes in framework assumptions
- Summary and Conclusions
- Annexes
    - Annex 5.1 – MAPLE-C model,
    - Annex 5.2 – Initiatives/Measures

[68] In January 2006, a new federal government was elected. Formerly-announced initiatives are under review as the GoC designs a new environmental agenda for reducing air pollution and GHG emissions.

5.2 PROJECTION PROCESS

The projections presented in this chapter (and in the Outlook) were for the most part generated from the Model for Analysis of Policies Linked to Energy-Canada (MAPLE-C).

To develop MAPLE-C, NRCan adapted the United States' National Energy Modeling System (NEMS) to reflect the Canadian economy and its provincial components. The projections in MAPLE-C are developed using a market-based approach to energy analysis. For each fuel and consuming sector, MAPLE-C balances energy supply and demand, accounting for economic competition among the various energy sources.

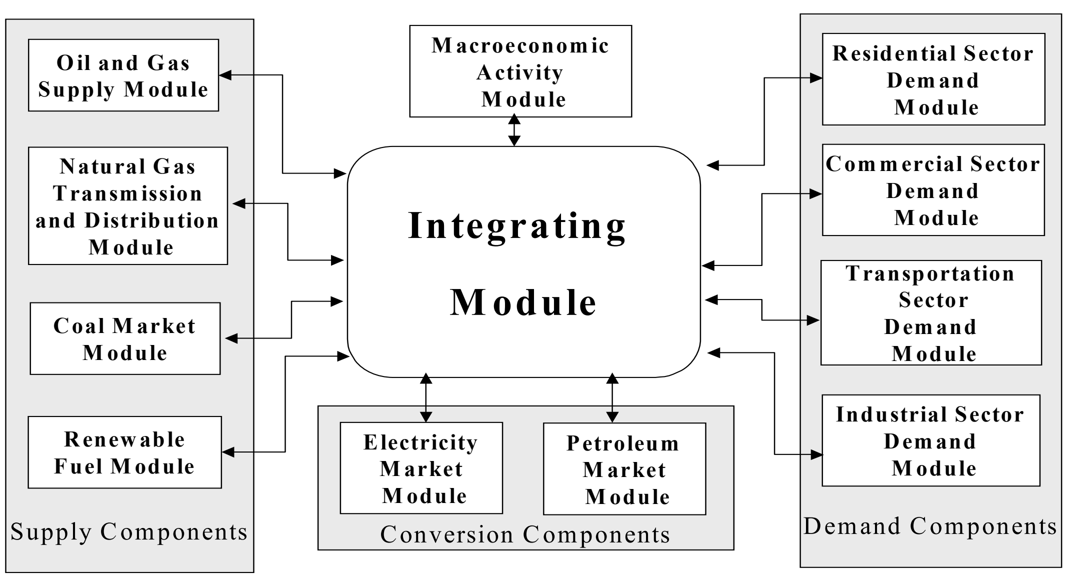
This tool ensures consistent results among the sectors and regions. The model's main feature is that it can be operated in a forecasting mode or an analytical mode. In forecasting mode, the model generates an annual energy and emissions outlook to 2020. In analysis mode, it is used to assess broad policy options, specific programs or regulations, new technologies or other assumptions.

The model's primary outputs are tables showing energy consumption, production and prices by fuel type, year and region. It also identifies many of the key macroeconomic indicators (e.g. Gross Domestic Product or unemployment) and produces a coherent set of all GHG emissions (such as carbon dioxide or CO_2, methane or CH_4 and nitrous oxide or N_2O) by sector and by province.

The structure of MAPLE-C is displayed in Figure 5.2.1. The component modules of MAPLE-C represent the individual supply, demand, and conversion sectors of domestic energy markets and include the macroeconomic module. In general, the modules interact through values representing the prices of the energy delivered to the consuming sectors and the quantities of end-use energy consumption. The elements of the model are further explained in Annex 5.1.

In order to develop this projection of energy use and related emissions, it was necessary to provide a view of the Canadian economy as far as the forecast horizon, in this case to 2020. The level and composition of energy supply and demand and the resulting GHG emissions are determined based on many assumptions that influence the overall size and growth rate of the economy.

Figure 5.2.1: Model for Analysis of Policies Linked to Energy – Canada



The programs and initiatives that received spending authority have been reviewed and incorporated into the Outlook. Their introduction, however, was not a matter of replicating the anticipated GHG emissions reductions, but of assessing their energy impacts. Because the model fully integrates all energy sectors, this approach eliminated the possibility of counting policy impacts twice.

Annex 5.2 provides a detailed description of the programs and initiatives that were and were not incorporated in the analysis.

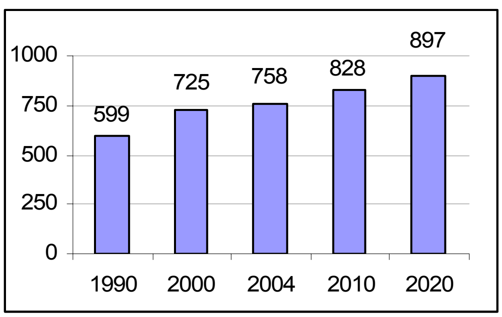
5.3 CURRENT PROJECTION OF GHG EMISSIONS

5.3.1 Overview

GHG emissions are projected to increase by about 1.5% annually between 2004 and 2010, while economic growth is expected to increase by more than 2.5%.

Canada's GHG emissions have increased from 599 Mt CO_2 eq. in 1990 to 758 Mt in 2004,[69] an average growth of 1.7% annually.

Figure 5.3.1.1: Total GHG Emissions (Mt CO_2 eq.)



By 2010, emissions are expected to reach 828 Mt (Figure 5.3.1.1), an increase of more than 70 Mt in total emissions between 2004 and 2010. Table 5.3.1.1 highlights the changes in emissions by sector, and Figure 5.3.1.2 provides a breakdown of the emissions by sector.

Table 5.3.1.1: Changes to Annual Emissions by Sector (Mt)

Sector	2004 - 2010	2010 - 2020
Upstream Oil and Gas	7	-10
Upgrading synthetic crude oil	27	19
Refining (heavier grades of crude oil)	7	6
Electricity	1	-4
Industrial	4	8
Commercial and Residential	1	13
Transportation	16	25
Other	8	11
Total	**71**	**68**

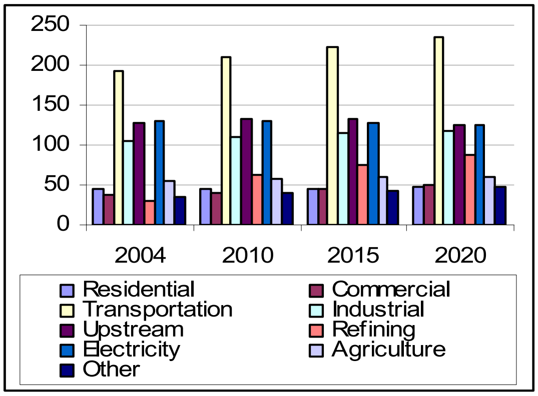
Between 2004 and 2010, emissions from the electricity sector are not expected to increase considerably. However, between 2010 and 2020, this sector's emissions are expected to decrease by 4 Mt due to the retirement of coal plants in Ontario, replaced largely by natural gas.

From 2010 to 2020, emissions from the upstream oil and gas sector will decline somewhat, as conventional oil production declines, while emissions from refining and synthetic crude oil production will continue to increase, due to higher production from the oil sands and the refining industry's reliance on heavier crude. Emissions from all other sectors (with the exception of electricity) will increase further, notably in the transportation, industrial, residential and commercial sectors.

Transportation will continue to account for the largest share of emissions – about 26% of total emissions in 2020. More significant changes are expected to take place in the refining sector, whose share is expected to increase from 4% to 8% by 2010, and to 10% by 2020.

[69] 2004 is the latest year of published data for Canada's GHG inventory.

Figure 5.3.1.2: GHG Emissions by Sector ($Mt\ CO_2$ eq.)



5.3.2 Residential

GHG emissions from the residential sector are expected to remain at 45 Mt from 2004 to 2010 as a result of energy-efficiency programs and fuel switching. By 2020, emissions will increase to 48 Mt, reflecting the projected growth in energy demand. The GHG emissions for this sector include about 2 Mt associated with agricultural, non-transportation activities. Emissions for the sector are mostly (96%) CO_2, but include approximately 2 Mt of CO_2 eq. of CH_4 and N_2O associated with the use of wood.

5.3.3 Commercial

GHG emissions from the commercial sector are expected to increase slightly from 38 Mt in 2004 to 40 Mt in 2010, as most of the increase in energy requirements will be in the electricity sector. Emissions are projected to increase by 9 Mt to 49 Mt by 2020, mainly as a result of increasing floor space, somewhat offset by the impacts of improved energy intensity.

5.3.4 Transportation

The emissions from the transportation sector[70] are estimated to increase by 16 MT (1.4% per year) between 2004 and 2010 and by 25 Mt (1.1% per year) thereafter to reach 235 Mt by 2020. Despite fuel efficiency gains, the expectation of strong growth in travel demand and the expected slow penetration of new technologies using alternative fuels will result in the continued growth of emissions from the transportation sector. These forecasts include a reduction of N_2O emissions (1 Mt of CO_2 eq. by 2010), reflecting the memorandum of understanding (MOU) with the automobile manufacturers. The overall rate of growth of emissions over the projection period is significantly lower than the 2.1% growth experienced in the 1990s.

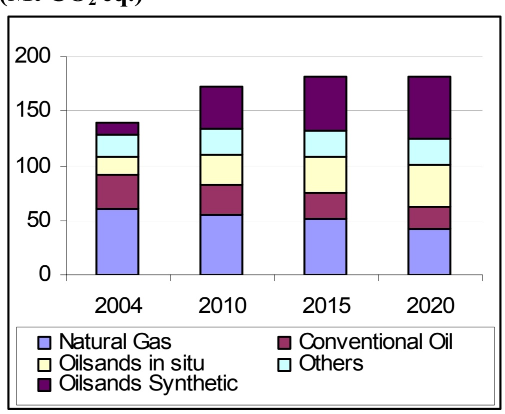
5.3.5 Industry

Emissions in the industry sector (which excludes refining and the upstream oil and gas industry) are expected to increase at about 0.7% per year for both the 2004-2010 and the 2010-2020 periods. Emissions will be 110 Mt and 118 Mt by 2010 and 2020 respectively.

5.3.6 Upstream Oil and Gas

The emissions associated with the upgrading of oil-sands[71] bitumen are included in the refining industry. However, for illustration purposes, Figure 5.3.6.1 displays these emissions. Emissions from fossil fuel production[72] are estimated to grow from 127 Mt in 2004 to 133 Mt in 2010, then decline to 124 Mt in 2020, reflecting the anticipated changes in the production mix. Including the emissions from the production of synthetic crude oil causes the total emissions to increase to 171 Mt in 2010 and 180 Mt in 2020.

Figure 5.3.6.1: GHG Emissions Upstream ($Mt\ CO_2$ eq.)



[70] The IPCC guidelines require transferring emissions from off-road uses in the industrial sector to the transportation sector, but exclude lubricant emissions.

[71] By UNFCC convention, emissions from the production of synthetic crude oil are linked to the petroleum refining industry.

[72] Includes natural gas, conventional light and heavy crude oil, and *in situ* bitumen from oil sands.

From 2010 to 2020, coalbed methane production is expected to increase as conventional gas production declines. This change will tend to reduce emissions from this sector, since coalbed methane does not require as much processing as conventional gas. The drop in conventional oil production between 2010 and 2020 is expected to offset the increases in *in situ* oil sands production. The net result of those changes is a small decrease in emissions.

5.3.7 Petroleum Refining

As noted above, the GHG emissions from upgrading bitumen into synthetic crude oil are included in the petroleum refining industry. In 2004, emissions from this sector were 29 Mt. It is expected that by 2010 they will increase to 63 Mt, and by 2020 to 87 Mt. The emission growth rate will be about 13% annually between 2004 and 2010, diminishing to 3.4% after 2010. This growth is substantially higher than all other sectors as a result of increased throughput, a heavier crude slate, and increased production of synthetic crude oil.

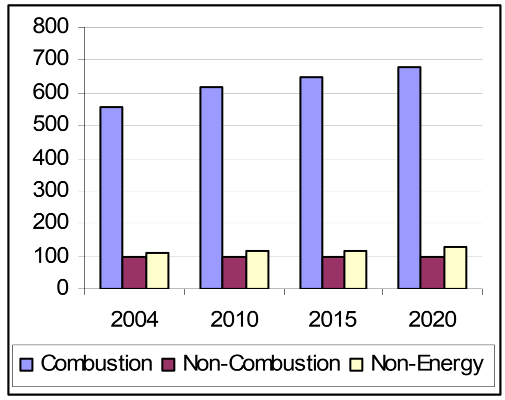
5.3.8 Electricity Generation

The GHG emissions associated with electricity generation, which accounted for 130 Mt in 2004, will increase slightly to 131 Mt in 2010. Between 2010 and 2020, emissions from this sector will decline moderately and then increase to 126 Mt, due to the assumed retirement of coal-fired plants in Ontario, replaced mainly by natural gas. The expected increase in coal-fired generation, mainly in Saskatchewan and Alberta, will dampen this decline.

5.3.9 Emissions by Source

Energy (both combustion and non-combustion) is projected to remain the major source of GHG emissions (Figure 5.3.9.1), maintaining the same share (85%) throughout the projection period. However, the share of the combustion component is expected to increase, as associated emissions will increase by 1.3% per year, (compared with 2.1% for the 1990s). The emissions associated with the non-combustion of fuels[73] are expected to decline slightly from 97 Mt in 2004 to 95 Mt by 2020, owing in part to the lower fugitive emissions associated with a lower production of conventional natural gas and heavy crude oil.

Figure 5.3.9.1: GHG Emissions by Source ($Mt\ CO_2$ eq.)



Emissions from non-energy sources (mostly agriculture)[74] are expected to increase by 1% per year from 108 Mt in 2004 to 127 Mt by 2020. The share of non-energy emissions is expected to remain close to 15% throughout the projection period.

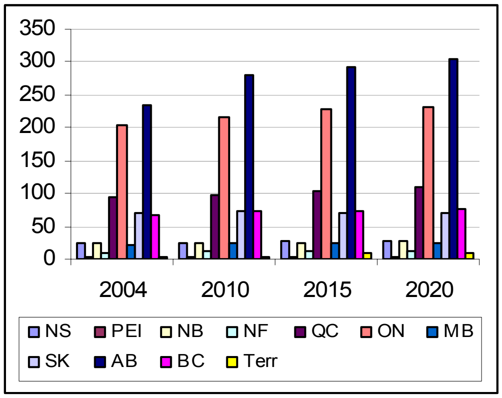
5.3.10 Emissions by Province or Territory

Figure 5.3.10.1 displays the projected emissions by province and territory. Alberta and Ontario will continue to have the largest emissions, although their share in total emissions will change slightly during the projection period.

[73] Non-combustion emissions comprise fugitives (CH_4 and CO_2) from fossil fuel production and distribution, CO_2 emissions associated with petrochemical feedstock, coke used in the iron and steel industries, and petroleum coke in the aluminium industries.

[74] In 2000, agriculture contributed 61 Mt of GHG, waste contributed 25 Mt, and the remaining 20 Mt of non-energy GHGs came from the production of cement, lime, soda ash, nitric acid and adipic acid, and use of SF6, PFCs, land use change, forestry and HFC.

Figure 5.3.10.1: GHG Emissions by Region ($Mt\ CO_2$ eq.)



Alberta's share is expected to increase from 31% in 2004 to 34% by 2020 (mainly due to higher oil sands production). Ontario's share will decline from 27% to 26%. Quebec and British Columbia are the next two largest emitters, with 12% and 9% of Canada's total emissions respectively. Atlantic Canada is expected to maintain its 8% share of total emissions: in 2020 Nova Scotia and New Brunswick will emit about 28 Mt and 27 Mt respectively, followed by Newfoundland and Labrador at 12 Mt, and finally Prince Edward Island at about 2 Mt per year.

5.4 IMPACTS OF THE REVISIONS MADE TO METHODOLOGIES AND ASSUMPTIONS

This section compares the emissions projection of 770 Mt for 2010 reported in the Third National Report with the current emissions projection of 828 Mt. The difference between the two projections suggests an increase of 58 Mt. Many revisions of the methodologies used for assessing the emissions inventory have been introduced since the publication of the third report. Examples of changes in methodologies include: emissions from agro-ecosystems, decreasing by about 14 Mt; emissions from the oil and gas industries (including fugitives), increasing by almost 20 Mt; and emissions from domestic aviation, decreasing by 8 to 10 Mt.

Changes in **methodologies** typically affect all the years since 1990 and may change emissions forecasts if their impacts are not similar in every year. Projections also change where new or different **assumptions** increase or decrease emissions forecasts. The combined effect of the changes in methodologies and the changes in assumptions is an increase of 58 Mt.

5.4.1 Revisions made to Methodologies

Since the Third National Report, Environment Canada has revised many methodologies that affect the emissions inventory and projections. A few sectors have seen changes in their emissions for the base and subsequent years. GHG emissions for 1990 were reduced from 607 Mt (reported before) to 599 Mt, a change of 8 Mt. The application of the same methodologies to the year 2010 results in a small increase of 1 Mt rather than a decrease.

The impacts of these revisions on the inventory and projections are estimated as follows:

- For the allocation of fuels between international and domestic aviation, an emissions reduction of 4 Mt in 1990 and of 8 Mt by 2010;
- From agro-ecosystems, an emissions reduction of 14 Mt for all years;
- From industrial process, an increase in emissions of 2 Mt for all years;
- From residential wood, an emissions reduction of 3 Mt by 2010; and
- From the oil and gas industries, an increase in emissions of 6 Mt in 1990 and of almost 20 Mt by 2010.

Once adjusted for changes in methodologies, the previously reported emissions would have been about 8 Mt lower in 1990 and 1 Mt higher in 2010. Expressed differently, emissions for 1990 and 2010 would have been 599 and 771 Mt, respectively. With regards to our current projection of 828 Mt for 2010, this means that a net change in emissions of about 57 Mt should be attributed specifically to changes in **assumptions**.

5.4.2 Revisions made to Assumptions

The projections presented in the previous National Report were based on the economic conditions forecasted at that time. Since then, many events have changed those conditions and altered the economic growth profile. A comparison of the key macroeconomic variables used for the Third National Report and the current projections is provided below. Some of the new assumptions increased the emissions projections, while others decreased them.

As highlighted in Table 5.4.2.1, the current economic projections to 2010 are more optimistic than those assumed a few years ago. By 2020, economic activity is expected to be more than 5% greater than what was assumed in the previous report. It is also noteworthy that this economic performance is due mainly to higher growth in Services rather than Industry. Higher crude oil prices have a dampening effect on energy demand, but they encourage the development of conventional and non-conventional oil and gas resources, resulting in more emissions from that sector.

In addition, the Outlook assumes that refinery feedstocks will be composed of heavier crude oil that is more difficult to refine, reflecting a general decline in the availability of light crude in the longer run (domestically and worldwide).

Table 5.4.2.1: Summary of Changes in Assumptions

	2000-2010		2010-2020	
	3rd Report	*Current Projection*	*3rd Report*	*Current Projection*
Canada GDP (AAGR)	2.30%	2.70%	2.20%	2.30%
Industry (AAGR)	2.20%	2.20%	2.20%	2.00%
Services (AAGR)	2.30%	3.20%	2.20%	2.50%
	2010		**2020**	
	3rd Report	*Current Projection*	*3rd Report*	*Current Projection*
Population (millions)	34	33.5	37.4	35.8
Households (millions)	13.8	13.5	16.1	15.2
Light Duty vehicles (millions)	19.3	20.1	23.5	23.8
Real Disposable Income ($'000 ('97)/HHD)	$55	$61	$57	$67
Oil prices (WTI, US $(2003)/bbl)	$25	$45	$25	$45

AAGR: average annual growth rate
HHD: household
WTI: West Texas Intermediate
bbl: barrel

These changes in assumptions have counterbalancing effects on emissions. For example, a smaller number of households would result in less energy consumption (and lower emissions levels), while higher disposable income (e.g. a larger number of vehicles, etc.) would result in higher energy consumption.

Table 5.4.2.2 provides rough estimates of the changes associated with the new *assumptions*. The changes in assumptions, since the last report, increased the emissions for 2010 by almost 57 Mt.

Table 5.4.2.2: Impact of Changes in Assumptions on GHG Emissions for 2010

	Changes
Buildings	10
Transportation	15
Electricity	6
Refineries	21
Oil and Gas Industry	9
Industry	-5
Total GHG Emissions	**57**

This increase in forecasted GHG emissions can be attributed to the higher levels of energy required by conventional refineries (to meet an increasing demand, mainly from the transportation sector, with heavier crude as feedstock) and the additional upgrading of oil sands.

5.5 SUMMARY AND CONCLUSION

This chapter provides an update on Canada's most recent GHG emissions projection and a comprehensive explanation of the changes made since the Third National Report.

The main conclusion of this chapter is that Canada's GHG emissions are forecasted to increase by about 1.5% annually between 2004 and 2010, to reach 828 Mt by 2010 and almost 897 Mt by 2020.

5.6 REFERENCES

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ANNEX 5.1: MODEL

The data in *Canada's Energy Outlook: The Reference Case 2006*, which provide the basis for the emissions projections in this chapter, are generated from the Model for Analysis of Policies Linked to Energy - Canada (MAPLE-C). MAPLE-C is a Canadian version of the US National Energy Modeling System (NEMS) and it reflects the Canadian economy as well as its provincial components. The projections in MAPLE-C are developed using a market-based approach to energy analysis. For each fuel and consuming sector, MAPLE-C balances energy supply and demand, accounting for economic competition among the various energy sources.

The diagram in Figure 5.2.1 of this chapter shows the structure of MAPLE-C. The model is structured in such a way that it acknowledges three main components to energy production and use. The integrating module is at the core and links all the components together. The model considers the market as three distinct but interconnected components: the supply of energy, the conversion of energy from one form into other forms, and the end-use demand.

The supply-of-energy component includes crude oil, natural gas, coal and renewable energy. The supply of energy depends on prices, available resources and demand. The conversion component refers mainly to the oil refineries and electrical power plants that convert natural resources into the different forms of energy required to satisfy end-use demand.

The Macroeconomic Activity Module is an annual dynamic econometric model of the Canadian economy. Key macroeconomic variables include gross domestic product (GDP), industrial output, interest rates, disposable income, prices, and employment. This module forecasts economic drivers for housing stock, commercial floor space and vehicle sales.

The Building sectors are divided into two distinct modules: residential and commercial. The Residential Demand Module forecasts consumption of energy by end-use services, based on energy prices, a menu of equipment available, the availability of renewable sources of energy and housing starts. The Commercial Demand Module forecasts energy consumption by category of end-use and is also based on energy prices. This module responds to macroeconomic variables such as interest rates and floor space.

Both modules estimate the equipment stock for the major end-use services, incorporating assessments of advanced technologies, including representations of renewable energy technologies and effects of both building shell and appliance standards.

The Industrial Demand Module forecasts the consumption of energy for heat and power as well as for feedstock and raw materials. It is subdivided into 12 industry groups. Industrial demand responds to the delivered prices of energy and macroeconomic variables representing the gross output for each industry. Most industries are modelled with components for boiler/steam, buildings, and process/assembly use of energy. A representation of cogeneration is also included based on steam demand.

The Transportation Demand Module forecasts the consumption of different fuels, including petroleum products, electricity, methanol, ethanol and compressed natural gas. Demand responds to energy prices and macroeconomic variables such as disposable income, GDP, driving-age population, interest rates and the value of output for industries in the freight component. The module also provides for the assessment of the penetration of alternative-fuel vehicles.

The Electricity Market Module represents capacity planning, generation, transmission and pricing of electricity. The module uses the prices for coal, petroleum products and natural gas as determined in the supply modules. This module also incorporates costs of generation by all generation plants, including capital and operating costs; macroeconomic variables for costs of capital; environmental emissions regulations; electricity load shapes; and end-use demand. Non-utility generation from combined heat and power (CHP) and other facilities whose primary business is not electricity generation is represented in those specific modules. All other non-utility generation, distributed generation and electricity trade are represented in the module. The module includes a full suite of generation technologies including advanced coal and nuclear options.

The Oil and Gas Supply Module represents domestic crude oil and natural gas supply. It captures the interrelationships among the various sources of supply, onshore and off-shore, by both conventional and non-conventional techniques. Conventional supply includes light and heavy oil and natural gas. Non-conventional supply includes gas recovered from coalbeds and bitumen from oil sands. Bitumen extraction from oil sands is subdivided into two categories, *in situ* and mining. *In situ* bitumen requires blending with lighter hydrocarbons, such as condensates; the mining product is upgraded to an equivalent of light sweet crude. The energy required by this industry is based on the level of each type of production for both oil and natural gas using unit energy-consumption coefficients.

The Petroleum Market Module represents domestic refinery operations and the marketing of petroleum products to consuming regions. It provides product prices, crude oil and product export and import activities, domestic refinery capacity and refinery fuel consumption.

ANNEX 5.2: POLICY ASSUMPTIONS

Over the past few years, the GoC has introduced individual climate change programs through Action Plan 2000, Budget 2001 and Budget 2003. Of these, the programs with emission reduction targets were included in the model. It is assumed that funding for these programs extends to 2007/2010, depending on the program. Only those programs with spending authority from Treasury Board as of May 2006 are reflected in the Outlook. The major impacts of these programs are assumed to have occurred by 2010.[75]

The impacts of these programs, other than those embodied in consumer behaviour, are assumed to cease when the approved funding terminates. There will be, however, some carryover effects, especially with equipment regulations.

The Large Final Emitters (a proposed program to reduce emissions in energy-intensive industries) and the programs proposed during 2005 and Project Green were not included, since it would be too soon to properly interpret their implications. In addition, all the programs that were terminated or cancelled by May 2006 were not reflected in the Outlook.

The programs included in the Outlook were first bundled into logical groups, e.g., the measures affecting appliance efficiency in the Residential sector are treated as a bundle. Moreover, instead of using the emissions reductions estimated for each program, its market outcome was estimated. The market outcome was determined in consultation with the individual program managers.

A summary of the measures included in the Outlook is provided below.

Residential and Commercial Equipment Standards

- Accelerated Standards Action Program (ASAP) and Equipment Labelling

The expected market outcomes are:

- Equipment regulations and standards will require that new gas furnace efficiency be 90% in 2009 and that new gas boilers be 85% efficient by 2010. For other equipment, energy efficiency was assumed to improve from 5 to 40% by a particular year, depending on the equipment. For example:
    - Gas Water Heaters are assumed to be 5% more efficient in 2007.
    - Heat Pumps are assumed to be 10% more efficient in 2006.
    - Clothes washer/dryers are assumed to be 20% more efficient in 2007.

Transportation

- Light-Duty Vehicles
    - In April 2005, the Canadian Automotive Industry,[76] through an MOU, agreed to voluntary commitments to reduce emissions through the introduction of new technologies, such as advanced emissions controls, advanced diesel, alternative fuels, hybrids and fuel efficiency.
    - Advanced Technology Vehicles Program (ATVP) to evaluate advanced vehicles and technologies.
    - Marketing of efficient vehicles and driving/maintaining vehicles for efficiency.

- Freight Efficiency and Technology Initiative (FETI)
    - Training and awareness among freight operators is expected to increase adoption of innovative environmental technologies, best practices and voluntary performance agreements.

- Freight Efficiency Program (FEP)
    - Support to companies in the rail, marine and aviation freight transportation sectors is assumed to result in purchase of emission reduction technology and equipment.

[75] The GoC is currently developing a new environmental agenda. Decisions regarding continuation of programs beyond 2006/2007 will be made in the context of the new agenda.

[76] Memorandum of Understanding between the Government of Canada and the Canadian Automotive Industry Respecting Automobile Greenhouse Gas Emissions. April 5, 2005.

Alternative Transportation Fuels

- The newly established Canadian Transportation Fuel Cell Alliance (CTFCA) is expected to evaluate various options for providing the hydrogen to power fuel-cell vehicles.
- Future Fuels and Ethanol Expansion Program supplies 1.3 billion litres of ethanol per year.

The expected market outcomes are:

- Vehicle manufacturers are assumed to achieve a 15% improvement for light -duty vehicles under the MOU. The vehicle manufacturer determines the technology choice.
- N_20 emissions will be reduced by about 1 Mt of CO_2 eq. by 2010
- An assumed annual improvement of 1.1% in aviation efficiency, which includes 0.1% due to the FETI and FEP freight programs.
- An assumed annual average improvement of 0.35% in marine efficiency, which includes 0.05% from FEP.
- An assumed annual average improvement of 1.5% in rail efficiency, which includes 0.03% from FEP.
- Increased ethanol production assumed to reach 1.3 billion litres per year (29 PJ).

Industry

The projected energy intensity reductions for energy intensive industries are consistent with the Canadian Industry Program for Energy Conservation (CIPEC), a group of ongoing voluntary energy conservation initiatives undertaken by these industries through to 2010. The expected rate of improvement varies from industry to industry. The Aluminium industry has a target of 0.1% per year, whereas the Iron and Steel industry has a target of 1% per year. The industries that are not part of CIPEC are assumed to achieve intensity reductions of 2% per year.

Electricity

The Wind Power Production Incentive (WPPI) is included. This program provides a financial incentive of 1.2 cents per kilowatt-hour from 2002 to 2005, and in 2006 it declines to 0.8 cents. Eligible production receives the incentive for up to 10 years from the date of initial production, until 2017. Note that the expansion of the WPPI announced in Budget 2005 is not reflected in the Outlook.

The effects of other programs, such as the Market Incentive Program and Consumer Information are assumed to be captured by the WPPI incentive.

Upstream

There are five projects under the CO_2 Capture and Storage program. A key research project is the IEA Weyburn CO_2 Monitoring and Storage project, which measures and monitors CO_2 injected into the Weyburn field. Other funded demonstration projects include three enhanced oil recovery (EOR) projects and an enhanced coalbed methane recovery project, all of which use industrial CO_2 sourced in Canada.

Since these are principally demonstration projects, the emissions reductions and changes to oil and gas production are small and were not specifically reflected in the Outlook.

Chapter 6 Vulnerability Assessment, Climate Change Impacts and Adaptation Measures

6.1 INTRODUCTION

Canada has made significant advances in the area of climate change impacts, adaptation and vulnerability assessment on several fronts since the publication of *Canada's Third National Report on Climate Change*. An increasing body of research and observations, summarized in a number of reports and assessments from sub-national to global scale, demonstrate that the impacts of a changing climate are already evident in many regions of Canada. Advances in vulnerability research have greatly expanded our understanding of the environmental and societal risks presented by climate change and our capacity to adapt. Increased investments have expanded our knowledge about regions, sectors and issues that had received little or no study at the time of the last communication.

Canada's vulnerability to climate variability and change have been clearly demonstrated by a number of extreme events in the past few years, including flooding and landslides triggered by extreme rainfall and snowmelt, storm surges, drought, heat waves and associated forest fires. Such events have occurred in all regions of the country, resulting in major economic impacts, social disruption and loss of life. Examples include an August 2005 storm in southern Ontario that saw more than 100 mm of rain in less than one hour at many sites, resulting in extensive flooding and the largest insured losses in Ontario's history. The drought of 2001-2002, which was unusual in that it affected many regions of the country, resulted in losses of $5 to $6 billion due to crop losses, insurance payouts, etc. Partly in response to these events, governments at all levels have taken initial steps to address adaptation to climate change.

Recent research findings provide new insights into vulnerabilities in natural and human systems, climate-related thresholds, and incentives and barriers to adaptation decision-making. It is clear that adaptation occurs in response to multiple factors, one being a changing climate. Drawing from many sources of information, including traditional knowledge and research in other relevant disciplines such as hazards mitigation, is necessary to develop innovative and robust strategies. Research has shown that for adaptation measures to be effective, they must be developed within the context of other factors, such as anticipated population growth and land use changes, and that adaptation needs to be integrated into broad decision-making rather than being treated as a stand-alone process. Furthermore, adaptation measures must be doable; the communities for which the measures are developed must have the legal authority, resources and capacity to adopt them.

The Canadian federal government, all provinces and territories, several municipalities, business and non-government organizations (NGOs) have recognized the need for adaptation. Acknowledging the value of collaboration among jurisdictions in addressing climate change adaptation, federal, provincial and territorial governments set up an Intergovernmental Climate Change Impacts and Adaptation Working Group (IAWG) in 2002 to enhance cooperation. On a project basis, the federal government has worked cooperatively with other jurisdictions on climate variability and climate change adaptation issues over the past few decades. More recently, significant joint initiatives have arisen among governments, academics and industry, as best reflected in the creation of the *Ouranos Consortium on Regional Climatology and Adaptation to Climate Change* to address the impacts of, and adaptation to, climate change in Quebec. Several municipalities, such as Halifax, Hamilton, Ottawa, Toronto and Vancouver, have started to work on ways to incorporate adaptation into their municipal planning and operations.

6.2 PROGRAMS AND MEASURES

The largest program dedicated to funding climate change impacts and adaptation research, capacity building, networking and policy development is the Government of Canada's (GoC) *Climate Change Impacts and Adaptation Program* (CCIAP), which received $37.5M in funding between 2001 and 2006. Given the sparse nature of the information on some regions and sectors of Canada, and the increasing demand for information for adaptation decisions, CCIAP's primary focus was placed on building a foundation of knowledge about climate change impacts and the process of adaptation, as well as enhancing expertise in this field. It was recognized that in order to avoid costly maladaptation, some decisions being made today – with implications extending up to several decades – need to incorporate climate change considerations using the best available information. For this reason, emphasis was placed on adaptation research aimed at understanding the capacity of Canadian society to respond successfully to climate change impacts, and assessing ways to incorporate the uncertainties in climate change projections and other key factors into the decision-making process, in both the public and private sectors. These two aspects demand that decision-makers be more actively involved in the research process.

As a key to ensuring that the knowledge and interests of decision-makers were prime considerations in adaptation research, and to enhance the transfer of new findings to them, CCIAP encouraged research teams to include end-user stakeholders at the earliest stages of projects. The program also developed a strategy to diversify the research community through the encouragement and support of studies integrating physical, biological, social and economic components and, where feasible, to engage government, industry or relevant other decision-makers. The program funds projects lead by researchers based at universities, all levels of government, NGOs, and the private sector.

6.2.1 Research

Prior to 2001, most of the research on impacts and adaptation in Canada focused on understanding the biophysical impacts of changing climatic conditions. These investigations sometimes also took a preliminary look at adaptation options, in many cases developing lists of possible actions.

Since 2001, the CCIAP has funded 130 research projects examining vulnerability, impacts and adaptation in Canada in the areas of water resources, food supply (fisheries, agriculture and non-commercial), forestry, coastal zones, communities, human health and well-being, tourism and recreation, transportation, and landscapes and ecosystems. In selecting the research to be funded through this program, decisions were made to encourage research in previously under-represented geographic regions (Atlantic Canada and the North) that addresses geographic areas and socioeconomic sectors known to be sensitive to changes in climate (e.g. water supply in the Prairies and food access and security in the North). To increase the transfer of project knowledge to decision-makers, projects were required to provide written indication from the intended end-users that the results of the research were well targeted and would help lead to the development of adaptation actions. While most of these research projects are still ongoing, some final reports are available via http://adaptation.nrcan.gc.ca, with others to be added as projects are completed.

In addition to the CCIAP, many federal departments have research programs that address impacts and adaptation. These programs generally have similar goals of improving our understanding of, and reducing vulnerability to, climate and climate hazards, improving our understanding of biophysical and socio-economic impacts, and providing information to Canadian decision- and policy-makers. The research conducted within federal departments, including but not limited to the Environment, Natural Resources, Agriculture, Fisheries and Oceans, Health, and Infrastructure departments, reflects their mandates and expertise. These include:

- research on incorporating considerations of the impacts of climate change, including uncertainties, into the federal environmental assessment process;
- developing new methods for assessing the implications of climate change for sustainable development;
- assessment of the impact of climate change on water resources, sea ice, agriculture, coastal zones (sea level rise and storm surge), transportation, permafrost, groundwater, freshwater and marine fisheries, arctic marine mammals, forests (including pests and fire), infrastructure and implications for management of resources, human health and well-being (water-borne and vector-borne diseases, zoonotic disease, extreme heat), and communities;

- hazard assessment in light of climate change and incorporation of this information in disaster mitigation and response plans; and,
- assessment of the impacts and possible adaptations to climate change with specific regard to the operations and management of the National Parks system in Canada.

Reducing Canada's Vulnerability to Climate Change (RCVCC) is a research program led by the Earth Sciences Sector of Natural Resources Canada. It aims to reduce Canadian vulnerability to climate change through effective adaptation strategies informed by geoscience and geomatics. RCVCC comprises several projects that target leaders, policy-makers and decision-makers in key economic sectors, communities and governments. The program includes both targeted regional studies in collaboration with stakeholders and national-scale change detection using satellite data, monitoring of glaciers and monitoring ground conditions in permafrost regions.

Several federal departments also have targeted programs that fund research that contributes to our understanding of climate change vulnerability, impacts and adaptation. For example, Environment Canada's *Northern Ecosystem Initiative* is providing $1.0 million over five years to fund 14 projects that improve our understanding of how northern ecosystems and the people that depend on them are affected by climate change. These projects use both traditional ecological knowledge and traditional science to address issues of concern to northern peoples and governments. Northern Aboriginal organizations are full participants in the design of the program and selection of projects. Current projects address concerns such as caribou herd changes, observations of changes in sea ice and their implications, and the effect of climate change on mercury in char.

The Health Policy Research Program at Health Canada has provided $700K to examine risks to health expected from climate and identify potential adaptation strategies.

Canada's national granting councils – the Social Sciences and Humanities Research Council (SSHRC), the National Science and Engineering Research Council (NSERC), and the Canadian Institutes of Health Research (CIHR) – fund significant research in the university sector that directly or indirectly addresses the impacts and adaptations of climate change. Through Canada's *Networks of Centres of Excellence (NCE)* Program, NSERC, SSHRC and CIHR also fund *ArcticNet*, which is focused on vulnerability, impacts and adaptation in the coastal Canadian Arctic. *ArcticNet* brings together scientists in the natural, human-health and social sciences with their partners in Inuit organizations, northern communities, federal and provincial agencies, international partners and the private sector in undertaking Integrated Regional Impact Studies. In addition to their work in northern communities, *ArcticNet* researchers use the Canadian research icebreaker CCGS Amundsen to conduct marine research and access coastal Arctic sites. A major goal is to provide a multi-disciplinary and cross-sectoral environment to train the next generation of specialists, from north and south, needed to manage the Canadian Arctic of tomorrow. Others NCE's, such as the *Canadian Water Network* and the *Sustainable Forest Management Network*, are also directly relevant to climate change impacts and adaptation issues.

Several Provincial and Territorial governments have initiated programs to fund research on impacts and adaptation so as to enhance understanding of anticipated impacts and provide information for adaptation decision-makers. The provinces of Alberta, Saskatchewan and Manitoba, along with the GoC, jointly support the *Prairie Adaptation Research Collaborative (PARC)*. PARC has supported research addressing a wide range of impacts and adaptation issues of common concern to the three Prairie Provinces, with particular focus on the impacts and management of water resources in a region characterized by recurrent drought and frequent, severe flooding. Saskatchewan has conducted adaptation research in such areas as non-commercial food supplies, protected areas, biodiversity and terrestrial ecosystems. The Northwest Territories are conducting extensive research on climate-change related impacts on permafrost and the regional transportation system. Ontario has been actively researching a strategy for allocating afforestation stock in response to the new environmental conditions resulting from climate change. The *Pacific Climate Impacts Consortium (PCIC)*, established in May 2005 by the Province of British Columbia with support from BC Hydro, is putting in place plans to initiate research projects in hydrology and forest pests in British Columbia.

The largest province-based impacts and adaptation initiative is the *Ouranos Consortium*, a joint initiative of the Government of Quebec, industry (Hydro Quebec) and the GoC (Environment Canada). Announced on May 16, 2002, the Ouranos Consortium brings together resources and more than 200 experts from nine Quebec government ministries, the federal government, universities, associations and foundations to advance the understanding of regional climate change in Quebec and its environmental, social and economic impacts. Its research activities include development of detailed regional climate change scenarios and decision-making tools. It also performs assessments of expected sectoral impacts in order to optimize adaptation. The Ouranos Consortium's research projects are defined in cooperation with end users and aim to respond to specific short- and medium-term concerns of Quebec society and business.

Several private sector companies have also recognized the need to start considering climate change in their current planning. Fuelled by concerns regarding extreme events and reliability of natural resources, both Manitoba Hydro and Hydro Quebec provide substantial support for research aimed at increasing their understanding of projected impacts with regard to hydro power generation operations and management, as well as reducing their vulnerability and minimizing potential economic impacts to power supplies. In 2001, private sector companies in Nova Scotia established *Climadapt*, to provide innovative climate change adaptation expertise in Canada and internationally.

6.2.2 Building Capacity and Awareness

Adapting to climate change will require the skills and involvement of a wide cross section of Canadians. Since 2001, a conscious effort has been made to expand research capacity beyond its foundation in physical and biological sciences to be able to address the adaptation issues of concern to a broad range of Canadian sectors. It has also been recognized that all stakeholders have important information to contribute to the understanding of vulnerability and adaptive capacity. A number of initiatives have been undertaken to increase the capacity of both the research and the decision-making communities to address adaptation to climate change.

The *Canadian Climate Impacts and Adaptation Research Network* (C-CIARN) was established in 2001 to bring researchers together with decision-makers from industry, governments, and NGOs to share the latest information about impacts and adaptation, and identify information gaps and priorities for future work. It also worked to reach out to researchers in the social and health sciences to increase their participation in this issue. Recognizing the cross-cutting nature of most climate change issues, the network consists of six regional offices and seven sectoral offices that focus on issues of concern to their constituents and contribute to larger national goals. Since its inception, C-CIARN has held more than 130 workshops engaging community and professional stakeholders across the country, with membership exceeding 2,000 people. Other networks sponsored by the federal government include the *Climate Change Scenarios Network* and the *Climate Change, Air Pollution and Health Research Network*.

The Ouranos Consortium, which hosts the Quebec regional office of C-CIARN, holds frequent local workshops and discussions with regional stakeholders, increasing their awareness of the potential issues they face and engaging them in research and policy discussions. The Ouranos Consortium also brings together researchers from a variety of disciplines to work together on the issues at its facility in Montreal, and convenes researchers to present the latest findings to stakeholders on a biennial basis.

The *Canada Research Chairs* program, which has a goal of establishing 2,000 research professorships in Canada by 2008, had by 2005 funded 15 chairs across the country that will contribute to impacts and adaptation research in a variety of disciplines. Also, in conjunction with Manitoba Hydro and Alberta Climate Change Central, PARC has funded three climate change research professors at the Universities of Regina, Winnipeg, and Lethbridge. It has also undertaken a series of workshops across the three Prairie Provinces that raised awareness of climate change and its implications for the environment, natural resources and communities.

Health Canada and the Public Health Agency of Canada have developed the document “Your Health and A Changing Climate: A Risk Management Toolkit for Public Health Professionals” which assists public health practitioners and policymakers in better understanding the health-related implications of climate change and in communicating information about climate change to health decision-makers in local communities. The Toolkit includes a series of fact sheets and other useful materials and is being made available to medical officers of health and other health professionals in Canada for their use in promoting adaptation actions.

Aboriginal peoples of Canada, while sharing the climate change related concerns of other Canadians, also have specific concerns that arise from their close relationship to their natural environment including, in many cases, significant use of traditional food sources. They also possess a vast body of traditional knowledge that provides insights into both impacts and our capacity to adapt. To assist aboriginal organizations to participate in climate change adaptation discussions, and to build awareness among their member communities, short term funding was provided to four First Nations and Inuit organizations.

Practitioners in many fields have key roles to play in adapting to climate change. Since 2001, partnerships have been developed among government and key professional and practitioner organizations, including engineers, planners, and hazard managers. For example, the *Canadian Council of Professional Engineers (CCPE)* is working with the associations that regulate the practice of engineering in Canada to implement a *Climate Change Impacts and Adaptation Plan*. Items in the plan include:

- raising awareness within the profession and industry and among decision-makers and the public on the need for adaptation to climate change;
- developing an education strategy aimed at engineering students and professional engineers; and,
- establishing formal and consistent linkages between scientists and engineers to exchange information and communicate the needs of engineers for research and modelling, particularly at the regional and local levels.

An example of building awareness within professional organizations is provided by the *Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA)*, which includes consideration of climate change impacts in its *Guideline for Environmental Practice*. The document states that, as a result of climate change, “statistics governing the return frequencies of extreme weather events such as ice storms and floods may no longer be accurate or relevant. Structures designed based on historical (climate) information may not be robust enough to withstand weather events that are now much more common. In the best case this could results in higher repair costs. In the worst case, the inadequate design could present a significant risk to the safety of the public…” The federal government is also working with national codes and standards committees to ensure that the climatic design information integrated into infrastructure codes and standards incorporates the most recent data and information on the changing climate. The APEGGA encourages its members to stay informed of climate change and apply reasonable improvements to the design of systems and structures in order to accommodate the anticipated changes.

6.2.3 Policy

Adapting to climate change will be an incremental process involving decision-makers at all levels. In Canada, the federal government and a few provincial and territorial governments have interdepartmental policy committees focused on climate change adaptation and the development of policy responses. There is also the IAWG, which was initially organized to develop a framework for collaboration across jurisdictions on adaptation. Recognizing that climate change will directly or indirectly affect most government activities, and that effective adaptation policy requires a strong horizontal approach, these committees and working groups generally cross a wide range of disciplines. For example, the GoC’s *Assistant Deputy Minister Climate Change Impacts and Adaptation Committee* includes officials from 20 separate departments and agencies.

The IAWG agreed upon a *National Climate Change Adaptation Framework* in 2005, which presented areas of potential interjurisdiction collaboration to increase Canada’s capacity to adapt to climate change, to recognize and reduce risks, and to identify and pursue opportunities. It encompassed six elements, each with associated objectives and guidance on actions to facilitate their achievement. The six elements aim to:

1. raise awareness of adaptation;
2. facilitate and strengthen capacity for coordinated action on adaptation;
3. incorporate adaptation into policy and operations;
4. promote and coordinate research on impacts and adaptation;
5. support knowledge-sharing networks; and,
6. provide methods and tools for adaptation planning.

There are ongoing activities related to these elements within every jurisdiction. All orders of government have shown interest in information sharing, enhanced collaboration and cooperation on issues of common concern as being important for effective adaptation.

In addition, a number of policy and program initiatives are directly related to reducing vulnerability to climate change. For example, the Canadian Environmental Assessment Agency (CEAA), in conjunction with Provincial counterparts, produced *Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners* (CEAA, 2003). The objective is to help practitioners assess, reduce and manage the adverse impacts that climate change may have on development projects in order to reduce risks to the public and the environment. This *Guidance* adopts a risk management approach to assess potential risks and adaptation measures. A more detailed consideration of climate change impacts is found in guidelines developed by Parks Canada Agency, which has implemented a system-wide impact assessment screening system for use in National Parks and protected areas.

Many provinces and territories have implemented, or are in the process of developing, policies or programs specifically targeted at climate change impacts and adaptation. These programs and plans, while differing in scale and scope, all aim to help determine adaptation priorities, increase awareness of climate change impacts and adaptation issues, reduce vulnerability, and increase capacity to adapt. For example, British Columbia is piloting the use of a decision-making framework that incorporates projected climate variability and change into risk assessment and management decisions. In addition, all provinces and territories have various other programs that, while not climate change specific, work to reduce vulnerability to current climate variability and extremes, and those exacerbated by climate change. Examples of such programs include the *British Columbia Provincial Fire Management Program*, Alberta's *Water for Life Strategy*, the *Water Conservation Plan* in Saskatchewan, the *Manitoba Crop Insurance Corporation Programs,* Ontario's *Emergency Management Act,* and the New Brunswick *Coastal Areas Protection Policy*.

Municipalities also have a critical role to play in adaptation. Decisions regarding land-use planning, re-design or retrofitting of outdated infrastructure, and actions to reduce the risk of new or exacerbated public health threats, will require municipal or regional decisions. While climate change is generally not yet an immediate concern for most local or regional decision-makers, many municipalities have begun to undertake adaptation actions. These often involve long-term (twenty years or more) infrastructure investments, particularly in regions that have been significantly affected by extreme weather events. Many municipalities are attempting to reduce current vulnerability as a result of recent climate trends and extreme events (flooding, forest fires, increasing number of freeze/thaw cycles). For example, in 2001 the City of Toronto, with support from the federal government, implemented a public heat-health alert system to help protect high-risk individuals during heat waves. The City of Montreal has developed its own health alert system to protect vulnerable populations. Another example is the Greater Vancouver Regional District (GVRD) and its member municipalities, which are developing Integrated Stormwater Management Plans that integrate climate change scenarios with considerations of watershed health, land-use planning, engineering, and community values.

6.3 RESULTS

There is abundant evidence that the impacts of a changing climate are already evident in many regions of Canada, as summarized in documents from the Intergovernmental Panel on Climate Change (IPCC), 2001 and in preparation; Canadian Council of Ministers of the Environment (CCME), 2003; Natural Resources Canada, 2004; Barrow *et al*, 2004; and Arctic Climate Impact Assessment (ACIA), 2005. These impacts are most evident in northern Canada, where observed increases in mean annual temperature approach 0.5°C per decade over the past 50 years. Documented impacts include decreased sea ice and glacier extent, river flows, permafrost warming and melt (active layer thickness), enhanced coastal erosion and ecosystem changes.

Expected future changes in climate vary across the country, with the Arctic and the southern and central Prairies projected to experience the greatest warming, which is generally consistent with the temperature trends observed over the past several decades. Projected annual warming by the year 2080 ranges from 2°C to 5°C in southern and western Canada, to between 6°C and 9°C over the High Arctic, with significant regional and seasonal variation (Barrow *et al,* 2004). For example, a projected warming of 6°C to 7°C in the central Prairies contrasts with a projected warming of only 2°C to 3°C in the southern Atlantic region. These patterns and magnitudes of change are strongly related to winter and spring warming.

Average annual precipitation is expected to increase in most regions of Canada, and changes in precipitation patterns are also likely, including more frequent, heavy-precipitation events and larger year-to-year variability. Furthermore, most models indicate that there will be reduced precipitation during summer months and increased precipitation during winter months. These changes in seasonal precipitation patterns are likely to have greater impacts on both natural and human systems than those that would be projected by considering only changes in mean annual precipitation. Changes are also anticipated in the frequency of extreme events, such as heat waves, droughts, floods and storms.

As a result of this range and variation in projected climate changes, as well as the existing regional and socio-economic variations across Canada, adaptation measures will need to be tailored to specific local and regional circumstances. While lessons can be learned from other regions experiencing similar impacts, and while general principles of successful adaptation can be transferred, engaging local decision-makers in the discussion of climate change, in the context of all other issues they deal with, is essential to long-term effectiveness.

6.3.1 Sectoral Implications

Refinements in our understanding of the timing, extent and severity of the direct impacts of climate change have enabled efforts to be focused on geographic regions and socio-economic issues of greatest concern. A detailed discussion of, and the associated references regarding, the anticipated impacts for each sector cannot be included in this chapter, but they are available in several reports, including *Climate Change Impacts and Adaptation: A Canadian Perspective* (Natural Resources Canada, 2004), *Adapting to Climate Change* (Ouranos, 2004) and the Arctic Climate Impacts Assessment (ACIA 2005).

Climate Change Impacts and Adaptation: A Canadian Perspective provides an overview of impacts and adaptation research between 1999 and 2004, as it relates to Canada. The report consists of chapters focusing on specific sectors (water resources, agriculture, forestry, fisheries, coastal zones, human health and well-being, transportation, communities, and tourism and recreation), while other chapters address research methodologies, costing, background information and knowledge gaps. The report concludes that:

- Significant uncertainties are inevitable and unavoidable when dealing with climate change, and therefore adaptation is best addressed in the context of risk management, as would any other issue dealing with potential future conditions.
- Important shifts in Impacts and Adaptation Research that have occurred in the past five to ten years include:
    - growing recognition of the importance of considering social, economic and political factors, in addition to biological and physical ecosystem factors;
    - increasing use of the concept of vulnerability, focusing on the need to develop a solid understanding of the current state of the system being studied by involving stakeholders early and directly in research, and by taking an integrative, multidisciplinary approach;
    - identification of the significance of improving our understanding of how adaptation occurs, and what barriers exist

to successful adaptation;
- o recognition that climate change impacts, and our ability to adapt to those impacts, will differ both among sectors and among the various regions of Canada;
- o acknowledgment that there will be both positive and negative impacts in all sectors (while there is a general consensus in the literature that negative impacts are expected to dominate, comprehensive assessment of the net balance has not yet been possible because of existing information gaps); and,
- o recognition that a rise in the frequency or intensity of extreme climate events would present challenges for most sectors, with currently stressed systems at the greatest risk. Enhancing adaptive capacity through a range of technological, regulatory and behavioural changes would bring both immediate and long-term benefits.

6.3.1.1 Water Resources

In contrast to many other parts of the world, Canada is a water-rich country, possessing 9% of the world's renewable freshwater and only 0.5% of the global population. This water, however, is not evenly distributed across the country, and many of the country's major river systems flow northwards, away from the regions of highest population density. Furthermore, Canadians and Canadian industries are also among the highest per capita users of water in the world.

There is confidence that warmer temperatures will affect variables such as evaporation and snow cover. Uncertainties about the nature of regional precipitation patterns, as well as the complexity of natural ecosystems, limit the ability to project hydrological changes at the watershed scale. In general, it is expected that for many regions of Canada, climate change will likely result in increased winter flows, decreased summer flows and warmer summer water temperatures. This is particularly true for snowmelt-dominated systems that are found across most of the country. Warmer water temperatures and lower seasonal flows will also lead to degraded water quality, affecting ecosystems, treatment for consumption, and waste management.

Some of Canada's regions most vulnerable to the impact of climate change on water resources are already under stress, including south central British Columbia, the southern Prairie Provinces, and parts of Atlantic Canada. In many cases, these regions are accustomed to dealing with both severe water deficits and excesses. However, the consecutive droughts of 2001, 2002 and 2003 also affected several regions across Canada less accustomed to dealing with droughts. Previously reliable water supplies failed, demonstrating that present resource management practices were not capable of dealing with this additional degree of climate stress in the context of high population growth and development rates, increasing agricultural and industrial demands, etc.

In addition to water supply concerns, projections indicate that warmer winter temperatures will likely increase the frequency of mid-winter thaws and rain-on-snow events. This increases the risk of winter flooding in many regions as a result of high flows and severe ice jams. At the same time, reduced winter snow cover would likely result in fewer and less severe spring flooding events.

Canada's provinces and territories have primary jurisdiction over water management and protection. Broad provincial water policies that address climate change issues are in place in British Columbia and Manitoba. A special focus has been put on the Okanagan Basin in British Columbia, where recent research points to potentially significant water shortages in the future due to projected climate change and population growth. Drought Action Plans and Water Conservation Plans exist for many provinces and territories, including British Columbia, Saskatchewan, Ontario and Quebec.

Other recent and ongoing studies have identified needs that could represent barriers to facilitating adaptation in the water resource management sector in Canada. These include further defining jurisdictional roles and responsibilities, providing for more integrated management among jurisdictions, enhancing adaptive capacity through existing institutional frameworks (e.g., water licensing systems), improving understanding of local water systems and users, and fostering local partnerships and establishing transparent institutional arrangements at all levels. For example, considering jurisdictional roles alone, at least three federal departments or agencies, three provincial departments or agencies, watershed-based organizations and municipalities all play significant roles in water-shortage management in Ontario. The recent development of a provincial drought response plan in Ontario has helped to clarify local responsibilities for drought management, which improves the capacity of communities to address water-shortage issues. In Alberta, the 2001 *Water Sharing Agreement* was found to enhance adaptive capacity by instituting an effective means of conserving water and distributing it equitably on a large scale.

6.3.1.2 Food Supply

Agriculture

In 2002, the value of Canadian agri-food exports was an estimated $25.8 billion, or about 10% of total merchandise exports. Important Canadian agri-food exports include value-added and processed goods, prime-quality meats, live animals, bulk grains, oilseeds and vegetables. Farming operations are spread across the country; while the greatest area of farmland is in the three Prairie Provinces, Ontario has the largest number of individual operations. Although agriculture is a vital component of the Canadian economy, only a small percentage of the country is actually farmed due, in large part, to climate and soil limitations.

Much of the research on the impact of climate change on Canadian agriculture has suggested positive gains in production associated with (1) increased production of wheat in the Prairies, (2) increased corn and soybean yields in Atlantic Canada, and (3) increased soybean, potato and winter wheat yields across the country. These gains are generally associated with higher temperatures and extended growing seasons. In other studies, negative impacts were projected to result from increased winter damage of forage crops, increased problems with insect pests, and water shortages.

In addition to its impact on crops, climate change is also expected to affect livestock operations. It is projected that there will be both negative and positive impacts on livestock, with warmer weather decreasing feed requirements, increasing survival of young and reducing energy costs, while increased heat stress would adversely affect milk production, meat quality and dairy cow reproduction.

The range of adaptation options of agriculture is large, and includes technological developments (such as the development of new crops, irrigation technologies, etc.), government programs and insurance (crop insurance, subsidies, etc.), farm-level production practices (diversification and intensification of crops, timing of operations, etc.), and farm financial management (investment in crop shares and futures, diversification of household income, etc.).

Recent research involving agricultural producers highlights their attitudes toward climate change and their understanding of the potential for farm-level adaptation. While they are always concerned about current weather and climate, they are less concerned about future climate change than about the more dominant factors of fluctuating markets and commodity prices. It is therefore suggested that addressing climate change in this community is best achieved by integrating consideration of climate change risks into the decision-making processes used for dealing with current climate variability. Similarly, it is likely that successful adaptations to future climate change involve both modifications to existing farm practice and public policy decision-making processes. There remains a need to improve our understanding of the relationship between potential adaptation options and existing farm-level and government decision-making processes in a risk management framework.

Numerous current policies and programs at both the federal and provincial levels may play important roles in adaptation to climate change, including crop insurance programs, livestock building design for extreme events, the promotion of best management practices to reduce vulnerability to changes in water supply, extreme events and crop disease, and increased water-use efficiency in crop and livestock operations.

Fisheries

Canada has the world’s longest coastline, largest offshore economic zone and largest freshwater system. The fisheries encompass the Atlantic, Pacific and Arctic Oceans, as well as the freshwater system. For many small coastal and aboriginal communities, fishing is a way of life.

Climatic factors, including air and water temperatures, precipitation and wind patterns, strongly influence fish health, productivity and distribution. Most species of fish have a distinct set of environmental conditions under which they experience optimal growth, reproduction and survival. Changes to these variables could result in shifts in species distribution, reduced or enhanced growth, increased competition from exotic species, greater susceptibility to disease and parasites, and altered ecosystem function. Aquaculture has been considered to be relatively adaptable to climate change, although environmental, social and regulatory considerations may limit the ability of the industry to respond rapidly.

Climate change has been linked to declining salmon stocks on the Pacific coast. In addition, reports from the Arctic of sockeye and pink salmon captured well outside their known range may be related to recent warming trends. Recent shifts in river flows have also been linked to changes in fish populations in various regions across the country.

There is growing recognition within the fisheries sector of the need to anticipate and prepare for climate change. There is evidence that marine ecosystems are relatively resilient to changes in the environment, although individual species differ greatly in their adaptive capacity. Mobile species, such as fish, swimming crabs and shrimp should be able to move to more suitable habitats, whereas less mobile species such as clams and oysters will require more time to adjust. Management decisions in some regions remain challenging due to a lack of data on key species such as char in the Arctic. Reducing non-climatic stresses on fish populations reduces the vulnerability of both fish species and the fisheries sector.

Non-commercial foods

There is significant value in non-commercial food supplies in Canada, and subsistence activities play an important role in the cultural, social and economic well-being of many Canadian communities. Climate change presents a number of risks to communities that rely on the natural environment for food and medicine, particularly in Canada’s North, where it is anticipated that the impacts of climate change will be more pronounced than in other parts of the country.

Climate change will have implications for food access, availability and security owing to changes in the geographic range and timing of fish, animal and bird migrations and availability, the availability of medicinal and culturally important plant species, and the safety and reliability of transportation to hunting grounds. For example, northern Aboriginal communities have traditionally been located to intercept annual caribou migrations. In turn, hunting success has been associated with the abundance of caribou, annual migration patterns and environmental conditions such as ice break-up and snowmelt. Despite the economic and social consequences that changes in, or loss of, non-commercial food supplies would have in Canada’s North, scientific research and traditional knowledge on these issues is limited, particularly with respect to adaptation.

Ongoing research across Canada is using indigenous and local non-aboriginal ecological knowledge of past climate change and associated human adaptation to provide insight into human adaptation in the face of contemporary climate change processes. Further research focuses on changes in resource availability for communities dependent on hunting, fishing, trapping, and gathering; the current and future role of joint management structures and their capacity to respond to the impacts of climate change; and human health implications of changes in traditional food sources.

6.3.1.3 Forestry

There are more than 300 million hectares (ha) of forested land in Canada, accounting for approximately 30% of its total landmass. The forest industry is a significant contributor to the Canadian economy and the GDP, bringing in about $80 billion annually. More than 361,000 individuals find direct employment in the forest industry.

Given the long-term nature of tree growth and evolution of forest composition, the nature and rate of projected climate change will be important. It is expected that climate change will result in significant changes in fire and insect disturbances, ecosystems, plant growth and the carbon cycle. As temperature increases, species are expected to migrate northward and to higher altitudes. The species located near the southern edges of their current range and those with poor dispersal mechanisms would be the most threatened, and local extinctions are possible.

Higher winter temperatures will have mixed effects on forests. Warmer winter temperatures will likely reduce winter twig breakage, while at the same time increase risk of frost damage and increase the over-winter survival of some insect pests. This is considered to be a key factor in the current outbreak of the Mountain Pine Beetle in British Columbia. Reduced snow cover, however, could increase the mortality of other pests. It is anticipated that most regions will experience an increase in forest fires. Current fire occurrence and area burned is highly variable, with the average area burned being approximately 2.5 million ha annually. Cumulative impacts arising from the interactions among disturbances, such as drought, insect and disease outbreaks, and fire, are also likely. Spruce budworm outbreaks – which are widespread disturbances in the boreal forest – are thought to increase the occurrence of wildfires by increasing the volume of dead tree matter, thus increasing the available fuel matter for fires. Recent research has concluded that the drier conditions anticipated with climate change would increase the frequency and intensity of spruce budworm outbreaks, which would increase wildfire occurrence.

For much of Canada, climate change is expected to result in drier conditions that will result in more frequent droughts, increasing the probability of more frequent and intense forest fires. *FireSmart* is an initiative designed to alter forest fuels in the boreal forest to reduce the number and size of wildfires and the risk associated with the use of prescribed burning. Where employed, these techniques have resulted in a 25% to 30% decrease in area burned and a reduced incidence of large fires. The effectiveness of the approach will take several decades to become established, but its impacts and benefits will accumulate over time. It is anticipated that its wide-spread implementation will lead to fewer timber supply shortages, lower potential future carbon emissions, and additional tools for forest managers to ensure sustainable forests in the face of a changing climate.

Several provinces have initiated forest-related initiatives that will likely contribute to improved adaptation to climate change, including British Columbia's *Action Plan for Mountain Pine Beetle* and the *Provincial Fire Management Program*, Saskatchewan's *Forest Fire Management Strategy*, New Brunswick's *Fire Protection and Forest Pest Management Programs*, Prince Edward Island's *Forest Diversity and Climate Change Initiative*, and the Yukon Territory's *FireSmart* and *Fire Management Zone Directive*.

6.3.1.4 Communities and Infrastructure

Most of Canada's population is located in a small number of urban centres, with low population densities elsewhere. Communities in Canada, including their built environment and connecting infrastructure, are sensitive to climate variability and extremes, and in many cases will be at the forefront of many adaptation decisions, particularly with regard to community infrastructure and services. It is anticipated that even small shifts in climate norms will have potentially large ramifications for existing infrastructure. Sensitivities include impacts to built systems (roads and buildings), natural systems (watersheds and forests) and human systems (health and health care systems). For many communities, particularly those dependent on natural resources or tourism and recreation, climate change poses a threat to economic sustainability. For example, more than 1,600 communities in Canada have economies that are 30% or more dependent on agriculture, forestry or fisheries.

The nature and magnitude of likely climate change impacts on Canadian communities will largely be determined by location. For example, coastal communities are sensitive to sea-level rise, including secondary impacts such as groundwater salinization and storm-surge flooding. Communities on the southern Prairies are particularly sensitive to decreases in water supply, as the clay-rich soils of the region are prone to cracking during drought, sometimes fracturing building foundations and other built infrastructure. The primary concerns of larger urban centres are extreme climate events, as most major Canadian cities have recently experienced severe flooding due to extreme, short-duration rainfall that exceeded their existing flood control systems, as well as other storm damages. There is also a growing concern about the effects of increased heat stress and associated air-quality issues, particularly in the largest urban areas of southern and eastern Ontario and southern

Quebec. In response to the increasing losses from climate and weather-related hazards, some provinces have legislated emergency and disaster management planning. The federal government has tailored atmospheric hazards information and web-based materials to address the needs of the jurisdictions (e.g. municipalities) required by law to perform disaster risk management planning.

Communities in Canada's Arctic face many challenges as a result of a changing climate. While many residents of aboriginal communities participate in the wage economy, many others are engaged in subsistence activities, which demand a high level of knowledge of one's surroundings and environmental conditions. Changes to species' range and availability, access routes to these species, a perceived reduction in weather predictability, and travel safety in changing ice and weather conditions will pose significant challenges to human health, food security and culture.

Many impacts on northern infrastructure will be related to changes in permafrost conditions and associated changes in land stability. Indeed, permafrost underlies 50% of Canada's landmass. Changes in seasonal thaw depth and the temperature of the frozen ground are two parameters that must be accounted for in the design and construction of infrastructure built on permafrost. In areas of continuous permafrost, projected climate change is not expected to have an immediate impact on infrastructure, assuming permafrost engineering design procedures have been followed. However, projected changes will very likely have significant impacts on existing infrastructure in areas of discontinuous permafrost. The greatest engineering challenges are likely to found in the coastal zone, where increased wave action, sea-level rise and thermal erosion all interact, such as occurs at the community of Tuktoyaktuk. A project-screening tool using a risk-based procedure to assess permafrost engineering structures and their sensitivity to climate change has been developed and is currently in use in Canada.

The Government of Canada is encouraging adaptation to climate change by requiring such action when accessing certain programs. For example, through current programming, Infrastructure Canada has contributed to a number of projects that could help to mitigate and adapt to climate change impacts including northern infrastructure, the Manitoba Floodway, and water supply infrastructure in drought -prone areas.

6.3.1.5 Human Health and Well-Being

The relationship between health and climate in Canada is demonstrated by the strong seasonal variability in the incidence of infectious diseases and the persistent seasonal pattern of mortality. Monthly numbers of deaths reach their lowest point in August and peak in January. Other links between climate and human health are seen in the impacts of extreme events and weather disasters, such as flooding, drought and severe storms.

Your Health and a Changing Climate: Information for Health Professionals identifies several significant climate-change-related health effects expected to increase in the future (Health Canada, 2005). These include temperature-related morbidity and mortality, water- and food-borne contamination, vector-borne and zoonotic diseases, air pollution, exposure to ultraviolet rays, and extreme weather events. These effects are expected to be particularly significant for vulnerable populations such as the elderly, children, the infirm and the poor. Rural residents, who are required to travel further distances for health-care, and those relying directly on natural resources for their livelihood or food, are also considered to be more vulnerable. A host of broad socioeconomic issues related to climate change raises other concerns, including health care costs and the health and social benefits of action taken to mitigate climate change and its attendant risks.

International research and development collaborations have been initiated on developing vaccines against viruses and other infectious organisms, including influenza, which will help limit the future spread and health impact of emerging diseases. In addition, monitoring for emerging diseases and developing public information programs that provide information on reducing the risk of exposure and transmission will also serve to limit this threat. Ongoing research projects are examining a number of climate-related health concerns, including the potential spread of Lyme disease, the increased risk of water-borne disease, and the capacity of the health care system through an investigation of the relationship between climate and hospital presentation and admission patterns.

The impact of extreme climate events and climate-related natural disasters on health can be mitigated to some degree by emergency response planning. Many Canadian municipalities have emergency management plans in place, but emergency management capacity varies widely. Several jurisdictions are taking action to improve this. In addition to emergency management, early warning systems can be effective in reducing the impacts of extreme heat and cold events on health. The City of Toronto, with support from the federal government, has implemented both a *Heat-Health Alert and Emergency Response System* and an *Extreme Cold Weather Alert System*, which are designed to protect the City's most vulnerable populations through actions such as media alerts, distributing water bottles in summer and hot food in winter, and distributing transit tokens to those in need of transport to cooling centres. The City of Montreal is also currently investigating a response strategy to better address extreme weather. Ongoing research is examining the effectiveness of planning tools to enhance community capacity to adapt to climate-related natural hazards.

6.3.1.6 Recreation and Tourism

According to the Canadian Tourism Commission, the tourism sector in Canada contributed $22.5 billion or 1.9% of Canada's GDP in 2003. Recent statistics indicate that this has increased in the past two years. Climate has a strong influence on the tourism and recreation sector, and in some regions represents the resource on which the industry is predicated. In addition, weather and climate affect the length and quality of outdoor recreation seasons and the natural resources that, in some cases, are the basis for tourism (for example, water levels for boating, snow cover for winter sports, and species habitat for ecotourism). One example of current adaptations to reduce vulnerability to unreliable weather conditions is the use of new snowmaking technology, which in some areas of southern Ontario has significantly extended the ski season.

6.3.1.7 Transportation

Given the vast size and varying nature of the country, the Canadian transportation system is massive and consists of a variety of different modes, including major highway systems in the south, seasonal winter roads in the north, air, rail and marine. In addition, the planning, construction and use of many of these systems, which endure for decades, require significant investments of resources. Current planning cycles therefore must take into consideration how future economic, social and physical conditions, including changes in climate, are likely to impact both transportation demand and technological advances, and what types of adaptation strategies would increase the resilience of the system.

Climate change is likely to create both challenges and new opportunities for transportation systems in Canada. The components of the transport system that are most vulnerable to a changed climate include northern ice roads, Great Lakes shipping, coastal infrastructure that is threatened by sea-level rise, and infrastructure situated on permafrost.

Transportation in southern Canada accounts for the vast majority of domestic and cross-border movement of freight, and more than 90% of domestic passenger trips. The limited work that has been done in this area suggests that milder and shorter winters could translate into savings in winter maintenance costs, but the state of knowledge is not adequate to make quantitative estimates. Furthermore, higher temperatures and changes in precipitation, including changed frequencies of extreme climate events, may exacerbate other weather hazards or inefficiencies. Nonetheless, it appears at this time that the potential impacts of climate change on transportation may be largely manageable, particularly if climate change considerations are included in investment and decision-making.

In northern Canada, many communities and mining and forestry operations in isolated regions depend on seasonal winter roads for access and transport of essential food, fuel and other supplies. The roads require solidly frozen ground and sufficient lake and river ice thicknesses to support large trucks and equipment. When weather conditions do not permit construction of winter roads, supplies need to be transported by airplane at considerable cost. Another issue of significant concern is the decreasing sea ice cover of the Northwest Passage and other areas of the High Arctic, creating more favourable conditions for marine shipping that, in turn, would create potential for both economic opportunities and environmental impacts from increased shipping. Some projections indicate that the passage may be largely ice-free in the summer months in less than two decades.

6.4 NEXT STEPS

6.4.1 Research and Assessment

Canada is presently undertaking a national-scale assessment of climate change vulnerability, impacts and adaptation, to be completed in 2007. Building on Canada's previous national assessment, *The Canada Country Study* (Environment Canada, 1998), the new assessment will examine the existing and growing body of impacts and adaptation knowledge to address key questions regarding the risks and opportunities that climate change presents to Canada. A key aspect of the assessment is the integration of multiple knowledge sources, including conventional scientific knowledge, the traditional knowledge of Canada's aboriginal peoples, the knowledge of practitioners and local knowledge, particularly as it relates to understanding adaptive capacity. Case studies will be used to highlight key findings and illustrate adaptation actions taking place at the community and regional levels. The primary goals of the initiative are to assess the current state of knowledge of Canada's vulnerability to climate change and to provide Canadians with an up-to-date source of information that can be used to inform decision-making and policy development.

A number of communication products are planned for the 2007 assessment, in addition to a scientific volume and synthesis report. One of these will be a series of regional posters highlighting key issues and adaptation measures being taken in each part of Canada. The new posters will complement the highly popular climate change impacts poster series created in 2001, as more than 145,000 posters have been distributed (see Chapter 9 on Education, Training and Public Awareness).

In addition to the regional-focused, national-scale assessment described above, there are plans for a number of sectoral and regional assessments of climate change vulnerability, impacts and adaptation. The most advanced of these is the *National Climate Change and Health Vulnerability Assessment*, which also will be completed in 2007. Following the guidelines outlined in the World Health Organization's *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change*, the assessment will allow leading experts across Canada to contribute to a better understanding of the vulnerability of Canadian communities to climate change, and to gauge the capacity of Canadians, their communities and their institutions to adapt to the risks associated with climate change and climate variability. Another example is an initiative being lead by the CCPE to produce an assessment of the vulnerability and resilience of Canada's public infrastructure to climate change. The goal is to move beyond an initial assessment and to identify the codes, standards and practices that need changes in order to ensure that the infrastructure will be sustainable in the face of a changing climate.

Canada also will continue to invest in strengthening the knowledge base for adaptation decision making. For example, the federal government has approved funding of $150 million over six years to support innovative, interdisciplinary research as part of the 2007-08 *International Polar Year*. Funding will be used to support research and building capacity to address two of Canada's most important challenges for its northern regions: climate change impacts and adaptation, and the health and well-being of northern communities.

6.4.2 Policy Development

Building on the intergovernmental *Adaptation Framework*, an enabling environment for climate change adaptation is required to provide the knowledge and tools needed to integrate climate change into planning and policy processes. The components of an effective response are likely to include:

- developing appropriate adaptation tools, including risk management, to understand the risks and opportunities presented by a changing climate;
- integrating adaptation into the long-term investment and planning processes;
- enhancing industry-government-stakeholder partnerships in the development of instruments to facilitate adaptation to climate change, particularly to the increasing frequency of extreme events; and,

- increasing knowledge and understanding through a research agenda focusing on the impacts of climate change, and further work on the vulnerability of Canadians.

There is increasing interest from all orders of government, including municipalities, and the private sector in the development of tools for managing the risks and opportunities presented by climate change, and integrating adaptation considerations into their current decision-making processes. Work has begun in this area. For example, the Meteorological Service of Canada is developing a new web-based interface and network to deliver climate change scenarios (see Chapter 8 on Research and Systematic Observation). The *Climate Change Impacts and Adaptation Program* has recently funded six projects to develop methods and tools to assist community planners and managers in incorporating adaptation to climate change into their planning processes. The development, testing and implementation of tools to assist mainstreaming of climate change adaptation is likely to be one of the highest priorities for future activities related to climate change vulnerability, impacts and adaptation.

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CHAPTER 7 FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

7.1 INTRODUCTION

Preventing climate change is a global challenge that requires a global solution.

The Intergovernmental Panel on Climate Change (IPCC), established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) and comprising over 2,000 leading scientists, has provided strong evidence that the majority of the warming that has occurred in the last 50 years can be traced to anthropogenic activities. It also projected that climate change will occur more quickly than previously anticipated.

According to the IPCC, average global temperatures will rise, sea levels will rise, and millions of people will be affected by diminished food security, water scarcity, expansion of the range of vector-borne diseases, and more frequent and intense severe weather events.[77] These impacts will adversely affect developing countries most, due to their greater reliance on climate-sensitive economic activities and limited financial, institutional and human capacity. When productive land and potable water are hard to obtain, the poor often have no option but to deplete natural resources to satisfy their basic needs.

Women and children in particular are more vulnerable to the adverse effects of climate change on the environment. Decreased water supply and less access to the commons result in a greater workload for subsistence and less income, which in turn leads to malnutrition and ill health.

Efforts to address climate change – both its causes and its consequences – are intimately related to efforts to eradicate poverty, owing to the fact that food security, water availability and health depend on climate.

The Canadian International Development Agency (CIDA) is Canada's main government department responsible for delivering international assistance programs. In 2000, the Government of Canada (GoC) established the $100 million Canada Climate Change Development Fund (CCCDF), managed by CIDA. The CCCDF was designed to help address the causes and effects of climate change in developing countries, while contributing to sustainable development and poverty reduction.

Recognizing the cross-cutting nature of climate change, CIDA programming provides a means to integrate climate change issues where they relate to other development priorities. Examples of integrated approaches include adapting agricultural and rural development to changes in climate, fostering economic growth through investments in clean technologies, enhancing environmental programming in health and nutrition, providing humanitarian assistance, and linking environmental assessments to conflict prevention and security.

In July 2005, the G8 leaders agreed to the Gleneagles Plan of Action on Clean Energy, Sustainable Development and Climate. This plan provides a framework for action by important multilateral organizations such as the International Energy Agency (IEA) and the World Bank. Canada supports these G8 action plan initiatives that will help to develop and promote action and cooperation amongst the world's largest economies to address climate change.

Canada remains committed to working with other countries to combat climate change in fulfillment of its obligations under Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC) and Article 11 of the Kyoto Protocol. Canada has taken action in this regard through both multilateral and bilateral channels.[78] This chapter outlines Canada's financial contributions and technology transfer efforts over the past five years.

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[77] The IPCC reports can be viewed at www.ipcc.ch/index.html.

[78] Multilateral aid is administered by international institutions active in development, which collect resources from multiple countries and redistribute them to recipients.
Bilateral aid refers to assistance given directly from a donor government to a recipient country.

7.2 FINANCIAL CONTRIBUTIONS

Canada supports international efforts to develop climate change solutions through financial contributions to the Global Environment Facility (GEF), World Bank, United Nations programs, regional development banks, and other international institutions. In addition to the contributions made by CIDA, the Department of Foreign Affairs and International Trade (DFAIT) and other federal departments and agencies make contributions to the regular budgets of certain international organizations.

Table 7.2.1 and Table 7.2.2 summarize Canada's contributions to these institutions and programs. A brief description of some of the work supported by this assistance follows.

In addition to its ongoing development assistance, Canada provides new and additional funding to combat climate change through the GEF. Operating as the financial mechanism of the UNFCCC, the GEF provides financial resources for mitigation and adaptation activities in developing countries and Countries with Economies in Transition. It provides this assistance in accordance with guidance from the Conference of the Parties (CoP) on its policy priorities, and reports to each meeting of the CoP. Climate change projects funded by the GEF have focused on, among other things, reducing the costs of energy technologies with low greenhouse gas (GHG) emissions, removing barriers to energy conservation and energy efficiency, and promoting environmentally sustainable transport.

Through the Canada Climate Change Development Fund (CCCDF), Canada was also one of the first donors to support the operation of the Least Developed Countries (LDC) Fund under the UNFCCC, with a contribution of $10 million. This Fund provides funding to LDC for the preparation of their National Adaptation Programmes of Action (NAPAs).

In 2000, Canada contributed $14.53 million to the World Bank's Prototype Carbon Fund (PCF). The PCF is a partnership between seventeen companies and six governments. Its mission is to pioneer the market for project-based greenhouse gas emission reductions while promoting sustainable development. In doing so, the PCF offers a learning-by-doing opportunity to its stakeholders.

Within the United Nations (UN) system, the United Nations Development Programme (UNDP) has identified energy and environment as one of five priorities and has a critical role to play in helping developing countries integrate global environmental issues into their poverty reduction efforts. Canada is currently the eighth largest contributor to the UNDP, making an annual core contribution of $56.5 million through CIDA.

The UNEP is the environmental authority within the UN system. It is responsible for coordinating the development of environmental policy and law, keeping the global environment under review, and bringing emerging issues to the attention of governments and the international community for action. In 2005, Canada provided an annual core contribution of $2.5 million through CIDA and DFAIT.

Canada also supports several regional development banks whose goals include fostering economic growth, supporting human development, improving the status of women, and protecting the environment. These banks can directly and indirectly integrate climate change issues as co-benefits of projects with other development priorities.

Table 7.2.1: Financial Contributions to the Global Environment Facility (GEF)

	Contribution (millions of Canadian dollars)		
	1994-1998	**1998-2002**	**2002-2006**
	First Replenishment	**Second Replenishment**	**Third Replenishment**
Global Environment Facility	111.11	122.09	158.94

Table 7.2.2: Financial Contributions to Multilateral Institutions and Programs

Institution or Program	Contribution (millions of Canadian dollars)				
	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004
Multilateral Institutions					
1. International Monetary Fund [(a)]	349.41	365.73	262.02	430.94	147.74
2. World Bank					
– International Development Association [(b)]	0.00	79.47	14.84	11.67	0.00
– Specific Funds	14.54	1.53	0.00	2.50	0.75
3. African Development Bank [(c)]	42.81	40.00	54.00	72.00	67.23
4. Asian Development Bank					
– Core Funding [(c)]	43.06	43.06	97.38	48.69	0.00
– Specific Funds	0.00	5.00	0.00	0.00	0.00
5. European Bank for Reconstruction and Development [(d)]	7.46	13.52	15.66	21.21	16.67
6. Caribbean Development Bank [(c)]	4.07	0.00	9.67	18.29	9.02
7. Inter-American Development Bank [(c)]	2.00	0.00	0.00	0.00	0.00
8. United Nations Development Programme (Core Funding)	41.30	42.30	42.30	44.00	56.50
9. United Nations Environment Programme (Core Funding)	N/A	N/A	N/A	2.52	2.52
10. UNFCCC					
– Core Funding		0.46	0.24	0.25	0.46
– Voluntary Contributions	0.00	0.00	6.39	4.26	0.03
Multilateral Scientific, Technological, and Training Programs					
1. World Meteorological Organization	1.82	1.69	1.44	1.64	1.56
2. InterAmerican Institute for Global Change Research (USD)	0.05	0.11	0.17	0.12	0.12
3. IPCC (Swiss Francs)	0.09	0.27	0.00	0.70	0.14

(a) Amounts represent payments to the International Monetary Fund’s Poverty Reduction and Growth Facility (formally Enhanced Structural Adjustment Facility); amounts do not include contributions to various trust funds held by this organization.

(b) Amounts represent encashment of notes for the International Development Association and do not include contributions to various trust funds held by this organization.

(c) Amounts are issuances for concessional funds and represent Canada’s core contributions to these organisations.

(d) Amounts are encashment for capital subscription as recorded in Main Estimates.

Canada contributed financial assistance and scientific expertise to the IPCC. The IPCC assesses available scientific information and potential climate change impacts, formulates strategies to respond to climate change, and generates international consensus on the state of knowledge. Canada is involved in IPCC activities, including its Special Reports and scientific analyses. Canada hosted the 24th session of the IPCC (IPCC-24) in Montreal in September 2005. At IPCC-24, countries accepted a Special Report on Carbon Dioxide Capture and Storage and a Summary for Policymakers, which is the culmination of an exhaustive scientific review by experts worldwide on the state of carbon capture and storage technology as part of a suite of mitigation options. Input from

Canadian governments, the private sector and research institutions featured prominently in the final report. The IPCC is currently preparing its Fourth Assessment Report (AR4), to be completed in 2007. Some 28 Canadian experts from the federal government and Canadian universities have substantial roles in the AR4 as Coordinating Lead Authors, Lead Authors and Review Editors. Furthermore, Canada holds positions on both the IPCC Bureau (Working Group II) and on the Bureau of the Task Force on National Greenhouse Gas Inventories.

Canada also contributed financially to the Climate Technology Initiative (CTI). The CTI was launched in 1995 by 23 member countries of the Organisation for Economic Co-operation and Development (OECD), together with the IEA and the European Commission. The mission of the CTI is to promote the objectives of the UNFCCC by fostering international cooperation for accelerated development and diffusion of climate-friendly technologies and practices for all activities and GHGs.

Canada, through its Department of Natural Resources (NRCan), plays a role on the UNFCCC's Experts Group on Technology Transfer (EGTT). Since the group's formation in 2002, NRCan has provided a member to sit as an expert on the EGTT, also serving as the group's Chair for 2004. The EGTT identifies and analyses ways to facilitate and advance activities for the development of climate change technologies and their deployment in and diffusion to developing countries. It also advises the UNFCCC negotiations on the issue of the development and transfer of technology. Canada hosted a successful UNFCCC *Workshop on Innovative Options for Financing the Development and Transfer of Technologies* in Montreal (September 27-29, 2004) that brought together country representatives, private sector financing practitioners, non-governmental organizations (NGOs), and technology transfer experts from around the world. The workshop was the first forum within the UN climate change process to address the issue of financing the development and transfer of technology.

7.3 CAPACITY BUILDING AND TECHNOLOGY TRANSFER

In addition to supporting local capacity through direct assistance programs, Canada has been involved in promoting an effective multilateral response to global environmental problems. Recognizing the different capacities and responsibilities of nations to address issues like climate change, the GoC proposed to ensure that global environmental considerations more effectively integrate the development and poverty reduction priorities of developing countries.

7.3.1 International Assistance Programs

Table 7.3.1.1 provides a summary of Canada's bilateral and regional financial contributions related to the implementation of the UNFCCC. Annex 7.1 contains estimates of the proportionate value of the GoC's international projects (including projects under the CCCDF and regular CIDA programming related to climate change). These projects, in operation during the 2000/2001 to 2004/2005 period, addressed climate change in developing countries and countries with economies in transition.

While not exhaustive, the figures in these tables reflect some of the broader changes in development programming that have taken place since the last reporting period of the third national report. The donor community at large has become more cognizant of the need to incorporate climate change concerns into development programming.

The estimates in Table 7.3.1.1 encompass projects and initiatives that were either focused on climate change, had climate change as one of their objectives, or had climate change benefits. It is important to note that these figures represent an estimate of the climate change work being supported by Canada in developing countries. Due to the cross-cutting nature of this issue, it is difficult to categorically identify all the funds that may have direct and indirect benefits in combating climate change.

Table 7.3.1.1: Summary of Bilateral and Regional Financial Contributions Related to the Implementation of the Convention (thousands of Canadian dollars)[a]

		Mitigation [b,c]						Adaptation [c]		
Fiscal Year	Total	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
1997/1998	33,512	21,636	590	2,114	1,107	1,118	3,414	3,084	327	122
1998/1999	35,872	20,172	304	3,900	1,962	1,640	3,337	3,741	647	169
1999/2000	42,082	22,504	452	6,042	2,997	1,452	3,136	4,847	334	318
2000/2001	37,458	17,503	702	2,786	2,301	1,397	4,149	7,463	267	890
2001/2002	46,282	13,929	463	5,303	4,088	1,402	5,965	14,031	391	710
2002/2003	45,371	14,813	1,184	4,927	2,893	1,769	5,403	12,162	650	1,569
2003/2004	47,569	11,184	1,064	5,938	3,591	1,088	7,954	13,983	354	2,413
2004/2005	28,765	9,173	1,351	2,290	995	660	4,757	7,866	1	1,671

(a) Detailed contributions by country are provided in Annex 7.1 (Tables a to e), at the end of this chapter.

(b) Mitigation includes capacity building for mitigation.

(c) Project activities identified in the above sectors may relate to one or more sectors.

- **The Canada Climate Change Development Fund (CCCDF)**

The CCCDF was established in July 2000 by the GoC. The goal of the Fund has been to contribute to promoting activities in developing countries that address the causes and effects of climate change while at the same time contributing to sustainable development and poverty reduction.

The Fund was a five-year, $100-million initiative administered by CIDA. While CIDA is responsible for the management of the CCCDF, a Governance Board, comprised of Assistant Deputy Ministers from GoC Departments actively working against climate change, has provided CIDA with strategic advice to ensure cohesion between the CCCDF and the GoC's other climate change activities. The CCCDF was extended for a sixth year (through fiscal year 2005/2006) in order to continue its successful projects and to help support developing country participation and events on related issues at the climate change conference in Montreal in 2005.

At the end of the fifth year of the CCCDF, 34 major projects and 70 small projects had been implemented. In addition, a contribution to the UNFCCC's LDC Fund had been made, along with contributions to the following multilateral funds: the Canadian Cooperation Fund on Climate Change (CCFCC), established at the Asian Development Bank; the World Bank's Asia Alternative Energy Program (ASTAE); the World Bank's Multilateral Consultant Trust Fund, directed to the dedicated climate change component of the Fund; and the International Federation of the Red Cross and Red Crescent Societies, in 2004-2005, for work on disaster prevention preparedness and management (CCCDF Secretariat Report, 2004-2005).

- **CIDA's Sustainable Development Programming**

CIDA's regular programming supports sustainable development in developing countries in order to reduce poverty and contribute to a more secure, equitable and prosperous world. In doing so, action is being taken on climate change indirectly through projects in areas such as environmental management, energy efficiency, conservation, sustainable forestry practices, water resource management, and emissions reductions.What follows is a description of a few CIDA projects that demonstrate ways in which programming for poverty reduction and sustainable development can contribute to actions on climate change.

Landfill Gas Project in the Latin American and Caribbean (LAC) Region: In operation from March 2002 through to December 2005, this project supported the promotion of landfill gas recovery in Latin America through ESMAP (Energy Sector Management Assistance Program), a World Bank initiative. The rationale for the project is that a successful strategy for landfill gas recovery and utilization in the region depends on having good local capacity for urban waste management, along with effective national policy frameworks for non-conventional energy and environmental management. In the short term, there is a need to clarify the landfill gas recovery potential in the region and to begin building the capacity of countries in the region. The project helped to improve solid-waste management practices in the LAC Region, through dissemination of landfill gas-related information, and led to the completion of feasibility assessments and the implementation of pilot landfill gas recovery projects. Through CIDA, a contribution of $1.1 million was made to support this project.

The ARPEL Environmental Project Phase III: This Project was developed by the Environmental Services Association of Alberta (ESAA) and the Asociación Regional de Empresas de Petroleo y Gas Natural en Latinoamérica y el Caribe (the Regional Association of Oil and Natural Gas Companies in Latin America and the Caribbean or ARPEL) and supported by CIDA from 2000 to October 2005. The project involved strengthening the efficiency and capacity of ARPEL member companies (many of them state-owned) to develop and implement environmental protection technologies and more effectively address their social responsibilities in hydrocarbon producing areas, by increasing the dialogue among industry, government and local communities, and improving the accountability to the public for all industry activities. CIDA contributed $4.8 million to this project over its 4.5 year timeframe.

Canada-Ukraine Environment Cooperation Program: This project focused on building both government and civil capacity for climate change management in Ukraine. It assisted the government in developing legislation, a national action plan, and a management structure for compliance with the Kyoto Protocol, and assisted with the creation of a Ukrainian GHG inventory. The project also promoted and assisted in the development of public-awareness materials on environmental issues. CIDA contributed $1.4 million to the project, which ran for five years, from 1998 to 2003. The project was implemented by the Institute for Public Administration of Canada.

- **International Development Research Centre (IDRC)**

As noted in Canada's Third National Report on Climate Change, IDRC's contribution to addressing climate change issues is made largely through the Centre's programs in environment and natural-resources management. The Urban Poverty and Environment (UPE) team seeks to reduce vulnerability and implement policies to prevent the negative effects of natural hazards and climate change. One of the objectives of the Rural Poverty and Environment (RPE) team is to employ adaptive learning approaches for increasing local ecosystem quality and productivity in order to adapt to climate change, environmental degradation and water scarcity. RPE supports activities that strengthen ecosystem monitoring, identify effective learning strategies for adaptive ecosystem management, and evaluate environmental management and governance strategies. Some examples of recent climate change projects at IDRC follow.

Adaptive Policymaking for Agriculture and Water Resources: The project uses a vulnerability mapping approach to select pilot sites that include agriculture activity and that have experienced environmental change in the last two decades. At each pilot site, researchers work with communities and policymakers to understand how policies have allowed people to adapt to climatic conditions beyond those for which the policies were originally designed. Such research will help agriculture and water-resource policymakers in Canada's and India's governments to design policies that adapt to circumstances as they emerge over time and that are robust across a variety of possible futures, rather than optimized for a specific future. Ultimately, such policies help people to adapt to the uncertainty and surprise associated with the future impacts of climate change. In March 2005, IDRC provided $1.0 million to the International Institute for Sustainable Development (IISD) to support this four-year project involving The Energy and Resources Institute (TERI) of India.

Making the Clean Development Mechanism Work for Developing Countries: The Kyoto Protocol on Climate Change established the Clean Development Mechanism (CDM) as a process for identifying projects that reduce GHG in the atmosphere, such as investments in reforestation or conversion of a power plant from coal to natural gas. The CDM thus provides a means by which developed countries can achieve their reduction targets in part by promoting cleaner development options in developing countries. IDRC contributed $44,500 to the IISD over an eight-month period to convene and support an international task force that is exploring how to improve the CDM to better realize this potential and be more sensitive to the needs of countries that host such projects. The task force consists of representatives from North and South, including governments, development agencies, multilateral institutions, the business community, NGOs, and CDM brokerage firms.

Communities and the Impact of Climate Change Conference: In March 2004, IDRC helped sponsor a three-day international conference in Winnipeg, hosted by CUSO, which brought together 180 people from the South, Canada – including many from Arctic and First Nations communities – and other parts of the world to discuss the impacts of climate change in their communities and on their economy.

- **Other assistance**

NRCan, under the auspices of the Canadian Transportation Fuel Cell Alliance (CTFCA), contributed over $20,000 to co-sponsor a hydrogen policy study entitled *Prospects for Hydrogen and Fuel Cells*. The study was conducted by the IEA Hydrogen Coordinating Committee between January and December 2005.

NRCan provided annual support for the operation of the Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET), an international information source that helps managers, engineers, architects and researchers learn about renewable energy and energy-saving technologies that have worked in other countries. CADDET's objective was to enhance the exchange of information on new, cost-effective technologies that have been demonstrated in applications such as industry, buildings, transport, utilities and agriculture. From 1994 to 2004, NRCan contributed over $1 million to CADDET. Although CADDET concluded in March 2005, its database is still accessible at www.caddet.org/.

Canada participated in, supported and sponsored many international events, such as workshops, conferences, etc. For example, Canada participated in a high-profile Climate Technology Bazaar, organized by the Government of India on November 10 to 13, 2003. The Bazaar combined two events: (1) a business trade show of clean energy technologies at which companies from around the world could exhibit their products; and (2) a set of international government policy discussions on climate change impacts, adaptation and technology transfer. Canada represented the largest delegation of companies at the Bazaar, complete with a high-tech, interactive Canada Pavilion and a large business centre serving as a hub that facilitated matchmaking between Canadian and Indian companies.

7.3.2 Technology Early Action Measures (TEAM) Program

An initiative of the GoC, TEAM brings together private and public sector partners to identify, develop and support the most promising clean energy and GHG reducing technology solutions for Canada and abroad. The program serves as a catalyst for innovation, operating under the leadership of NRCan, Environment Canada and Industry Canada, with the participation of several other federal government departments.

TEAM's mission is to facilitate late-stage technology development and the demonstration of technologies that have significant potential to reduce GHG emissions nationally and internationally while sustaining economic and social development. TEAM also addresses projects that provide benefits related to clean energy, such as increased energy efficiency, reliability, and diversity and security of supply. TEAM funding is driving the application of Canadian research and development to provide clean-energy solutions that support the Canadian economy, create jobs, and offer new international development opportunities. A detailed description of TEAM programs can be found in the technology section of Chapter 4, Policies and Measures, of this report.

TEAM has provided a unique set of international projects that demonstrate the benefits of linking the business strategies and technology capabilities of Canadian companies with global business opportunities and Canada's international policy objectives to assist developing countries. TEAM international projects have complemented the federal government's international mandates by fostering partnerships with Canadian companies and transferring their technology to private and public sector partners in a growing number of developing countries. This has served to demonstrate, on the international scene, that GHG reduction and economic development can be done together.

TEAM, in partnership with Canadian and foreign government programs, has supported 17 international projects in 15 countries, with contributions of $16.4 million since its inception in 1998. Some examples of international TEAM projects follow.

Natural Gas Vehicle Flagship Project in India: Led by Advanced Technology & Fuels Canada (ATFCan), a consortium of Canadian technology companies in the natural-gas vehicle (NGV) and infrastructure industry are undertaking an integrated approach to demonstrate Canadian NGV technologies designed for the Indian market. As announced in November 2005, TEAM will contribute $3.6 million to this project, which is scheduled to end in 2008. The project in Delhi and Mumbai, India, includes the introduction of low emission natural gas engines for the bus market, use of lightweight compressed natural gas (CNG) cylinders, conversion kits for light duty fleet vehicles and demonstration of an advanced, high-volume, fast-fill fuelling station. Potential benefits to India include addressing urban air quality and GHG reductions, job creation, and skills transfer as part of a comprehensive long-term sustainability strategy.

Multiple Benefits from Landfill Gas: A demonstration-scale landfill gas (LFG) utilization system designed in Ontario by Conestoga-Rovers & Associates is in operation at the Canabrava landfill site in Salvador, Brazil. This is the first LFG system in operation in South America. TEAM contributed $0.8 million to this project from October 2001 to February 2002. The system is providing electricity to the local grid and the approach has gained wide public attention in Brazil. The project consortium was honoured with an award in the "Partnership" category at the Ontario Global Traders Forum.

Automation of Photovoltaic Manufacturing in China: Joint Canada-China venture, Canadian Solar Inc.: ATS Automation Tooling Systems developed and successfully implemented a semi-automated equipment line for the manufacture of photovoltaic (PV) panels in China. Implementation was done through the formation of Canadian Solar Inc. (CSI), a joint Canada-China venture, with ATS in Changshu, Jiangsu Province. Funding of $3.3 million from TEAM, between November 1999 and March 2002, was crucial to the success of this project. The benefits accrued to China include automated manufacturing technologies, GHG reductions, skills transfer and local job creation. CSI solar module products now produce 10MW annually for its customers in China and around the world.

7.3.3 Clean Development Mechanism and Joint Implementation (CDM and JI) Office

Canada's CDM and JI Office, housed within DFAIT, was established in 1998 and has played a role in facilitating the participation of Canadian entities in these mechanisms.[79]

The activities of Canada's CDM & JI Office cover four key areas: (1) Canadian approval of participation in CDM and JI projects; (2) project development and facilitation; (3) domestic and international outreach; and (4) policy input to the development of CDM and JI positions for negotiations. More specifically, its activities included:

[79] Clean Development Mechanism (CDM) is a project-based mechanism that allows public and private entities from Annex 1 countries to invest in GHG mitigating activities in developing countries and earn abatement credits towards achieving compliance with their quantified emission limitation and reduction commitments. In addition to reducing emissions, CDM projects have the dual objective of contributing to the sustainable development of the host country, not included in Annex 1.

A CDM program of activities is one in which emissions reductions are achieved by multiple activities executed over time as a result of a government measure or private sector initiative.

Joint Implementation (JI) is a mechanism that allows Annex I countries to participate in emission reduction projects with other Annex I countries leading to the generation, transfer or acquisition of emission reduction units.

- Acting as Canada's Designated National Authority for the CDM and focal point for Joint Implementation
- Providing financial and technical assistance to Canadian companies in order to facilitate their participation in CDM and JI projects, and supporting the development of portfolios of CDM and JI projects, including methodologies and Project Design Documents
- Working with Trade Commissioners in Canada's missions abroad in order to identify and facilitate Canadian participation in the CDM and JI. This included market studies to identify project opportunities.
- Supporting capacity-building overseas, particularly for other Designated National Authorities or focal points in order to increase their ability to host and evaluate projects. Most capacity-building efforts have been made via bilateral initiatives and multilateral funds.
- Participating in the World Bank's Prototype Carbon Fund, Community Development Carbon Fund and BioCarbon Fund
- Raising awareness about the CDM and JI within Canada and internationally through workshops, Office website, advertising campaigns, trade shows and conferences such as Globe, Americana and Carbon Expo, and environmental trade missions

Canada's CDM and JI Office received $28.7 million in funding for the 2001 to 2006 period. To date, the Office has facilitated the development of more than 50 CDM and JI projects involving Canadian entities. These projects are in various stages of the development and approval process. Market studies have been completed for Argentina, Brazil, Bulgaria, the Caribbean, Central America, Chile, China, Costa Rica, El Salvador, Guatemala, Honduras, India, Kazakhstan, Malaysia and South Africa, while CDM project portfolios have been produced or are under development in Chile, Russia, India, China, Latin America, Indonesia, Nigeria, Mexico and South Africa.

The Office has worked to strengthen opportunities for Canadian entities to participate in CDM and JI projects by concluding bilateral arrangements such as Memoranda of Understanding (MOUs) and Letters of Intent (LOIs) with CDM and JI host countries. As of January 2006, Canada has signed 28 such MOUs and LOIs.

7.3.4 Canadian International Technology Initiative (CITI)

The CITI addresses the needs of Canadian enterprises wanting to capture part of the growing international market for climate change technologies. The primary objectives are to identify and develop climate change technology transfer projects overseas, facilitate the expansion of market opportunities for such technologies for Canadian companies, and provide a sound analytical base for international technology marketing activities. The secondary objective is to support and build effective partnerships with the CDM and JI instruments. The GoC invested $9.75 million over five years, from 2001/02 to 2005/06, in this initiative. The CITI consists of the following two components.

- **Technology Transfer and Promotion**

This first component, comprising 80% of the initiative, features four strategies that enhance ongoing activities and capitalize on past endeavours. This program component aims for short- to medium-term impacts by identifying projects that promote climate change technology transfer and secure potential emissions credits. These four strategies are:

Canadian Initiative for International Technology Transfer (CIITT): This initiative is designed to facilitate trade and to support the identification and development of Canadian climate change technology projects for demonstration in developing countries. Assisting Canadian businesses, NGOs, learning institutions and other government departments, CIITT aspires to catalyze Canada's technology prospects by offering financial assistance to viability studies, proposal development, knowledge sharing and relationship management. The program focus is on the commercial and capacity building aspects of projects. All of the approximately $2.0 million that has been made available in program funding until March 31, 2006, has been committed. So far, 22 projects have been funded in 17 countries.

Climate Change Technology Promotion Officers (CCTPO): Canada's CCTPOs are strategically posted at three locations abroad to promote Canadian climate change technology to developing countries and economies in transition. One officer is located at Canada's High Commission in New Delhi, India, and two others are working at Canadian embassies in Mexico City, Mexico, and Warsaw, Poland. The role of the CCTPOs is to build effective partnerships within their respective regions and provide matchmaking opportunities for Canadian companies to market their climate-friendly technologies, products and services in countries that can benefit strongly from them. Nearly $3.0 million has been allocated since November 2002 to fund the positions. CCTPOs support the efforts of Canada's CDM and JI Office and offer a broad range of services, such as workshops, cross-Canada outreach, market and technology seminars, the coordination of missions coming to or leaving Canada, information on market prospects, key contacts, local companies, face-to-face briefings and troubleshooting.

In January 2003, NRCan and Industry Canada joined forces to establish Canada's Clean Energy Portal as an internationally renowned site for clean energy technology information exchange. The portal is a compendium of information on over 600 Canadian clean energy technology companies and their capabilities. It provides contacts to Canada's clean energy firms, financing resources, information related to Canadian climate change mitigation expertise, and up-to-date details on international climate change initiatives and events.

Technology Showcasing: Industry Canada's popular Canadian Climate Change Solutions (CCCS) compact disc and website showcase new technologies. This comprehensive database profiles export-ready Canadian climate change technologies for domestic and international audiences. The enhanced CCCS features additional technology exporters, updates, including technical edits, and marketing and outreach potential for CDM and JI partners.

Workshops and Missions: Dedicated to climate change issues, industries and technologies, CITI workshops and missions serve as forums to foster effective partnerships between Canadian businesses and foreign markets by facilitating networking and disseminating information. Through *Trade Team Canada Environment (TTCE)*, CITI has held 15 outgoing missions in 9 countries, such as India, China, Mexico, Brazil, and Poland, 14 in-coming missions, 47 workshops, 30 briefing sessions, and 47 networking events. Past workshops and missions have enabled the dissemination of market intelligence, promoted business opportunities and allowed for contacts and partnerships to become established.

- **Analytical Support**

The second CITI component helps refine marketing strategies to take into account changing market conditions. It comprises 20% of the overall initiative and involves the following two activities:

Market Analysis: Examines the mid- and long-term technology needs of international markets. The analysis will provide the government with tools to respond to future needs of Canadian investors and help guide domestic research and development (R&D) programs so that investments have international commercial potential.

Statistical Monitoring of Climate Change Technologies: Complements the market analysis to help determine the availability of climate change technology solutions, to evaluate current exports by industry, region and destination, to identify climate change technology export barriers, and to record R&D expenditures on climate change technologies. This initiative offers access to valuable information such as obstacles to adoption of GHG emission systems and factors that drive the implementation of new, GHG emission reduction equipment. This information has allowed Canadian companies to better focus their marketing activities.

7.3.5 CANMET Energy Technology Centre (CETC)

CETC is Canada's leading federal government science and technology (S&T) organization with a mandate to develop and demonstrate energy efficient, alternative and renewable energy technologies and processes. CETC has facilities in Devon, Alberta; Varennes, Quebec; and Ottawa, Ontario. CETC is involved in technologies related to buildings, community and industry energy efficiency, renewable energy, alternative transportation fuels, and advanced combustion. NRCan has been working closely with developing countries to undertake joint research and pave the way for successful technology transfer by Canadian companies. It has also been instrumental in helping Canadian companies transfer clean energy technologies and establish joint ventures in developing countries.

NRCan's role in technology transfer has included business development and the establishment of linkages with key government officials, matching Canadian companies with foreign partners, signing government-to-government MOUs to help establish frameworks for collaboration, R&D funding to adapt technology to developing-country markets, and funding provisions for demonstration projects. These activities have facilitated the transfer of Canadian technologies to India (wind and small-hydro power projects), China (reduction of CO_2 emissions from coal-fired utility boilers, solar), Romania (natural gas vehicles), Poland (low-head hydro), and Nepal (small hydro).

7.3.6 Trade Team Canada Environment (TTCE)

TTCE is a public-private partnership aimed at increasing Canada's export of environmental products and services, ensuring that our industry is recognized as a major global player. It works to identify and implement trade promotion activities accessible to the environment industry as a whole. As part of this ongoing commitment, TTCE collaborates with private sector associations and companies, government sector experts, as well as Trade Commissioners, both in local markets and at DFAIT headquarters.

Within Canada, TTCE organizes many activities at domestic tradeshows and conferences. Interested parties who are drawn to these events benefit from the many information sessions, workshops and networking opportunities organized on their behalf.

One of TTCE's main activities throughout the year is to organize outgoing missions focused on priority markets external to Canada. A key component of these missions is the development of programs, often covering many different cities or regions within a target country. Mission events are based on priorities established through consultation with stakeholders and are focused primarily in places where government assistance would facilitate greater market access.

Typical program elements and services provided in both domestic activities and business development missions abroad include:

- market intelligence, onsite briefings and tailored business programs;
- technical seminars and showcasing opportunities;
- networking opportunities with foreign buyers and decision makers; and,
- site visits, both abroad and for incoming delegations.

As a result of a series of consultations in the early part of 2004, TTCE is currently focused on the emerging markets of China and India. Some examples of TTCE trade missions follow.

Trade Team Canada Environment Urban Sustainability Mission to China: For the third consecutive year, TTCE, in partnership with the Canadian Trade Commissioner Services in China, provincial governments and industry associations, led the environmental trade mission to China from February 27 to March 10, 2006. China's unprecedented urbanization is generating tremendous environmental concerns that create significant business opportunities for those that can bring innovative solutions targeting urban sustainability. The mission focused on climate change technologies, air pollution control and waste management (including hazardous waste, industrial waste control, wastewater and agriculture waste).

Business Development Mission to India: TTCE partnered with the Canada-India Business Council (C-IBC) to deliver the environment and energy tracks of the C-IBC 2005 Business Mission to India from December 9 to 16. There is a tremendous need for environmental solutions in India and, accordingly, TTCE's component of the C-IBC mission focused on technologies and services related to climate change, alternative energy, energy efficiency, wastewater and water treatment, waste management, green buildings, and air pollution control.

7.3.7 Strategis Web Site

Strategis, an Internet-based technology solutions provider (http://strategis.ic.gc.ca), was launched in 1996 by Industry Canada to make information on a wide range of Canadian technologies easily accessible.[80] Canadian companies, including those in the environment, transportation, petroleum and oil and gas industries, are listed in this large database, which facilitates the transfer of Canadian technologies to developing countries and countries with economies in transition. *Strategis* contains more than 2 million electronic documents and over 50,000 links to related business sites; at least 7,000 outside Internet sites feature a link to *Strategis*.

Canadian Environmental Solutions (CES) is an on-line directory of export-oriented Canadian environmental firms available on *Strategis*. With its compendium of Canadian-developed solutions to global environmental problems, this comprehensive on-line database promotes Canadian technologies and services that can provide solutions to climate change problems worldwide. The CES (www.strategis.gc.ca/ces) directory currently hosts the profiles of around 2,200 Canadian environmental businesses that provide solutions for around 2,000 environmental problems listed on the website. On average, more than 2,000 visitors, of which over half are foreign, access the CES website each month.

7.3.8 Sustainable Cities Initiative (SCI)

As an innovative partnership among the GoC, NGOs and the private sector to pursue sustainable economic development, the SCI focuses on sustainable urban development, in particular on: clean water, waste management, clean energy, transportation, housing, capacity-building, urban planning, telecommunications, urban infrastructure projects, and port development. Although this initiative is not targeted at climate change, it does have a direct and indirect impact on climate change.

By partnering with cities in developing and emerging economies, the SCI helps cities meet their quality of life and sustainable development objectives. Multi-sectoral and multi-stakeholder City Teams (Canadian private sector, government and NGOs) combine efforts and resources with local authorities to develop and implement sustainable development plans for cities.

7.3.9 International Partnerships and Agreements

Canada has developed partnerships and signed agreements with several countries on issues relevant to climate change. Examples of arrangements that promote information exchange, bilateral cooperation and technology transfer are noted below.

In June 1986, Meteorological Service of Canada (MSC) signed an MOU on Cooperative Meteorological Matters with the China Meteorological Administration. In October 2001, a renewed relationship was launched through a new MOU on Science and Technology, which focuses on cooperation in Meteorology, Hydrology, Environmental Predictions and Climate Change. A Joint Working Group (JWG) meets every second year to review progress and agree on a work plan for the following biennium. The latest meeting of the JWG was held in the spring of 2006.

Environment Canada and Hong Kong's Environmental Protection Department (HKEPD) signed an MOU on Environmental Cooperation in September 1992. This MOU was renewed in 1998 and again in 2003. The EC - Hong Kong MOU represents an important mechanism for engaging Hong Kong, China, bilaterally on a broad range of regional and global environmental issues. The primary goals of the MOU are addressing transboundary pollution, transferring Canadian environmental expertise, sharing of policy frameworks, best practices and marketing Canadian technology. To date, activities under the MOU have focused on the management of toxic chemicals and hazardous waste; climate change; ozone depletion, migratory species and wetlands protection, freshwater ecosystems, the importance of sustainability and greening in government operations, the demonstration and transfer of Canadian environmental technology and expertise, education and capacity building, and the adoption of an environmental impact assessment processes.

An MOU on Environmental Cooperation between Environment Canada and the State Environmental Protection Agency (SEPA), first signed in 1993, was renewed in September

[80] In addition, the following sites describe Industry Canada's work on renewable energy and the hydrogen economy, respectively: http://strategis.gc.ca/rei, http://strategis.gc.ca/hydrogen .

2003. The MOU provides a framework for cooperation on regional and global environmental issues with a focus on transboundary air and toxic substance control, water resource management, smart growth and sustainable development, environmental management policies and regulations, ecosystem and biodiversity protection, as well as transfer of clean technologies. Through annual work plans, the MOU is implemented through workshops, missions, exchange of information, hosting Chinese officials and study tours.

The Canada-China Framework Statement, which was signed in November 1998, reflects a shared interest in enhancing cooperation on environmental and sustainable development issues. It provides an umbrella for collaboration on the environment, especially climate change and sustainable development, through the coordination of all federal efforts with China on environmental and sustainable development issues. The Framework Statement created the Canada-China Joint Committee on Environment Cooperation (JCEC) with Environment Canada and the Chinese SEPA as the lead agencies. The JCEC held its inaugural meeting on March 20 and 21, 2000. The fourth and most recent meeting took place in Montreal in April 2005 and focused on air pollution, environmental legislation and sustainable urbanisation.

The GoC and the Government of Mexico signed an MOU on Energy Efficiency and Alternative Energy (EAE) in 1996. Its objective is to contribute to the EAE objectives of Canada and Mexico by improving the design and delivery of EAE programs and enhancing trade, investment and exchanges (technical and other) related to energy efficiency products, energy management services, and alternative energy goods and services. Under the MOU on EAE, Canada sponsored Dollars to $ense workshops in Mexico City in 2002, northern Mexico in 2005, and Puebla in 2006. These training sessions feature discussions and demonstrations that show how to recognize low-cost and no-cost energy savings opportunities in commercial, industrial, institutional and governmental facilities. Participants in the sessions were also instructed on the fundamentals of developing and implementing comprehensive energy management plans.

The Canada - Costa Rica Agreement on Environmental Cooperation (CCRAEC) was signed on April 23, 2001, and entered into force on November 1, 2002. The CCRAEC creates a framework to better conserve, protect and enhance the environment of the two countries through cooperation and effective enforcement of environmental laws.

Canada and the United States announced an agreement to expand and intensify their existing bilateral efforts to address climate change on March 7, 2002. This agreement led to the creation of a Canada-U.S. Climate Change Working Group, which has met annually to pursue increased cooperation on such issues as: science and research; technology development; carbon sequestration; emissions measurement and accounting; capacity building in developing countries; carbon sinks; targeted measures to spur the uptake of cleaner technology; and market-based approaches. Examples of opportunities for cooperation included, but were not limited to, clean coal technology and carbon dioxide capture and storage technology development, and expanded use of cogeneration and renewable sources of energy.

Canada and Costa Rica signed an MOU on climate change initiatives, including CDM projects, on December 3, 2002. It states the intention of both countries to work together on climate change, with a focus on facilitating CDM projects to reduce GHG emissions.

A Joint Statement between the GoC and the Government of the People's Republic of China, on climate change cooperation, was signed on October 22, 2003. The Statement confirms both countries' mutual interest to enhance cooperation in climate change in areas such as policy dialogue, CDM, clean technology, public awareness, energy efficiency and renewable energy, capacity building, climate science, impacts and adaptation, and other climate change issues as mutually acceptable. As a follow up to the Joint Statement, the Canada-China Climate Change Working Group (CCWG) was formed in March 2004 to co-ordinate and advance the bilateral effort to respond to climate change. The most recent CCWG meeting, held in July 2005, included a review of activities from the previous year, a discussion on respective national climate change plans and strategies and the drafting of a work plan for the new program year.

An MOU was signed between Canada's DFAIT and the National Development and Reform Commission of the People's Republic of China on CDM projects. The MOU, signed on January 20, 2005, states the intention for both countries to work together on CDM projects to reduce GHG emissions, to promote and facilitate the CDM, and to encourage sustainable development and GHG mitigation.

On December 7, 2005, the GoC signed an MOU with the Republic of Korea that will see both countries work together in support of new CDM projects. The Republic of Korea offers Canadian industry a wide array of opportunities to engage with local business leaders in developing climate-friendly technologies that will help improve local air quality while earning Certified Emission Reduction (CER) credits through the CDM. It is anticipated that economic and environmental cooperation between the two countries will increase as opportunities for CDM projects are identified.

Canada and Mexico signed a Joint Statement to *Strengthen Dialogue and Cooperation on Climate Change* on December 8, 2005. The two governments committed to addressing climate change in the areas of CDM, adaptation, technology development and deployment opportunities, as well as raising public awareness about the impacts of climate change and opportunities for GHG emissions reductions. To achieve these objectives, the Joint Statement calls for the formation of a Working Group on Climate Change that will be co-chaired by officials from the Ministry of Environment and Natural Resources from Mexico (SEMARNAT), and Environment Canada and DFAIT. Canada and Mexico have agreed to complete the first work plan of the Working Group in the coming year. In addition, Mexican officials have recently appointed a representative from SEMARNAT to work in Canada, which provides an opportunity for Canada to work more cooperatively with Mexico on a number of environmental issues, including climate change. Canada and Mexico also signed a LOI on Climate Change Initiatives, including CDM projects, on October 25, 2004. It states the intention for both countries to work together on climate change, with a focus on facilitating CDM projects to reduce GHG emissions.

The following international partnerships focus on advancing the active use of clean energy technologies in both developing and developed countries:

In 2005, Canada became a member of the *Methane to Markets*, a partnership focused on minimizing methane emissions from key sources, with particular focus on implementing projects in developing countries and economies in transition. This partnership, which does not include a funding mechanism, is currently focused on identifying key sources of methane emissions within partner countries, sharing experience in reducing emissions, and identifying opportunities for capturing and utilizing methane emissions.

The Renewable Energy and Energy Efficiency Partnership (REEEP) is a public-private partnership dedicated to accelerating the development of renewable energy and energy efficient systems. REEEP pursues this aim through the support of developing country projects that create new sources of finance or promote regulatory structures that encourage the integration of clean and efficient energy. Canada became a member of REEEP in 2005-2006, with a $100,000 contribution, which supported the development of a number of information sharing mechanisms as well as a guidance document on financing renewable energy and energy efficient projects through the voluntary carbon offset system.

The following federal programs support and facilitate international negotiations, partnerships and agreements:

International Policy and Related Activities Program: DFAIT works closely with Environment Canada, NRCan and CIDA in delivering this program that promotes and implements international agreements and partnerships to address climate change. It manages Canada's relationship with key international and regional organizations, and key bilateral partners. It also works to strengthen the government's analytical, policy and negotiating capacity as well as building strong policy and technical foundations. In particular, the program contributed to the strengthening of international partnerships with the U.S., China and India, and advanced collaboration with La Francophonie (a culturally and linguistically-based institutional community of 56 states and governments on five continents.)

Strategic Climate Change Partnerships Program: The program, co-led by Environment Canada and NRCan, encompasses climate change cooperation agreements with other countries. It also advances Canada's interests to help increase other countries' actions against climate change and lever technology opportunities.

Negotiating and Implementing International Climate Change Agreements Program: This program responds to Canada's technology transfer and development responsibilities under the UNFCCC, advances developing countries' understanding of the importance of the private sector, and enables environments in host countries through the support and hosting of numerous UN and Climate Technology Initiative Workshops. The program is co-led by Environment Canada and NRCan, with respect to international negotiation positions on mitigation as well as policies and measures, and with DFAIT on adaptation issues.

Use, Development, Deployment and Transfer of Technology Program: NRCan is the federal lead on this program, which enhances promotion and deployment of existing, new and emerging Canadian clean energy as well as climate change technologies. It also contributes to the greater engagement of developed and developing countries in the development of technological solutions to climate change.

7.4 SUMMARY AND CONCLUSION

The future of both developed and developing countries is increasingly being shaped by global trends and issues. Due to their less robust national capacity and resiliency to broad environmental challenges, developing countries remain generally more vulnerable to the negative impacts of climate change. To be effective, Canada's climate change activities and programs aimed at developing countries must focus on promoting sustainable development by addressing environmental, economic, political and social issues in an integrated manner, as well as taking cultural realities into account.

In fulfillment of its obligations under Article 4 of the UNFCCC, Canada has contributed substantial financial resources and assistance towards capacity building and the transfer of climate-friendly technologies to a wide range of developing countries.

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ANNEX 7.1: BILATERAL AND REGIONAL FINANCIAL CONTRIBUTIONS RELATED TO THE IMPLEMENTATION OF THE CONVENTION

Table A: Contributions for Reference Year 2000/2001 (thousands of Canadian dollars) [(a)]

	Mitigation [(b, c)]						Adaptation [(c)]		
Recipient Country/ Region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste Management**	**Industry**	**Capacity Building**	**Coastal Zone Management**	**Other**
Argentina	0		0	0			7		
Bangladesh	62			589		16	1,469	0	
Bolivia	27			68		23			
Brazil	368	0	151	0	368	602	509	0	0
Burkina Faso			107	138			60		
Cameroon			251				501		
Chile									0
China	2,494	54			552	1,423	328		91
Colombia	244	163							
Cote d'Ivoire				7					
Cuba							38		
Dominican Republic			0	0			0		
Ecuador	45						45		
Egypt	471				162	377	558		
El Salvador							125		
Ethiopia							31		
Ghana			8	383					
Guatemala			0	9			0		
Guinea	2,221								
Haiti	496			7			7		
Honduras	36		282				134		
India	1,661	63	73	115		282	171		
Indonesia	89				89	89	119		
Jamaica						49	146	0	
Kazakhstan	49					14	6		
Latvia					16				
Mali	89		88	29			89		
Mexico			0					0	0
Nepal	7		22					15	
Nigeria	104								
Pakistan	1,162		175			350	11		
Peru	525			65	175	350			
Philippines				171			0	0	
Poland	0	0	0	0	0	0	0	0	0
Russia	136	5	241	5	5	128	5	5	5
Senegal			63				31		
Sri Lanka									0
Thailand			0	0			0		
Tonga								0	
Tunisia	10					10			
Ukraine							380		
Vietnam							32		
Zambia							293		
Zimbabwe	297		7	7		297	14		

Table A – Continued	Mitigation (b, c)						Adaptation (c)		
Recipient Country/ Region	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Africa				120			152		
Americas	2,723	400		130			1,058		200
Asia			777	132		125	337		125
Multi-regional	4,182	15	524	315	27	14	794	231	465
TOTAL [d]	**17,503**	**702**	**2,786**	**2,301**	**1,397**	**4,149**	**7,463**	**267**	**890**

(a) Values shown as "0" represent contributions less than $5,000.00.

(b) Mitigation includes capacity building for mitigation.

(c) Project activities identified under each heading may relate to one or more sectors.

(d) Column totals may not add up due to rounding.

Table B: Contributions for Reference Year 2001/2002 (thousands of Canadian dollars) [a]

	Mitigation (b, c)						Adaptation (c)		
Recipient Country/ Region	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Argentina	0		25	0	450	20	26		
Bangladesh	45			451		15	1,651		
Bolivia	23			22		23			
Brazil	191		55		191	667	236		0
Burkina Faso			76	183			54		
Cameroon			215	59			427		
Chile									0
China	1,858	187	30		387	869	299		629
Colombia	228	152							
Cote d'Ivoire		0		77					
Cuba			0				61		
Dominican Republic			0	0			0		
East Timor			210						
Ecuador	25						25		
Egypt	1,134				259	615	627		
El Salvador							250		
Ethiopia							16		8
Ghana			6	91					
Guatemala			0	0			0		
Guinea	311								
Haiti	296		13	27			14		
Honduras	46		135				188		
India	1,396	62	53	43		582	194		
Indonesia	53		1,276			53	72		
Jamaica						56	169		
Kazakhstan	44					0	10		
Latvia					22				
Malawi				114			757		
Mali			83	28					

Table B – Continued	Mitigation (b, c)						Adaptation (c)		
Recipient Country/ Region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste Management**	**Industry**	**Capacity Building**	**Coastal Zone Management**	**Other**
Mexico			22						0
Mozambique				55			37		
Nepal	5		15					10	
Nicaragua	0					0			
Nigeria	294		8	8					
Pakistan	542		110			2,199	11		
Paraguay			159						
Peru	238			21	79	159			0
Philippines				147					
Poland	0	0	0	0	0	0	0	0	0
Russia	91	13	253	13	13	81	40	13	47
Senegal			63				32		
Sri Lanka									0
Tanzania				105			47		
Thailand		21	4	4			2		
Tunisia	2					2			
Ukraine							467		
Vietnam				12			147		
Zambia				67			249		
Zimbabwe	281		26	116		281	111		6
Africa			1,400	1,507		250	3,203		
Americas	2,080	28		41			2,192		
Asia	48		569	131		8	245		15
Multi-regional	4,697		496	765		83	2,170	368	0
TOTAL (d)	**13,929**	**463**	**5,303**	**4,088**	**1,402**	**5,965**	**14,031**	**391**	**710**

(a) Values shown as "0" represent contributions less than $5,000.00.

(b) Mitigation includes capacity building for mitigation.

(c) Project activities identified under each heading may relate to one or more sectors.

(d) Column totals may not add up due to rounding.

Table C: Contributions for Reference Year 2002/2003 (thousands of Canadian dollars) [(a)]

Recipient Country/ Region	Mitigation [(b, c)]						Adaptation [(c)]		
	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Argentina			14		840	712	14		
Bangladesh	94		14	14		10	2,032		
Bolivia	0		42	55			46		
Brazil	140		59	0	140	640	252	0	
Burkina Faso			47	241			103		
Cameroon			21				13		
Chile		309							
China	2,363		815		300	573	35		1,410
Colombia	240	160	0	0				0	
Cote d'Ivoire			59	154					
Cuba							98		
Dominican Republic			6	6					
East Timor			490						
Egypt	829				387	350	448		
El Salvador				10			257		
Ethiopia			18	18			130		56
Ghana			8	236			16		
Guinea	77								
Haiti	151		36	61			30		
Honduras	251		251				313	50	50
India	770	19	83	305		425	93	0	
Indonesia	26		1,615			26	26		
Jamaica						65	185		
Jordan			6	6			6		
Latvia					8				
Malawi				118			79		
Malaysia			0	0				0	
Mali			44	15					
Mexico			16						
Mozambique				57			38		
Nepal			0	0				0	
Nigeria	779		0	0					
Pakistan	351		78			1,550			
Paraguay			162						
Peru	262		11	24	87	175	61		
Philippines			0	56				0	
Russia	38	6	162	6	6	34	6	6	6
Rwanda				30					
Senegal			78				39		
Sri Lanka			0	0				0	
Tanzania				118			49		
Thailand		242	0	0			0		
Tunisia	49								
Ukraine							164		
Vietnam				15			382		
Zambia			6	75			140		
Zimbabwe	111		21	115		111	100		

Table C – Continued	Mitigation (b, c)						Adaptation (c)		
Recipient Country/ Region	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Africa				194		518	1,259		
Americas	2,488	448	0	25			4,240		0
Asia	1,264		581	147		45	320		45
Multi-regional	4,528		177	786		169	1,189	592	
TOTAL (d)	**14,813**	**1,184**	**4,927**	**2,893**	**1,769**	**5,403**	**12,162**	**650**	**1,569**

(a) Values shown as "0" represent contributions less than $5,000.00.

(b) Mitigation includes capacity building for mitigation.

(c) Project activities identified under each heading may relate to one or more sectors.

(d) Column totals may not add up due to rounding.

Table D: Contributions for Reference Year 2003/2004 (thousands of Canadian dollars) (a)

	Mitigation (b, c)						Adaptation (c)		
Recipient Country/ Region	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Argentina					416	631			
Bangladesh	72		18	18		15	2,140		
Bolivia	156		54	54			54		
Brazil	118				118	734	104		
Burkina Faso			0	59			30		
Cameroon			159	0			125		
Canada				23			23		
Chile		317							
China	2,884	231	504		320	551	9		2,048
Cote d'Ivoire				9					
Cuba			47				71		
Dominican Republic			7	7					
East Timor			158						
Egypt	1,343				232	512	440		
El Salvador				0			130		
Ethiopia			23	23			23		
Ghana				197			33		
Guatemala			0	5			0		
Guinea	762								
Haiti	8		33	54			26		
Honduras	250		750			1,200	465	150	50
India	591	0	25	157		1,236	171		
Indonesia	0		2,192			0	7		
Jamaica						57	171		
Malawi				114			76		
Mali	5		18	6			5		
Mexico			10						

Table D – Continued	Mitigation (b, c)						Adaptation (c)		
Recipient Country/ Region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste Management**	**Industry**	**Capacity Building**	**Coastal Zone Management**	**Other**
Mozambique			13	68			49		
Nigeria	221								
Pakistan	368		88			1,752	12		
Paraguay			36						
Peru			14	15			143		
Philippines				0					
Russia	9	0	150	0	0	8	0	0	0
Rwanda				20					
Senegal			84				42		
Tanzania				96			47		
Thailand		200							
Tunisia	149								
Vietnam				40			391		
Zambia			7	98			109		
Zimbabwe	10		79	197		10	169		
Africa			920	979		968	3,530		
Americas	1,698	312	5				3,240		10
Asia	1,123		462	75		200	386		236
Multi-regional	1,415		80	1,272		80	1,758	203	68
TOTAL (d)	**11,184**	**1,064**	**5,938**	**3,591**	**1,088**	**7,954**	**13,983**	**354**	**2,413**

(a) Values shown as “0” represent contributions less than $5,000.00.

(b) Mitigation includes capacity building for mitigation.

(c) Project activities identified under each heading may relate to one or more sectors.

(d) Column totals may not add up due to rounding.

Table E: Contributions for Reference Year 2004/2005 (thousands of Canadian dollars) [a]

Recipient Country/ Region	Mitigation (b, c)						Adaptation (c)		
	Energy	Transport	Forestry	Agriculture	Waste Management	Industry	Capacity Building	Coastal Zone Management	Other
Argentina					209	126			
Bangladesh	22			0		7	1,701		
Bolivia	234								
Brazil	38				38	785	26		
Burkina Faso				0			103		
Cameroon			22				20		
Chile		374							
China	2,699	244	399		299	412			
Cuba			53				40		
East Timor			109						
Egypt	2,414				114	201	328		
El Salvador							7		
Ghana				126			12		
Guinea	0								
Haiti			14	25			11		
Honduras	48					300	162		10
India	646					1,993	174		
Indonesia			979			6	21		
Mali	26		54	18			26		
Nigeria	132								
Pakistan	265		66			132			
Paraguay			18						
Peru							228		
Russia	0	0	142	0	0	0	0	0	0
Senegal			95				48		
Thailand		408							
Tunisia	164								
Vietnam							225		
Zimbabwe	18		28	28		18	28		
Africa			0	0		775	1,158		
Americas	795	324	0				543		1,602
Asia	1,667		129	23			768		59
Multi-regional			180	769			2,236		
TOTAL [d]	**9,173**	**1,351**	**2,290**	**995**	**660**	**4,757**	**7,866**	**0**	**1,671**

(a) Values shown as “0” represent contributions less than $5,000.00.

(b) Mitigation includes capacity building for mitigation.

(c) Project activities identified under each heading may relate to one or more sectors.

(d) Column totals may not add up due to rounding.

CHAPTER 8 RESEARCH AND SYSTEMATIC OBSERVATION

8.1 INTRODUCTION

The purpose of researching and monitoring climate change is to improve our understanding of the climate system and how natural and human systems interact with it. With this knowledge, Canada will be better positioned to make choices regarding the rate and magnitude of future emissions reductions and the strategies for adapting to the inevitable impacts of climate change.

Since the preparation of the *Canada's Third National Report on Climate Change* in 2001, several significant activities have taken place relating to climate research and monitoring. These activities have built on initiatives and programs introduced previously and have supported a significant portion of the new research that has taken place. This chapter begins with an overview of these activities and then reports on progress in research and monitoring, highlighting some results from recent initiatives. Research related to climate change impacts and adaptation is discussed in Chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*, of this report.

8.2 FUNDING AND PRIORITY SETTING

8.2.1 Climate Research and Monitoring in Canada

While a very broad community has become involved in conducting research on the impacts of climate change, federal government departments and the university community conduct the majority of Canadian climate change science. The Government of Canada (GoC) provides the essential scientific infrastructure, provides long-term coordinated programs, and produces science for the "public good", that is, the science required to understand and support the climate change policy decisions required both domestically and internationally. Universities conduct both knowledge-based and policy-relevant research on the climate system and on the vulnerabilities of natural and managed systems to climate change. Productive partnerships have been established between the two communities and both continue to make substantial contributions to Canadian and international programs.

The key GoC players in climate change science are Environment Canada, Fisheries and Oceans Canada (DFO), Natural Resources Canada (NRCan), and Agriculture and Agri-Food Canada (AAFC). These departments together have responsibility for the climate system since they share responsibility for the atmosphere, the oceans and the land surfaces of Canada. Other federal departments run programs that contribute to the national knowledge base on climate change, including Health Canada and Industry Canada.

Overall responsibilities among the key federal departments can be described as follows:

- Environment Canada – has the lead for atmospheric and hydrologic monitoring and analysis, snow and sea ice monitoring and analysis, climate system processes and modelling research, and sensitivities and impacts research for freshwater and terrestrial ecosystems. Environment Canada houses the Climate Research Division, the Canadian Centre for Climate Modelling and Analysis, the National Water Research Institute, the Canadian Wildlife Service and the Canadian Ice Service. Environment Canada also houses the Adaptation and Impacts Research Division.
- Fisheries and Oceans Canada (DFO) – has the lead on marine science and contributes to climate change science through ocean monitoring and analysis, research on climate system processes and modelling (focusing on atmosphere-ocean interactions), and sensitivities and impacts research on marine ecosystems. DFO's climate science programs are coordinated by the Oceanography and Climate Branch and are carried out in the department's five major oceanographic institutes in British Columbia, Manitoba, Quebec, Nova Scotia and Newfoundland.
- Natural Resources Canada (NRCan) – has the federal lead for earth science and houses the Canadian Forest Service, the Geological Survey of Canada (GSC), and the Canada Centre for Remote Sensing. In terms of climate change science, NRCan has the lead responsibility for monitoring and analysis of permafrost and glaciers; investigating the relationship between forests and climate change; and undertaking the analysis of past climates through proxy data sources such as ice cores and tree rings. NRCan also houses the Climate Change Impacts and Adaptation

Program (CCIAP), which is described in Chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*.
- Agriculture and Agri-Food Canada (AAFC) – conducts research on understanding and quantifying the sources and sinks of GHGs in the agricultural sector, identifying promising management practices that reduce net GHG emissions, and on the verification of removals and emissions of GHGs from this sector for GHG accounting purposes.

Priorities for climate change research in Canada are determined largely by consultative processes among government and academia. Major initiatives and programs since the preparation of the Third National Report include the following (program details are contained later in this section):

- *Action Plan 2000 (AP2000) on Climate Change.* AP2000 was the basis for the GoC's contribution to Canada's First National Business Plan (FNBP), completed in the year 2000 as part of Canada's effort to address climate change in the period before ratification of the Kyoto Protocol. While AP2000 focused primarily on federal investments in GHG mitigation measures, two of the measures contained in the plan focused on priorities in climate science: climate monitoring, particularly in the Canadian North, and understanding GHG sources and sinks.
- Extension of the *Climate Change Action Fund (CCAF)*. The CCAF, established by the GoC in the 1998 Federal Budget, was subsequently extended in 2001 for three years, ending 31 March 2004, with annual funding of $2.5 million per year for climate science (same as the funding from 1998-2001).
- *Climate Change Plan for Canada*. Released by the GoC in November 2002, the plan provided a framework for action on climate change in the context of Canadian ratification of the Kyoto Protocol, and proposed a further set of initiatives to reduce national GHG emissions. In addition, four priority areas for action on science were identified:
  - addressing climate model uncertainties;
  - providing regional-scale climate change information;
  - improving our understanding of future climate change in the Arctic; and,
  - improving our understanding of past climate variability and extremes in Canada's climate.
- *Budget 2003.* The GoC established the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) in 2000 to support university-based research in areas of national priority and policy relevance. Entrusted initially with a $60-million investment budget to be disbursed over six years, CFCAS received an additional $50 million in Budget 2003, and its mandate was extended through March 2011.

8.2.2 Major Funding and Coordination Programs

The investments described below that were allocated to climate change science through specific programs are additional to federal department core (A-base) funding, which still remains the major funding source for basic climate change research in Canada. Some of the programs reached the end of their funding period and were terminated during *Canada's Third National Report on Climate Change* analysis period.

Climate Change Action Fund (CCAF) (1998-2004)

The CCAF was established by the GoC in the 1998 Federal Budget, with a total budget of $150 million allocated over three years. Of that, $15 million was allocated to Science, Impacts and Adaptation (SIA), split evenly between Climate Science and Impacts and Adaptation. Climate science funding from the CCAF thus amounted to $2.5 million per year. The CCAF was subsequently extended for three years, ending 31 March 2004, with the same level of annual funding provided for SIA as in the first three years.

Science investments made under the first three years of the CCAF were directed toward the following priorities: climate modelling improvements, climate monitoring, GHG sources and sinks, arctic climate, climate and weather extremes, and development of climate scenarios for Canada. The results of Phase 1 of the CCAF were reported on in *Canada's Third National Report on Climate Change* to the UNFCCC Secretariat.

The broad objectives and goals that drove the first phase of the CCAF remained valid in the renewed CCAF period (2001-2004). CCAF Phase 2 funding, intended to complement other climate change science program funding, was directed at climate monitoring and studies of GHG sources and sinks (AP2000) and arctic climate studies and studies of extreme weather

(CFCAS). Therefore, CCAF Phase 2 focused on the following four priorities:

1. global and regional scale climate modelling;
2. development and provision of climate scenarios;
3. understanding key climate system processes of importance to Canada; and,
4. assessment, evaluation, coordination and communication of climate system science.

Highlights of CCAF phase 2 will be reported on below in section 8.4 of this chapter.

Action Plan 2000 (AP2000) (2000-2006)

AP2000 was announced in the federal Economic Statement of October 2000. A five-year, $500-million initiative, AP2000 focused primarily on GHG mitigation. It did, however, also include measures aimed at advancing knowledge- and foundation-building in climate change science, impacts and adaptation, northern and Aboriginal communities, and technological innovation. Funding for climate science under AP2000 totalled $20 million. This was divided evenly between GHG sinks and climate monitoring over a period of four years ending 31 March 2005, split among Environment Canada, DFO, NRCan and AAFC.

Climate science research initiatives were launched on biological GHG sinks, to provide information that would lead to a fuller assessment of Canadian carbon sink potential. Measures were also taken to address important gaps in Canada's systematic climate monitoring networks, particularly in the North, responding to the recommendations in the national Global Climate Observing System (GCOS) Plan (described later in the chapter.)

Overall, significant progress was made in filling gaps in our northern and ocean observation networks, and in initiating studies aimed at improving our understanding of GHG sources and sinks. Highlights of these programs will be provided in sections 8.3 and 8.4 of this chapter.

Canadian Foundation for Climate and Atmospheric Science (CFCAS) (2000-2011)

In 2000, the CFCAS received $60 million in funding over six years and in 2003 funding was increased by an additional $50 million. With a total budget of $110 million allocated for 2000 to 2011, CFCAS has become the main funding body in Canada for university-based research on climate and atmospheric sciences, and related oceanic work. It also supports research in air quality and extreme weather, both of which are areas of study closely linked to that of climate change. As of December 2005, CFCAS had invested $88.1 million in university-based research, in 17 major collaborative networks and 125 projects. The Foundation is an autonomous agency; its grants are awarded on the basis of peer-reviewed competition. Grants support research in areas of national priority and relevance to policy development.

CFCAS grants have attracted matching support in cash or in kind from universities, federal research laboratories, and the private sector – effectively doubling the impact of the Foundation’s investment. Several of the CFCAS-supported networks are linked to international research programs; all involve multiple partners. Of the 17 research networks, seven are related to climate science and have effectively replaced the former Climate Research Network in Canada (described in the Third National Report).

In September 2003, in light of the renewed funding and extended mandate, CFCAS revised its funding strategy, to guide future investments to where they were most needed, based on emerging scientific findings, identification of gaps in research or policy needs. As a result of this process, CFCAS decided to shift the majority of its funds (about 75%) toward major interdisciplinary and inter-sectoral initiatives, although individual projects would continue to be supported as well. CFCAS also identified four major themes toward which future investments would be targeted:

- Arctic, northern and cryospheric science;
- high-impact weather, including drought;
- physical impacts of climate change; and,
- use of analytical methods for monitoring and predicting of atmospheric and oceanic conditions.

The changes were implemented effective February 2004. The Foundation also approved support for international offices, including the International Project Office for SPARC (Stratospheric Processes and their Role in Climate), which moved to Canada in 2004.

CFCAS funded climate science networks operating over the 2001-2005 period include:

- Climate Variability: It’s Causes and Predictability (CLIVAR) (co-sponsored with NSERC);

- Fluxnet-Canada (co-sponsored with NSERC and BIOCAP Canada);
- Canadian Surface Ocean Lower Atmosphere Study (Canadian SOLAS) (co-sponsored with NSERC);
- Development of a Canadian Global Coupled Carbon Climate Model (GC^3M);
- Modelling of Clouds and Climate Network (MOC2);
- Modelling of Global Chemistry for Climate; and,
- Canadian Regional Climate Modelling Network.

Natural Sciences and Engineering Research Council (NSERC)

The core role of NSERC is to support university research and training in the fields of science and engineering. NSERC fulfils its mission by awarding scholarships and research grants through peer-reviewed competition, and by building partnerships among universities, colleges, governments and the private sector. Between 2000 and 2005, NSERC had an operating budget of \$3.3 billion that was spent on grant support, research and administrative activities. A breakdown of annual funding indicates that in 2004-2005, NSERC invested \$803 million in university-based research and training in all the natural sciences and engineering. This included a base budget of \$655 million and an additional \$148 million that flowed through NSERC for programs such as the Canada Research Chairs, Canada Graduate Scholarships and the Networks of Centres of Excellence (NCE).

In the fiscal year 2004-2005, NSERC funded over 600 separate grants worth \$41 million for climate change related research and technology. Of these, there were more than 300 grants for over \$22 million awarded at over 40 different universities and colleges in areas classified under 'Understanding Climate Change', which included research in the study of past climate changes, understanding and modelling the climate, the study of GHGs and atmospheric science, and climate impacts research. In addition, more than 300 grants for a total of \$18.5 million were awarded in areas classified under "Innovating for the Long-Term", which covered research into renewable and alternative energy, cleaner fossil fuels, energy efficiency in the transportation, housing and energy sectors, CO_2 sinks and storage, and agricultural and forestry practices. Most of the research that NSERC funds is discovery-driven. The project-based research is driven by the needs of the partners (i.e. industry and government), who are expected to apply the results.

NSERC also provides crucial financial support and co-sponsorship to a number of climate related research networks:
- CLIVAR (co-sponsored with CFCAS);
- Fluxnet-Canada (Surface Ocean Lower Atmosphere Study (SOLAS) – co-sponsored with CFCAS and BIOCAP Canada);
- Canadian SOLAS (co-sponsored with CFCAS);
- Canadian Arctic Shelf Exchange Study (CASES); and,
- Canadian contribution to the Global Energy and Water Cycle Experiment (GEWEX) – the Mackenzie GEWEX Study (MAGS).

BIOCAP Canada (1998-2006)

BIOCAP Canada is a national not-for-profit research foundation working to find solutions to climate change by using the opportunities presented by the forests and farmlands of Canada. Biosphere-based solutions to climate change include those that:
- sequester atmospheric carbon through enhanced carbon stores in forests, wetlands and croplands;
- reduce GHG emissions, especially methane and nitrous oxide, from agricultural sources and landfills;
- use biomass as a source of renewable energy and material; or,
- adapt biological systems to maintain biodiversity and carbon stocks in a changing climate.

Federal funding has been provided to BIOCAP through an agreement of \$10 million over five years, through to March 2006, with federal funding coming jointly from Natural Resources Canada, Agriculture and Agri-Food Canada, and Environment Canada. Since January 2002, BIOCAP has invested or committed \$6.2 million in research on biosphere solutions to climate change and has leveraged an additional \$27.5 million in funding. Significant co-funding of networks and projects was received from NSERC and SSHRC.

BIOCAP Canada is coordinating and funding a "network of research networks" that brings together different levels of government, granting agencies, researchers within government, industry and academia, as well as representatives from various non-governmental organizations. The process of priority setting for research includes consultation with stakeholders, during which research needs are identified for each of four main areas:

1. Forestry and Natural Ecosystems
2. Agriculture
3. Bioenergy
4. Human Dimensions.

BIOCAP's Research Overview Committee and Research and Development Advisory Councils then review the research needs to identify research priorities for a funding cycle. Research proposals are then sought and awarded through a competitive peer-reviewed process.

A total of 11 research networks are being supported through BIOCAP; three of these are well established (i.e. Greenhouse Gas Management Canada, Fluxnet-Canada, and Forest Management), while others are still emerging. Thirteen new research initiatives were launched in the 2004/05 period to build on the 24 existing and ongoing initiatives.

ArcticNet (2003-2008)

ArcticNet is one of a number of Networks of Centres of Excellence (NCE) funded by the GoC in the field of Natural Resources and the Environment, but the only one, at present, focused on the issue of climate change. The NCE initiative is supported by three Canadian federal granting agencies – the Canadian Institutes of Health Research (CIHR), NSERC and the Social Sciences and Humanities Research Council of Canada (SSHRC), and Industry Canada. ArcticNet was awarded $25.7 million by NCE for the years 2003-2004 to 2007-2008 (see Chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*).

The NCE program has been operating successfully for 15 years and currently has a program budget of $77.4 million per year. An integral part of the federal government's Innovation Strategy, these nation-wide, multidisciplinary and multi-sectoral research partnerships connect excellent research with industrial know-how and strategic investment.

ArcticNet will integrate research from the natural, medical and social sciences with partners in northern communities, federal and provincial agencies and the private sector in order to study the impacts of climate change in the Arctic. The central objective of ArcticNet is to translate the growing understanding of the changing Arctic into impact assessments, national policies and adaptation strategies. The direct involvement of Northerners in the scientific process is a primary goal of the Network that will be fulfilled through bilateral exchange of knowledge, training and technology. The Network is built around a newly refurbished research icebreaker, whose refit was funded by the Canadian Foundation for Innovation (CFI), which will help improve upon the paucity of observations in the coastal Canadian Arctic.

International Polar Year

International Polar Year (IPY) 2007- 2008 will be a major, international scientific effort featuring a global campaign of coordinated polar observations and analysis, focusing on both the North and South poles. IPY will provide an opportunity to deepen our knowledge of the polar environment and systems that are important to Canada.

Canada's participation in IPY was formally announced by the GoC in 2005, along with a commitment to provide $150 million in new funding over six years to carry out an innovative, interdisciplinary program for IPY along with our international partners. The GoC is supporting a targeted science and research program focused on two of Canada's most important challenges for its northern regions - climate change impacts and adaptation, and the health and well being of northern communities. The official research field season is March 2007 to March 2009.

Partnerships are critical to the success of IPY. Within Canada, this endeavour will draw together the federal departments of Indian and Northern Affairs Canada, Environment Canada, NRCan, DFO, IC and Health Canada, along with other federal agencies and bodies, territorial and provincial governments, Northern communities, Aboriginal organizations, universities, Northern research institutes and colleges and others. A Canadian IPY Secretariat has been established at the University of Alberta, a federal IPY working group has been set up to coordinate federal government activities, and a National Steering Committee, with multi-stakeholder representation, has also been established.

Program of Energy Research and Development (PERD)

PERD is managed by NRCan and involves the participation of 12 federal departments. A subcomponent of its overall program is focused on GHG sinks research, funded at about $2 million annually. Funding for PERD sinks research will continue until 31 March 2007.

PERD funding in GHG sinks supports targeted research by federal departments in the areas of forest sinks, agricultural sinks, ocean sinks, and hydroelectric reservoir fluxes. The ultimate aim has been to help develop the accounting tools needed for accurate and verifiable reporting of carbon sinks under the Kyoto Protocol. The Canadian Forest Service is continuing to support the sinks research until 31 March 2007 with added emphasis on impacts on the carbon balance of wildfires and insect/disease infestations.

A description of the PERD program is provided in Chapter 4, *Policies and Measures* (section 4.4), of this report.

8.3 MONITORING (SYSTEMATIC OBSERVATION)

8.3.1 Overview of Climate Monitoring in Canada

Systematic observations of the climate system are essential for understanding the natural variability of the system and its mean state over different periods of time. It is only through understanding and describing the climate of the recent past that we can detect any persistent change in climate, and it is only through understanding current climate in the context of the past, that we can determine the extent to which any recent climate changes are unusual. Systematic observations are therefore essential for climate change detection and quantification, but also for understanding climate system dynamics, assessment of sensitivities and impacts, prediction of seasonal or inter-annual changes, long-term projections and modelling of the climate system, and development of adaptation strategies.

Monitoring of the climate system covers five components: atmosphere, oceans, cryosphere (ice, snow, permafrost and glaciers), hydrosphere, and the land surface. As in other countries, the collection, quality assurance, archiving and provision of systematic observations of the climate system in Canada involve many agencies and institutions and arise out of a broad spectrum of requirements, applications and obligations. The constitutional division of responsibilities between different levels of government, however, means that no single jurisdiction has responsibility for all components of the climate system. This reality is reflected in the varying degrees to which observational networks and systems are nationally coherent. Where the atmosphere and the oceans are concerned, the GoC's lead role is unambiguous with coherent, long-established systems in place for atmospheric and oceanic observations (although existing ocean observing programs are limited in scope and have historically not been designed or resourced as a climate observing system). In contrast, provincial/territorial jurisdiction is generally paramount where natural resources (e.g. forestry, agriculture) are concerned and terrestrial observations are, as a result, addressed in a more dispersed manner.

Environment Canada maintains a national network of climate observing stations extending from coast to coast and into Canada's North that gather data on the atmosphere, water, ice cover, snow cover and GHGs. The networks adhere to standards set by the World Meteorological Organization and contribute to global observation networks such as the *Global Climate Observing System (GCOS)*. DFO has responsibility for the collection and management of key physical, chemical and biological variables describing the oceans that surround Canada, including the Northeast Pacific, the Beaufort Sea and the Labrador Sea. DFO leads national co-ordination of the *Global Ocean Observing System (GOOS)* in collaboration with other relevant GoC departments. NRCan maintains networks and data archives on permafrost and glaciers. Both of these national networks are linked to *Global Terrestrial Networks for Permafrost and Glaciers (GTN-P and GTN-G)*. These networks are described in brief in the section below.

To address Canada's GCOS obligations under the UNFCCC, a national workshop was held in 1999 to develop the elements of a national GCOS plan. The National GCOS Plan is a living document that continues to evolve. It has given direction and momentum to Canada's efforts to contribute meaningfully to the establishment and operation of GCOS. In 2002, a first national report on the Canadian Climate Observing System was completed and submitted to the

United Nations Framework Convention on Climate Change (UNFCCC), titled *The Canadian National Report on Systematic Observations for Climate: The Canadian Global Climate Observing System Program*.

The need for enhancements to Canadian climate monitoring networks was identified early in the process of formulating a national GCOS plan. Beginning with funds provided through AP2000, new resources have been allocated to enhance the coverage and quality of observations for the atmosphere, ocean and cryosphere, particularly in the North.

There are two new processes through which additional improvements to Canadian climate observing networks are being planned. One of these is the Canadian GEO program. At the first Earth Observation Summit in July 2003, Canada, together with 33 countries and over 20 intergovernmental organizations, endorsed a declaration for a coordinated international effort to improve earth observation capabilities. The Third Earth Observation Summit, held in Brussels in February 2005, launched the 10-Year Implementation Plan (2005-2014) for a Global Earth Observation System of Systems (GEOSS).

In response to this international initiative, the GoC is developing a Federal Earth Observation Strategy (FEOS) to improve our own earth observation capabilities. Informal consultations took place with provinces, territories and stakeholders in industry and academia by way of a survey. Inadequate geographic coverage, particularly in the North, was noted as an ongoing problem by 40% of respondents. Gaps in coverage over the oceans were also highlighted as problematic. It should be mentioned that although climate needs are an integral part of the FEOS strategy, understanding, assessing, predicting, mitigating and adapting to climate variability and change is but one of the nine societal benefits being addressed by GEO. Nevertheless, the goal of the eight federal departments and agencies collaborating on GEOSS is to build end-to-end systems that are coordinated in their approach and deployment toward comprehensive and integrated earth observation systems.

The second process is that of the Canadian IPY program. During IPY (2007-2008) Canadian and international scientists will conduct intensive research and observation activity in the Arctic. Pending funding approvals, due at the end of 2006, *in situ* and satellite observations along atmospheric, oceanic and terrestrial transects will be made, paleo-environmental data from proxy sources such as glaciers, marine and lacustrine sediment cores will be studied, and information on the changes in environmental conditions from traditional knowledge sources will be collected. Such information will be stored, managed and made accessible in a public database. The legacy of IPY will be fulfilled if other programs assume responsibility to continue monitoring after IPY is completed.

The GoC has made some significant investments in improvements to the climate system monitoring networks over the past few years. Given the growing concerns about climate change, and indications that many components of the climate system are already responding to global warming, the establishment of observational networks capable of fully capturing such changes throughout the many diverse regions of Canada remains critical.

8.3.2 Monitoring Networks

As part of Canadian efforts to organize effectively to respond to the needs of the recently created GEO, Canada has established a Canadian GEO Secretariat. The Canadian GEO Secretariat hosts a website that includes a listing of Canadian observing networks. The listing is not yet complete but will, in time, become a valuable resource. Those networks that contribute to observations of the climate system are described briefly below, but more detail will shortly become available through the website. The *Canadian National Report on Systematic Observations of Climate*, meanwhile, remains a valuable resource for information on Canadian observing networks.

Atmospheric Observing Networks

Climate

Environment Canada operates two surface networks related to climate change – the Canadian Reference Climate Stations Network (RCS) and the daily Climatological Network.

The RCS network consists of 302 stations. Of these, 87 report as part of the Global Surface Network (GSN). The original 192 of these stations were selected in 1992 based on their long record of quality temperature observations. In 1997 and again in 2002, this list of stations was revised and gradually increased to the current count of 302 stations. Over the last six years, Environment Canada has invested AP2000 funds to increase the network's coverage in the North by adding 45 stations north of 60 degrees (with five of them to be completed over the next two years). In addition, Environment Canada has invested in modernizing stations at risk. At this point, about 120 of the 302 stations have been modernized to a standard configuration. Environment Canada expects to modernize another 35 in the fiscal year 2006/07 and then continue the modernization at a rate of 17 stations per year. After the modernization of the RCS/GSN stations in the North and with the higher density of RCS stations in the southern segments of Canada, the remaining gap now focused on the "mid-latitudes", i.e. the northern portions of the provinces (from British Columbia to Labrador).

All modernized stations have been converted to the same standard configuration that includes observations of temperature, humidity, pressure, wind (both at 10m and 2m), precipitation, rate of rainfall (non-frozen season only) and snow depth. In addition, the global solar radiation is observed at 50 of these stations and soil temperature is also observed at selected stations. Observations are mostly hourly. Wind, precipitation and snow depth are also observed every 15 minutes. Solar radiation and rate of rainfall are observed every minute. All observations are transmitted on an hourly basis. Environment Canada has also developed an algorithm to derive snowfall from snow depth observations with implementation targeted in fall 2006. Prior to the full implementation of this algorithm, Environment Canada is maintaining an interim network of human snow observations reporting via the electronic data entry system of the daily Climatological Network (described below). Environment Canada also intends to add soil moisture sensors (at multiple depths) to this configuration.

In addition, Environment Canada also operates a Surface Weather (SWX) Network of about 330 stations in various states of automation. Many of these stations are located at airports or in urban settings, and do not necessarily offer long periods of records in pristine environment settings. Environment Canada has modernized 70 of these stations to the same standard configuration as the modernized RCS stations and is continuing to modernize the remainder of this network at a rate of about 21 stations per year.

Previous supplementary climatological networks have been incorporated in the modernized RCS and SWX networks as part of the standard or optional configuration. By exception, there is a small group of 50 to 100 stations observing only the rate of rainfall (and no other parameter) that did not coincide with RCS or SWX stations, and these will be maintained separately.

The daily Climatological Network currently consists of 1,450 stations taking once- or twice-daily observations of temperature (minimum and maximum) and precipitation (rainfall or snowfall) and snow depth. For most of these stations, the observations are reported in documents made available several weeks after the end of the month. Environment Canada has developed an internet-based data entry system to allow the observers to enter their observations in near real-time. Immediate automatic quality control and feedback alert the observer of any suspect entry. Another near real-time data entry system is based on digital touch-tone phone that also provides some limited quality control. Eventually, all data entry from this network will be through either of these near real-time electronic data entry modes.

Atmospheric Composition

There are two observing networks for atmospheric composition of particular relevance to climate change – Canada's Baseline Monitoring Network for GHGs and aerosols (5 sites) and the Surveillance of Atmospheric Change in Canada (SACC, formerly called CORE) network of 10 sites for tracking long-term changes in atmospheric composition in several major Canadian airsheds. Environment Canada is responsible for both these networks.

Canada has made some investments in recent upgrades to these networks. Aerosol mass and chemistry measurements have been enhanced at most of the SACC sites. The Baseline Network was enhanced by instituting high quality GHG and stable isotope measurements at the Boreal Ecosystem Research and Monitoring Sites (BERMS) Fluxnet-Canada study in Saskatchewan. There remains, however, a significant gap in the monitoring of atmospheric composition north of 60 degrees in Canada. The Alert Observatory is the only observatory making long-term measurements in this area. There are efforts being made to try to rectify this deficiency.

GHG data from the Baseline Network go into global databases, including WMO's World Data Center for Greenhouse Gases. The Alert Observatory is one of WMO/GAW's Global Observatories. Alert and the SACC sites also provide the infrastructure for measurements that are made by the international scientific community as part of various international programs.

Oceanic Observing Networks

Ocean Monitoring Network

DFO is responsible for the collection and management of physical, chemical and biological variables describing the climate of the oceans that surround Canada, including the Northeast Pacific, Northwest Atlantic, Hudson Bay, the Beaufort Sea and the Labrador Sea. Observations are made by ship, by moored and floating buoys and by remote sensing. Data rescue has been a significant initiative over the past few years. Historical records from paper or non-standard sources have been transcribed into the ocean databases so that they are available for analysis.

DFO research ships routinely monitor ocean conditions including vertical profiles of temperature, salinity, nutrients (i.e. N, P and Si) and biological (e.g. phytoplankton and zooplankton) data. The Atlantic Zone Monitoring Program (AZMP) includes a network of six stations sampled bi-weekly, 13 seasonal cross-shelf sections sampled one to two times annually, and fisheries resource surveys (2,000 stations sampled annually) covering the NW Atlantic continental shelf from 42-56 degrees north. The Labrador Sea cross section is an important, long-established ocean monitoring program for climate research, since each year it monitors the water masses that contribute to the Atlantic Branch of the thermohaline circulation. Similarly, the Pacific Line P (Vancouver Island to 50°N, 145°W), which is surveyed three times per year for temperature, salinity, oxygen, carbon dioxide, chlorophyll, nutrients and zooplankton, is a cornerstone of long-term observations of the effects of climate variability and change on ocean ecosystems. The Arctic climate programs are less sophisticated than in the Atlantic and Pacific, but include through-flow monitoring in key straights of ocean current through full depth, ice drift, temperature and salinity at the seabed and acoustic backscatter from zooplankton. In addition, there is monitoring of the pack ice in the Beaufort Sea by instruments on sub-sea moorings. The time series were 15 years long in April 2005. The instruments measure ice draft (related to thickness), ice ridges and leads, ice drift, ocean current through full depth, temperature and salinity at the seabed and acoustic backscatter from zooplankton. Deficiencies exist in the Arctic monitoring programs. Work to begin addressing these gaps is expected to commence as part of the IPY programs.

DFO also has responsibility for monitoring sea level. In addition to the existing Atlantic and Pacific National Sea Level Network of coastal stations, DFO installed a coastal Arctic component during the period 2002-2005 to address critical gaps in the Global Sea Level Observing System (GLOSS) array. Five new northern sites were established at: Alert, Ellesmere Island; Qikiqtarjuaq, Baffin Island; Nain, Labrador; and Holman, Victoria Island. All five sites were operational by July 2004, thereby addressing a major gap in this component of the monitoring program. The Canadian Hydrographic Service is collecting data from the tide gauging stations on a daily basis.

Finally, in the last three years, Canada has made a major contribution to the Argo project. Argo is an international venture that aims to deploy 3,000 profiling robot submersible floats around the world, and will for the first time allow a test of our ability to forecast ocean climate. The objectives of Argo are to obtain an unprecedented dataset for model initialization, data assimilation and dynamical consistency testing of the next generation of global ocean and coupled models. Argo will also produce an accurate global climatology, and accurate time-series of heat and freshwater storage (globally) and of the temperature/salinity structure and volume of the world's intermediate and thermocline water masses. It will also determine the dominant patterns and evolution of inter-annual variability in temperature and salinity, which can be used for analysis of coupled modes of air/sea interaction. Canada's contribution to ARGO to date has included deployment of over 160 ocean floats, primarily in the northwest Atlantic and northeast Pacific Oceans.

National coordination and integrity across the various DFO monitoring programs ensures common protocols for both observation and data archiving. The DFO Marine Environmental Data Service (MEDS) manages and archives ocean data collected by DFO, or acquired through national and international programmes in ocean areas adjacent to Canada. MEDS also assembles, processes, quality controls, and distributes large volumes of climate related data, as a data centre for the major international climate research programs. One example is CLIVAR, which seeks to address issues of natural climate variability and anthropogenic climate change.

Sea Ice Monitoring

Environment Canada's Canadian Ice Service (CIS) monitors sea ice on a daily basis in the ice-encumbered waters within and adjacent to Canada's exclusive economic zone, including the Great Lakes and Saint Lawrence River. Radarsat is the primary observing platform – CIS analyzes about 4,000 Synthetic Aperture Radar images from Radarsat annually. Visual and infrared (IR) satellite images complement these, with aircraft reconnaissance conducted in shipping areas, providing visual confirmation of satellite observations.

This information is valuable for climate studies as well as navigation support. CIS produces charts of sea ice distribution on a weekly basis specifically for ice climate monitoring. These data have been digitized back to 1968, when regular weekly charts began, and are available freely on the CIS website. The weekly charts are sent to the World Data Center for Glaciology (formerly named the World Data Center A for Glaciology (Snow and Ice), which is co-located with the US National Snow and Ice Data Center in Boulder). These data have been compiled into three climatic ice atlases for Northern Canada Waters, the East Coast of Canada and the Great Lakes. Additional analysis of the data, in the form of climate variability and trend analysis, and departure from normal, is available on request. The most recent *Departure from Normal* product is also available on the website. A data rescue project is currently underway to digitize additional charts as far back as 1959 to add this information to the digital archive. In addition, iceberg surveillance is conducted off the East Coast of Canada by aircraft on a regular basis. Daily charts of iceberg distribution are produced and are available for climate analysis.

Terrestrial Observing Networks

Hydrometric (Water Quantity) Monitoring

Environment Canada and, in the province of Québec, the Ministère du Développement durable, de l'Environnement et des Parcs currently collect water level and streamflow data at 2,370 hydrometric gauging stations in Canada. These data are collected to national standards, under formal cost-share agreements with the provinces and territories. The historical database contains information that can advance our knowledge of climate change and variability and their impacts on surface waters.

However, most of these stations are located in the southern half of the country, where the population and economic pressures are greatest. As a result, the adequacy of the network to describe hydrological characteristics, both spatially and temporally, decreases significantly in the northern part of the country. For example, there are significant limitations in our ability to estimate freshwater inflows to the Arctic Ocean, past, current or future.

A national network planning effort is underway in Canada that will lead to a network more responsive to science requirements. The Monitoring and Research Basin Network (MRBN) is intended to enhance the ability of Environment Canada and its partners to respond to priority issues such as climate change, secure water resources and biodiversity.

Continued modernization of the network during the past four years has resulted in over 50% of the stations now reporting data in near-real time. Archived Canadian hydrometric data are regularly supplied to the Global Runoff Data Centre (GRDC) in Koblenz, Germany. Work is in progress to make streamflow data available to the GRDC in near-real time.

Canadian Permafrost Monitoring Network

Permafrost monitoring is an important national priority for Canada; one third of the permafrost regions of the northern hemisphere lie within Canada and 50% of Canadian land mass lies within the permafrost zone. Two key parameters are measured through in situ observations: active layer and permafrost thermal state. About 100 active layer depth and/or thermal monitoring sites, with observation periods ranging from a few to over 20 years form the Canadian permafrost-monitoring network. The maintenance of these sites involves many agencies and institutions. Through AP2000 (2001-2005) funding, NRCan/GSC was able to maintain existing permafrost monitoring sites as well as upgrade and enhance the network with establishment of a few additional sites, and establish a data management and dissemination node and website. Between 2001 and 2005, collaboration between NRCan/GSC and Environment Canada resulted in the addition of weather stations with acoustic snow sensors at 11 permafrost-monitoring sites, which also enhanced the Environment Canada snow-monitoring network.

The GSC network is largely concentrated in the Mackenzie region and Laval University maintains numerous sites in northern Quebec. Extensive gaps exist in the northern prairies (southern portion of the discontinuous permafrost zone), Nunavut, west of Hudson Bay and in the Yukon.

Approximately 10 active layer and 75 thermal monitoring sites from the Canadian network currently contribute to the GTN-P that was established by the International Permafrost Association (IPA) under WMO/GCOS. NRCan/GSC coordinates the GTN-P and maintains the website through which summary data and information are disseminated. All observational data are archived with the World Data Center for Glaciology as a contribution to the IPA's Global Geocryological Database.

Canadian Glacier Monitoring Network

NRCan is responsible for the delivery of a National Glacier-Climate Observing System that measures and evaluates changes in glacier mass balance and related glaciological parameters (length, thickness, surface disposition and flow regime). The framework for this Earth Observation system is currently based on an in-situ network of 12 glaciers and ice caps located in the Cordillera and Arctic Islands. These sites broadly represent the variation in glacier-climate settings that exist in Canada. Aircraft and orbital remote sensing is used to extend these site perspectives to provide estimates of regional glacier-climate behaviour. Each system is maintained through the collaboration of the GSC, Geomatics Canada and University scientists and through an interdepartmental agreement with Environment Canada. Information from these sites is utilised in studies of freshwater vulnerability (e.g., water resources and sea-level rise), as well as studies that contribute to the understanding of natural and human induced environmental change. Data and analyses are provided under Communications to the Parties of the Convention - UNFCCC through WMO's GCOS GTN-G (for which NRCan is the Canadian co-ordinator) and the Glaciology Working Group of the Arctic Council's International Arctic Science Committee (IASC).

Under AP2000 improvements to the existing reference network were made. This included the re-establishment of sites that were abandoned after the close of the International Hydrological Decade, and the initiation of measurements at new sites. In both cases, site selection was based on the consensus of a formal working group established during the definition of Canada's GCOS plan for the cryosphere. These important reference in-situ "pinning points" provide critical information on seasonality of moisture and energy fluxes and fill information gaps from previous statistical research. Also, the remote sensing techniques require in-situ measurement - not only for validation needs, but also for designing retrieval algorithms (altimeters for example) for situations where surface returns may be ambiguous due to the effects of near-surface snow stratigraphy and complex topography.

Advances in observing techniques and development of a coherent and operational glacier-climate observing system continue to be supported by the Canadian Space Agency's Government Related Initiatives Program (GRIP). Four initiatives in particular are helping scientists to address issues of scale and make better regional assessments of glacier-climate change:

- LiDAR altimetry for systematic change detection and re-mapping initiatives;
- GLIMS (Global Land Ice Monitoring System Regional Data Centre– U. Alberta);
- RaDAR altimetry from space – ESA CryoSat; and,
- Regional mass balance scaling from space using AVHRR and MODIS.

Data and information on the state of Canada's reference glacier-climate observing sites are submitted to the World Glacier Monitoring Service (IUGG(CCS)–UNEP–UNESCO–WMO).

Fluxnet

The establishment of a Global Terrestrial Network – Carbon (Fluxnet), aimed at measuring the exchanges of carbon dioxide, water vapour and energy between terrestrial ecosystems and the atmosphere, has been identified as a vital component of GCOS. Its goals are to provide the observational data needed to understand the mechanisms controlling these exchanges across a spectrum of time and space scales and for validation of satellite estimates of net primary productivity and other parameters.

Fluxnet-Canada, the Canadian contribution to the global network, aims to provide continuous, multi-year, measurements of the exchanges of CO_2, water and sensible heat (and, in some cases, other GHGs) for mature and disturbed forest and peatland ecosystems in Canada's southern ecoregions. The Fluxnet-Canada research network was established with funding from NSERC, CFCAS and BIOCAP of approximately $12 million over five years, effective April 2002. There are 44 co-investigators from 13 universities, two federal government departments and three provincial research institutes. In 2005, the network operated flux towers at 29 research sites along an east-west continental transect of the commercial forest zone of Canada. Twenty-two of these sites make long-term, continuous measurements of carbon, water, and energy exchanges between ecosystems and the atmosphere using the eddy covariance flux measurement technique. Non-continuous measurements are also being made at seven additional sites during the growing season. A national database has been created that links a multi-year record of 30-minute carbon flux measurements to long-term changes measured in biomass inventories. Fluxnet maintains a publicly accessible database, containing flux and associated ecological data, which is updated on a regular basis.

Ecological Monitoring

The Ecological Monitoring and Assessment Network (EMAN) was established in 1994 as a national network to provide an understanding and explanation of observed changes in ecosystems. The network is a cooperative partnership of federal, provincial and municipal governments, academic institutions, aboriginal organizations, industry, environmental non-government organizations, volunteer community groups, and other parties involved in ecological monitoring. EMAN-North is a network dedicated to the coordination of ecological monitoring in northern Canada. Environment Canada is working in the three territories and northern Manitoba, Ontario, Quebec, and Newfoundland and Labrador, in close partnership with many agencies and programmes, to develop this network. The most recent additions to the network have been citizen science monitoring programs for tracking changes in ice (IceWatch) and plant phenology (PlantWatch) as indicators of climate change, programs that were launched in 2001.

Canadian Space Agency Program

Earth observation is a key priority of the Canadian Space Program. The Canadian Space Agency responded to the challenge of monitoring the environment and managing the Earth's natural resources with launch of a sophisticated Earth observation satellite, RADARSAT-1, in 1995. RADARSAT-2 will be the most advanced commercial Synthetic Aperture Radar (SAR) satellite in the world and will provide data continuity to RADARSAT-1 users over the planned seven-year lifespan for the satellite. The Canada Centre for Remote Sensing (CCRS) of NRCan will capture data and maintain archiving systems for RADARSAT-2 images.

Data from earth observation satellites are used to detect and assess the impacts of climate variability and change on Canada's landmass and coastal zones. Scientists at CCRS use remotely sensed data to monitor and evaluate the hydrological status of major Canadian waterways, to monitor the seasonal development and carbon uptake by vegetation across the Canadian landmass, to measure the flux of glacial ice entering the world's oceans, and to map the dynamics of sensitive sections of the Canadian coastline (e.g. Beaufort Sea coast). They have recently developed a methodology for mosaicing historical and the Near Real Time MODIS data over Canada at 250m spatial resolution.

DFO use satellite ocean observations and related products for monitoring of sea surface temperatures, oceans surface wind fields, sea ice parameters, ocean currents, and ocean colour.

8.3.3 Support for Developing Countries

Environment Canada, through its Water Survey Branch, provides technical and scientific support for the establishment and operation of hydrologic observing systems in developing and emerging countries. The scope of activities, conducted in partnership with the Canadian environmental business sector, include the evaluation, design, and establishment of observing networks and systems; the transfer and sharing of observing knowledge, expertise and methodology; and capacity strengthening in institutional approaches to the long term and sustainable operation of modernized observing networks.

Projects have included activities such as network design and training of water professionals in various countries and regions: under a joint Jordan, Israel and Palestine initiative; in the SADC region of Africa; in the northern basins of Mexico, and in Bangladesh.

8.4 RESEARCH

While a range of science-based institutions have been actively involved in climate change research in Canada, federal departments and the university community conduct the bulk of the activity. The key federal departments in climate change research are Environment Canada, DFO, NRCan and AAFC. Much of the work is collaborative in nature involving partnerships among GoC and university scientists, and many Canadian research programs are linked to larger international efforts. Funding agencies and programs have recognized the collaborative nature of climate change science and have been promoting and supporting the development of research networks that engage experts from different institutions and from different disciplines. Several new funding programs and research networks have recently been established, including CFCAS and ArcticNet, among others (see section 8.2). Funding for climate change research also recently came from both the CCAF and AP2000. As will be seen in the following sections, these programs have provided a useful infusion of support to ongoing programs in key areas such as climate modelling, climate impacts scenarios and GHG sinks; however, funding from CCAF and AP2000 has ended. The 2003 federal budget provided an additional $50 million to CFCAS, however almost all of this funding has now been committed to multi-year projects and networks.

While Canadian climate change research has already made significant contributions both nationally and internationally to our understanding of climate change and its impacts on our economy, environment and society, many unknowns and uncertainties remain. Further research is necessary to ensure Canada has the scientific information that is needed to support both mitigation and adaptation choices.

8.4.1 Climate Analysis/Climate Trends and Variability

Climate analysis makes use of climate observations (physical and chemical), proxy data and climate model outputs over a variety of time and space scales in order to investigate the past, present and possible future characteristics and behaviour of the climate system. Topics of investigation include analysis of trends, temporal and spatial variability, extremes, and the detection and attribution of climate change. Understanding Canadian climate trends and variability is a fundamental component of the work of Environment Canada's Climate Research Division. DFO likewise has a core program dedicated to monitoring and understanding the state and variability of the marine environment. Analysing the state of the Canadian cryosphere is the responsibility of both Environment Canada and NRCan and has been the core part of a larger national program dedicated to understanding the Canadian cryosphere – CRYSYS (CRYosphere SYStem in Canada). There is also a major research network - CLIVAR - linking government and university researchers, dedicated to understanding climate variability on multiple timescales. Paleoclimate analysis in Canada is led federally by NRCan, with an active research community both in government and academia.

Federal Research Programs

Atmosphere

Environment Canada's Climate Research Division has an ongoing program of assessing the current state of the climate, its variability and extreme events. In the past several years, the Climate Data and Analysis section has concentrated on the production of homogeneous temperature, precipitation and wind datasets suitable for trend analyses. Work on monthly data has been completed and station datasets have been used to generate national gridded time series of monthly anomalies dating back to the early 1900s and in collaborative production of a North American gridded dataset for GCM and Regional Climate Model (RCM) validation.

Recent research has included the rescue, recovery and verification of lesser known historical climatic data sets that involve climate records of the late 19th century and early 20th century; the development of new methods to detect climate change and to monitor and analyze climate extremes; the identification of climate change signals from historical and proxy data at global, national and regional scales; and the development of wind/wave hindcasts and future scenarios of extremes for offshore structure design. Recent analysis reveals that an anthropogenic climate change signal can be detected in annual and seasonal mean temperatures at global, continental, and sub-continental scales.

The *Climate Trends and Variations Bulletin*, an internet-based product, is issued quarterly by the Environment Canada's Climate Data and Analysis Section to inform Canadians about the state of Canadian climate in its historical perspective. The most recent annual summary noted that the national average temperature for 2005 was 1.7°C above normal, which tied for third warmest since nationwide records began in 1948. All of Canada experienced above normal temperatures in 2005, with more than 3°C above normal in the Yukon Territory. With the exception of the springs of 2002 and 2004, seasonal temperatures have remained above normal for more than eight years, and a longer-term warming trend of about one degree over the past century has been observed in Canada.

Oceans

The oceanography and climate science research program of DFO encompasses analysis, process and modelling research. The role of oceans in climate change, and the variability of ocean circulation systems are key areas of research, with Canadian research focused on the ocean adjacent to Canada's continental shelves. Projects have a strong focus on the Northeast Pacific, Northwest Atlantic, the Labrador Sea, Hudson Bay and the Arctic. The strength and variability of the ocean circulation systems in these regions is studied, as well as the changes in the temperature, salinities and biological properties of the ocean. Such work helps to understand how Canadian shelf waters and marine ecosystems change, and contributes to global and regional climate change and variability studies. These studies are strongly collaborative, internationally, through the international climate research programs such as CLIVAR and SOLAS (Surface Ocean Lower Atmosphere Study).

Our present understanding of the global climate system indicates that there are strong links between the often dramatic changes now happening in many other parts of the world and the behaviour of the climate in the Arctic. Data on the distribution of water-mass properties (temperature and salinity "signatures" associated with currents), on the presence of tracers and contaminants, and on the behaviour of these parameters over time and space are studies in order to understand these linkages.

Global changes in ocean climate are also reflected in the Northeast Pacific by variables such as sea level and sea surface temperature. Episodic variability of physical and biological conditions in these waters can also be caused by global events such as the El Nino-Southern Oscillation. Understanding the nature and causes of variability in our offshore waters is important and provides input to associated research programs that seek to understand the response of coastal ecosystems to such changes.

In the summer of 2004, the warmest surface waters in 45 years of observations were noted along Line P between 127ºW and 134ºW. Line P is the time-series program that samples along a transect extending westward from the southern coast of British Columbia to Ocean Station Papa (OSP) at 50ºN, 145ºW. Waters were as much as a degree warmer than during the strong El Niño summer of 1997, and exceeded any measurements made during the 1959 to 1981 period in which Weatherships were transiting to and from OSP every six weeks.

Warming is leading to an advance in the development of plankton in coastal and oceanic waters. Earlier spring growth is resulting in failures of higher trophic level reproduction (e.g. seabird colonies). The mismatch of predator and prey may extend detrimentally to juvenile salmon. Recent work has shown that warming waters around the Strait of Georgia may have been responsible for failure of the copepod *Neocalanus plumchrus*, which is likely an essential energy source for migrating juvenile salmon and other coastal organisms.

Fifty years of measurements at Station OPS also show a shoaling (thinning) of the winter mixed layer, a trend that appears constant throughout the subarctic Pacific (since it is reported off Japan also). An important consequence is the reduced ventilation of the subsurface ocean, resulting in declining oxygen levels. Off the coast of British Columbia, oxygen levels have declined by approximately 25% over 25 years at a depth of about 300 m. This information is important for predictions of impacts of climate change on fisheries since the oxygen tolerance of most NE Pacific fishes is poorly understood.

Cryosphere

<u>Permafrost</u>

NRCan/GSC maintains a permafrost-monitoring network that provides information on active layer and permafrost thermal state. Data collected through the permafrost-monitoring network has been used to characterize recent trends and variability in permafrost conditions across the

Canadian Arctic. Warming has varied regionally. Warming in the upper 30 m of permafrost in the western Arctic is observed since the mid- to late-1980s, with the largest change occurring in colder permafrost. In the eastern and high Arctic the warming has occurred later, with warming of permafrost observed since about the mid-1990s. While these trends are consistent with recent trends in air temperature, the impact of changes in snow cover is also a factor. Canadian permafrost trends are summarized in a recent newsletter by the Climate and Cryosphere (CliC) initiative of the World Climate Research Program (WCRP).

Rejuvenation of NRCan/GSC's High Arctic observatories allowed data collection and analysis that facilitated the reconstruction of ground surface temperature history and investigation of permafrost-climate relationships. The results from this project indicate that changes in ground surface temperature and therefore permafrost temperature vary spatially during and after the Little Ice Age. Correlations between ground surface temperature and climate variables (air temperature and snowfall) as well as the North Atlantic Oscillation (NAO) were also investigated.

NRCan/GSC participated in a multi-disciplinary project it co-led with Environment Canada on the impact of the extreme warming of 1998 on the Arctic cryosphere. Results from this project were published in 2001 (see section 'Reports of Interest' below). The warming was found to have a larger impact on the length of the thaw season and therefore on thaw depths and shallow ground temperatures in the western Arctic compared to areas further east or the High Arctic.

<u>Glaciers</u>
In Canada, glaciers and ice caps are found in the Western Cordillera region and in the Arctic Islands. Formal mass balance measurements in Western Canada began in 1965 at the inception of the International Hydrological Decade led by the United Nations Educational, Scientific and Cultural Organization (UNESCO). These studies grew from a variety of casual and professional observations dating back to as early as 1896. The studies were and continue to be centred on the role of glaciers in the hydrological cycle and water resources for human and natural systems. Some recent efforts have demonstrated that the role of glaciers in regulating stream flow may be in decline as the result of significant area-wide reductions in glacier cover. The role of these glaciers - all generally temperate and at the melting point - as harbingers of climate change has also been emphasized in recent re-assessments and ongoing analysis. An improved temporal context has been provided by rigorous pursuit of paleo-environmental indicators for certain reference glacier mass balance sites. Most notable is Peyto Glacier where seasonal mass balances have been estimated back to 1673.

Mass balance measurements began in the Canadian High Arctic in 1959. More than 40 years of measurements have been made since then. All the glaciers and ice caps in this region, with the exception of Meighen Ice Cap, show weak but significant trends with time towards increasingly negative balances. Our knowledge of several specific sites in the Canadian Arctic Islands has benefited from recent intensive study. For example, the Devon Island Ice Cap has been the subject of efforts to document its form, flow regime and particular components of its mass balance (e.g., iceberg calving). Much of the work has involved the use of space-based and airborne remote sensing. Historical in-situ mass balance and snow accumulation records have provided critical background information with which to place these more recent observations and assessments in context.

Data and information on the state of Canada's reference glacier-climate observing sites are submitted to the World Glacier Monitoring Service. An extensive database review is ongoing for the period 1995-2005 for reference site mass balance data. This is being conducted from the point of view of distinguishing a climate or reference mass balance from a hydrological one.

Paleoclimate

Paleoclimate research in Canada is carried out largely within the university community although federally, the Earth Sciences Sector of NRCan has an ongoing climate-change program in which paleo-environmental records for Canada have been reconstructed using a variety of proxy data sources. Ultimately, this work provides paleo-scenarios for evaluating the potential response of specific regions or environments in Canada to climate change and to constrain or validate simulations of past climatic changes.

In the past three years, the work has focused on developing national-scale paleo-environmental records of climate change; on regional-scale high-resolution reconstructions of paleo-climatic variability; and on defining critical process thresholds from past climate changes. Work on the deglaciation and vegetation history of North America has been completed and used to generate time-series maps at 1,000-year intervals or less for the last 14,000 years, showing (1) deglaciation and associated changes in land, sea, and lake areas, and (2) changes in the distribution of terrestrial biomes. Higher-resolution reconstructions are focused on developing past climate change reconstructions of the Northwest Pacific region using glacial ice cores from Mount Logan and marine and terrestrial sediment records from coastal basins. Other high-resolution work has reconstructed past temperature and hydro-climatic changes in the prairies and boreal forest regions from tree-rings.

Cores from arctic ice caps and seabed sediments, as well as whalebone and other fossils on raised beach deposits, have been used to develop an understanding of changes in Northwest Passage sea-ice cover over several thousand years and the temperature thresholds associated with these changes. Other research is focused on providing paleoclimatic data for validating a model of Great Lakes hydrology, and on providing a regional assessment of impacts of past droughts in the Canadian Prairies for use as potential future scenarios. Changes in relative sea level have been studied as a basis for estimating vertical motion of the crust, also measured directly from the Global Positioning System (GPS) and absolute gravity measurements. This information is required to adjust model-derived projections of future sea level for local vertical motion.

A paleo-environmental website hosted by NRCan provides progress and updates on these activities and links to publications. Future research activities planned as part of the IPY program will include more emphasis on paleo-environmental change in the Canadian Arctic.

Other Collaborative Research Programs

CRYSYS

CRYSYS has been a Canadian-led Interdisciplinary Science Investigation (IDS) in the NASA Earth Observing System (EOS) program since 1990. Since 1993, Environment Canada has led and funded this collaborative investigation involving scientists from Environment Canada, NRCan and DFO and ten Canadian universities, as well as collaborators in the private sector. The Canadian Space Agency (CSA) became a major supporter of CRYSYS in 2001 through its government-related initiatives program (GRIP). The primary goals of CRYSYS have been to develop capabilities for monitoring and understanding regional and larger scale variations in cryospheric variables of importance to Canada, to improve understanding of the role of the cryosphere in the climate system and to assemble, maintain and analyze key historical, operational and research cryospheric data sets. CRYSYS investigations utilize remote sensing, modelling, field studies and data integration. The addition of CSA funding support strengthened the project's capability to make use of satellite data sets and information for the investigation of cryospheric variability and change and relationships with climate. Details on research activities and scientific results can be found on the CRYSYS website. Public outreach and data management have been a recent priority, with the establishment of a Canadian Cryospheric Information Network (CCIN) hosted by the University of Waterloo, which serves as a portal for access to cryospheric and related data sets, and as an archive for data sets acquired as part of CRYSYS research projects. The CCIN also includes a State of the Canadian Cryosphere (SOCC) website that provides, in one convenient location, up-to-date information on the past, present and future state of important cryospheric variables in Canada.

In 2003, CRYSYS was renewed as a NASA IDS team for another three-year period. Since its inception as an IDS team in 1990, CRYSYS has evolved into a strong national research effort with a network of scientists that work together to enhance understanding of cryospheric variability and change in Canada. The CRYSYS network will continue to make significant contributions internationally through science activities as part of IPY and as a Canadian component of the CliC/ WCRP.

CLIVAR

The Canadian CLIVAR research network was established with $2.3 million over five years, effective April 2001, and is a major contributor to the International Climate Variability Research Program, a component of the WCRP. It is co-funded by CFCAS and NSERC and headed by McGill University. CLIVAR's research parallels the structure of the International CLIVAR in that it has three central themes based on timescales: the seasonal to interannual timescale, the decadal to inter-decadal timescale, and the centurial timescale. On the seasonal to interannual time scale the focus is placed on developing tools for seasonal forecasting. On the decadal to inter-decadal time scale the work concentrates on understanding the dynamics of the main modes of atmospheric and oceanic variability through observational and modelling studies. On the centurial timescale the emphasis is placed on improving techniques for the detection of climate change, and on developing new tools to assess the relative importance of natural variability and anthropogenic factors in the observed climate change. In total, the network brings together 23 Canadian researchers from nine universities and four federal government research labs, and provides training opportunities for more than 20 graduate students and postdoctoral fellows in each year of the project.

Reports of Interest

In 2003, the Canadian Council of Ministers of the Environment published *Climate, Nature, People: Indicators of Canada's Changing Climate*. This full colour publication describes changes to Canada's climate during the 20^{th} century and reviews trends and implications for 12 climate change indicators. Preparation of the Report was co-led led by Saskatchewan Environment and Environment Canada.

Results from the multi-disciplinary project investigating the impact of the extreme warmth of 1998 on the arctic cryosphere were published in 2001. The final report of the project team *The State of the Arctic Cryosphere during the Extreme Warm Summer of 1998: documenting cryospheric variability in the Canadian Arctic* is available online.

8.4.2 Climate Processes

Climate processes research addresses issues related to how the climate system functions. These issues include the role of clouds, the oceans, sea ice, permafrost, and land surface processes in the climate system, as well as the function of forests, agriculture, wetlands, and oceans in the global carbon cycle. Proper understanding of these and other processes is required to predict future climate with greater certainty to support actions on mitigation and adaptation. Expertise in this area is concentrated primarily within university and a number of federal government scientific institutions. Federal and university based research is integrated through a number of major collaborative research programs. The Canadian federal government program on climate processes involves a number of departments whose core programs include studies of atmospheric and ocean processes, the water and energy cycle and the cryosphere.

Federal Research Program

In Phase 2 of the CCAF, support was aimed at climate process research. Nine projects were supported under this theme. Research on atmospheric processes included studies dealing with clouds, aerosols, radiation and their interactions and representation in climate models. Of note, a project was supported that made use of Surface Heat Budget of the Arctic Ocean (SHEBA) data to make improvements to cloud and radiation parameterizations in the Canadian GCM appropriate for arctic conditions. This work led to the establishment of new methods for partitioning condensate between ice crystals and super-cooled water droplets.

With respect to the cryosphere, research led by Environment Canada and NRCan has improved knowledge of snow and ice in all its forms. Improved techniques to determine snow and sea ice characteristics from remote sensing have been developed. Work was completed that sought to improve the representation in models of various processes affecting snow cover in cold regions. One significant outcome was the incorporation and testing of five improved snow cover parameterizations in the Canadian Land Surface Scheme model (CLASS), which provides comprehensive state-of-the-art land surface modelling capability in the Canadian Global Climate Model (CGCM), the coupled Canadian Regional Climate Model (CRCM), and weather forecast models.

Research in tundra and taiga environments has resulted in a better understanding, quantification and modelling of critical components of the water and energy cycles in the climate system. For example, as part of the Mackenzie GEWEX, Environment Canada scientists and their colleagues have determined how much water originates outside the basin and how much is recycled within the basin in warm and cold seasons. These and other investigations have also led to important improvements in the CLASS model.

DFO provided international and national leadership for the major global Ocean Climate Programs of the last decade and a half. Joint government / academic research teams investigated the transport of heat and fresh water in the North Atlantic, North Pacific and Arctic Oceans through field expeditions, data analysis and model development. These studies have provided better knowledge of the heat, freshwater, and total mass flows through the Canadian Arctic Archipelago in recent decades and their relation to the variability of the meridional overturning circulation of the Atlantic. This is important since the outward flow of water from the Canadian Arctic Archipelago, and in particular its freshwater component, plays an important role in the strength of the global oceanic thermohaline circulation. These research studies are contributing to our understanding of the fate of this circulation pattern under climate warming, and the consequences for the climate of lands that border the North Atlantic Ocean, notably eastern Canada and Europe.

DFO researchers have also been involved in Canadian SOLAS activities (see report on SOLAS below) over the past few years. The July 2002 Iron (Fe) Addition expedition – tagged SERIES: Subarctic Ecosystem Response to Iron Enrichment Study – involved a Canadian research vessel, along with vessels from Mexico and Japan. SERIES investigated the consequences of iron fertilization in the NE subarctic Pacific. The findings suggest that iron enrichment could be detrimental to open ocean ecosystems, while providing no effective sink for carbon.

Other Collaborative Programs

MAGS

Canada's supply of fresh water exceeds that of any other nation, but naturally occurring climatic changes cause these water resources to fluctuate enormously. The Mackenzie River Basin is a 1.8-million square kilometre area in northwestern Canada that is the largest North American supplier of fresh water to the Arctic Ocean. For 12 years, Canada supported a major collaborative research program into cold climate energy and water cycles through MAGS, which was part of Canada's contribution to a global study under the WCRP. MAGS was funded by two network grants from NSERC and in-kind scientific contributions and project management support from Environment Canada.

This cross-disciplinary study involved about 100 scientists and engineers from university and government sectors. The goals of MAGS were 1) to understand the circulation, storage and distribution of water and energy in the Canadian north and 2) to improve our capability to predict the impacts of human activities and climatic changes on the northern environment. A final workshop was held in 2006, during which the International Advisory Panel gave high praises to MAGS for its significant contributions to the International GEWEX.

CASES

The environmental, socio-economic and geopolitical consequences of arctic climate change will be tremendous. Understanding the nature of climate change in the Arctic is critical to Canada and to the global community. Toward that goal the CASES Research Network was funded in March 2001 by NSERC to conduct CASES. CASES is an international effort under Canadian leadership to understand the biogeochemical and ecological consequences of sea-ice variability and change on the Mackenzie Shelf in the Beaufort Sea (Arctic Ocean). Supported by funding of $10.5 million over five years from NSERC, the network brings together over 70 leading experts in polar science from 13 Canadian universities, four federal departments (DFO, Environment Canada, NRCan and the Department of National Defence) and eight foreign countries. The Canadian Coast Guard and Québec-Océan provide the administrative, logistic and navigational expertise needed for an arctic endeavour of this scope.

The main thrust of the CASES field program was the sustained one-year expedition to the study area from September 2003 to August 2004, on board the *CCGS Amundsen*, the new Canadian research icebreaker. Over 225 Canadian and foreign scientists took turns on the ship to study all aspects of the Arctic ecosystem over an annual cycle. In all, the unprecedented CASES field program will provide a three-year inter-annual comparison of the ecosystem maturation in response to sea ice cover variability, and, for the first time ever, a year-round, highly-integrated, multidisciplinary study of an arctic shelf ecosystem, including a segment of the circum-Arctic flaw polynya system. Most importantly, time-series of key measurements initiated during CASES will be pursued within the framework of *ArcticNet,* discussed below.

In addition to training the next generation of arctic specialists, CASES is contributing to the revitalization of Canadian leadership in arctic sciences. One of the numerous outcomes of the network's activities will be more accurate predictions of the extent, intensity and environmental impacts of climate warming in the Arctic.

ArcticNet

ArcticNet (described in section 8.2.2) brings together scientists and managers in the natural, human health and social sciences with their partners in Inuit organizations, northern communities, government and industry to help Canadians face the impacts and opportunities of climate change and globalization in the Arctic. Over 80 ArcticNet researchers and 200 graduate students, post-doctoral fellows, research associates and technicians from 23 Canadian universities and five federal departments collaborate on 25 research projects with more than 100 partner organizations from Canada, the USA, Japan, Denmark, Norway, Poland, the United Kingdom, Spain, Russia, Greenland and France.

ArcticNet has been pivotal to the revitalization of the Canadian Arctic research program and has been a catalyst for changing the way northern research is conducted in Canada. It has proved a unique opportunity for a much needed alliance of researchers and Inuit in the study of the changing Arctic. Integration of disciplines is occurring as Arctic specialists from all fields of research are joining forces through ArcticNet to study the consequences of the present transformation of the coastal Canadian Arctic. Furthermore, due primarily to the coordination of community visits, the logistical support of partners and the central piece of infrastructure – the research icebreaker *CCGS* Amundsen - ArcticNet is providing Canadian scientists and their international collaborators with unprecedented access to the coastal Canadian Arctic and its communities.

Finally, ArcticNet is encouraging Network Investigators to incorporate their research project into one of several Integrated Regional Impact Studies (IRISes) around which the scientific program of the Network is built. Fieldwork for ArcticNet officially started in the spring of 2004.

Canadian Surface Ocean Lower Atmosphere Study

Bounded by three oceans, Canada has a vital interest in the impact of changing ocean processes on weather patterns, resources and transportation. The Canadian SOLAS research network is part of a new international initiative aimed at understanding the interactions between the oceans and the atmosphere as well as the implications of those interactions for global climatic change.

Funding of the Canadian SOLAS network was formally announced in 2001 with funding of $8.9 million from NSERC and CFCAS with substantial additional support from DFO to support activities planned over five years. SOLAS integrates a wide range of atmospheric and marine-research specialists. The network will involve 43 researchers from nine universities, 22 government researchers from DFO and Environment Canada, two industrial collaborators and a growing number of international partners. Together, they will examine the key interactions between the marine biochemical system and the atmosphere, and the impact of these interactions on climate change.

Oceanic and atmospheric data will result from two large field efforts (an iron patch experiment in the northeast Pacific during July 2002, and a spring bloom experiment in the northwest Atlantic in 2003), five other cruises (178 total days at sea during 2002-03), and a mooring in each ocean to collect temporal data for coordination with linked ocean-atmosphere models. The first field season occurred in 2002. Now with four major research expeditions successfully completed, C-SOLAS provided the scientific centrepiece for the first SOLAS International Open Science Conference, held from the 13 to 16 October, 2004 in Halifax, Nova Scotia, Canada. The conference was an acclaimed success and the C-SOLAS community has positioned itself as leader in the International SOLAS program.

8.4.3 Biosphere GHG Sources and Sinks

Canada held a national workshop several years ago under the first phase of CCAF, which identified research gaps related to biological GHG sources and sinks. This really set the stage for development of a Canadian research program in this field. Funding of such a program was enhanced through AP2000, which made GHG sinks research one of its two main science priorities (see section 8.2). Research funded by NSERC, CFCAS, and BIOCAP has also contributed to enhancing Canadian university-based research capacity in this field.

Federal Programs

GHG sinks and sources research on the vast Canadian biosphere is an important subset of federal climate processes research, and is aimed at enhancing our understanding of the role of forests, agricultural lands, peatlands, wetlands, oceans and tundra in the global carbon cycle. Research has demonstrated the complexity of the interactions among the various components of the carbon cycle, and the importance of properly understanding these interactions to ensure our actions to use carbon sinks to reduce our net GHG emissions are robust and verifiable. The GoC has been active in the following areas:

- modelling and flux studies to evaluate the potential of management practices to reduce GHG emissions and increase the sink potential of agricultural soils (supported by AAFC);
- monitoring programs, flux studies, and infrastructure support for the BERMS project; studies related to improvement of the CLASS model, and aquatic ecosystem studies (supported by Environment Canada);
- improving carbon budget models and estimates for Canada's forest ecosystem, changes in carbon stocks through climate change and natural variability, coalbed methane studies, estimation of components of the forest and terrestrial surfaces through remote sensing; carbon storage and dynamics of northern wetlands / peatlands (supported by NRCan); and,
- air /sea exchange, CO_2 transport and sequestration, carbon transformation and losses from the surface ocean, numerical modelling studies, biological uptake and removal to the deep ocean through convection studies (supported by DFO).

To elaborate on the latter, DFO research programs seek a better understanding of the processes that control the flux of GHGs into, within and out of ocean systems, assessing the potential and verifiability of measures to enhance oceanic GHG uptake (including environmental risks and consequences). The primary objective of this ocean processes climate research is "getting the carbon right" by reducing the uncertainties in coupled ocean-ice-terrestrial-atmosphere models. The communication of such information to policy makers is important as a scientific basis for the international discussions regarding ocean based GHG sequestration programs.

For the last several decades at least, the oceans have removed up to half of the CO_2 emitted into the atmosphere from human activities. The key scientific question being addressed is whether the oceans will continue to sequester this CO_2 and whether the oceans can sequester even a larger fraction of CO_2 emissions through purposeful fertilization. Making progress in this area requires the continued integrated approach of careful observations and model development from local to global scales.

Since the Third National Report, NRCan's Canadian Forest Service research has focused on a number of areas that involve climate science, including:

- understanding how forest growth may change under a changing atmosphere;
- demonstrating the feasibility of afforesting under-utilized land to sequester carbon in the near-term;
- evaluating the impacts of different harvesting practices on riparian ecosystems in light of changing forest conditions due to decreasing moisture and increasing temperatures;
- estimating and monitoring the effects of wildfire on the carbon balance, GHG emissions and indirectly on forest health and productivity; and,
- monitoring the biomass, growth and health of aspen forests in climatically sensitive areas of the western boreal forest and aspen parkland.

The Canadian Forest Service is the lead on the development of a carbon budget model of the Canadian forest sector. This work has reduced the uncertainties regarding the net carbon balance from the forest sector (both forest ecosystems and forest products), and provided a clear demonstration of the impacts of large-scale natural disturbances on GHG emissions.

AP2000's Water Covered Lands program increased knowledge of the carbon source/sink potential of aquatic systems in Canada. Activities over the period of 2001/02 through 2004/05 included instrumentation of field sites, hydrological and biological monitoring, research and experimental studies, and compilation and analysis of historical data, For example, the carbon budgets of several boreal lakes have been described; a map of organic carbon in Canadian peatlands has been produced and validated; and a conceptual model of carbon dynamics in shallow boreal aquatic systems was developed and validated.

For agricultural soils, funding from the AP2000 science component helped establish two closely linked programs: the National Carbon and Greenhouse Gas Accounting and Verification System (NCGAVS) for agriculture; and the Biological and Greenhouse Gas Sources and Sinks (BGSS) for Agriculture program. Contributions included development of a new version of the Soil Landscapes of Canada (SLC) database; a national database of land use for the years 1990 and 2000; a database of GHG-related agricultural activities by SLC for agricultural census years from 1976 to 2001; and a database of soil carbon change data obtained from research conducted in Canada and published in the scientific literature. Various simulation models were tested and improved for studies on soil carbon sequestration and GHG emissions under various land uses and management systems. The first phase of the NCGAVS agricultural soils program was completed by March 2006. The BGSS program was also completed in March 2006.

Other Collaborative Programs

Panel on Energy Research and Development (PERD): Biological Sinks

The PERD program has supported climate change related biological sinks research, and research on the enhancement and protection of carbon sinks in forests (as well as research on climate change impacts on the energy sector). The sinks research is planned to continue until 31 March, 2007 with added emphasis on impacts on the carbon balance of wildfires and insect/disease infestations.

The stability of the carbon sink is critical for Canada's international negotiations and subsequent obligations. Both types of disturbance impact on forest-dependant communities; consequently, careful management is needed to protect the resource. Management strategies have been developed under conditions of greater stability of climate and so may be inappropriate under a future climate. Since publication of the Third National Report, research under this program has determined a cause and effect link between a changing climate and the incidence and severity of wildfire.

Fluxnet-Canada

As described in section 8.3.2 on Monitoring Networks, Fluxnet-Canada's research program is adding to the current understanding of carbon cycling and storage in Canada's forests and peatlands and the role that these ecosystems play in the global carbon cycle. While climate-induced changes will almost certainly affect the stores of carbon in the terrestrial biosphere, the most important factors influencing the terrestrial carbon cycle are likely to be land use activities and natural disturbance. Fluxnet-Canada is therefore focusing many of its measurements on disturbed sites to understand how forest management, natural disturbance and wetland creation influence carbon cycling.

One of the key scientific results from the network is the quantification of harvesting impacts on the source/sink status of Canada's forest ecosystems. A network-wide synthesis showed large differences in net carbon uptake related to age since disturbance (fire or logging) and ecosystem type (broadleaf forest versus conifer forest versus peatland). Middle-aged stands (35-60 years old) had the greatest rates of carbon accumulation. Another key network result is the large impact of year-to-year climatic variability on the forest carbon sink. Researchers at a Douglas-fir site in British Columbia found that warmer temperatures associated with El Nino caused an increase in carbon emissions, reducing the net amount of carbon sequestered. Combined measurement and modelling activities at a boreal aspen site in Saskatchewan showed that the positive impacts of spring warming on forest carbon sequestration could be offset by the negative impacts of increased summer drought.

BIOCAP Canada

BIOCAP Canada (described in section 8.2.2) is supporting the work of more than 160 university researchers in over 25 Canadian universities. In the forestry sector, the Sustainable Forest Management Network is conducting work in measurement and modelling of forest carbon stock changes. On the subject of aquatic ecosystems and reservoirs, work included study of the effect of climate, vegetation and other factors on dissolved organic carbon in aquatic systems. Research in the Landscape Scale Cropping Systems network included linkage of upland management practices and GHG dynamics in hummocky till landscapes in Manitoba and Saskatchewan. Early results were presented at a major science/policy conference in Ottawa in February 2005.

8.4.4 Biophysical Sensitivities

A further subcomponent of climate process research is that which seeks to improve understanding of the biophysical sensitivities of systems to climate and climate change. Research on the biophysical aspects of sensitivity is one component of determination of vulnerability, which is defined as the degree to which a system is susceptible to, or able to cope with the effects of climate, including extremes. Research on the biophysical sensitivities of both unmanaged and managed resources to changes in climate is conducted mainly by federal departments through a mixture of A-base funding and funding from other programs such as the CCAF (also see Chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*).

Environment Canada's Aquatic Ecosystem Impacts Research Program and the Water and Climate Impact Research Centre (W-CIRC), jointly established with the University of Victoria, conducts a national, interdisciplinary program of ecosystem-based research in the aquatic sciences which includes research on hydrological and ecosystem processes that contribute to our understanding of the biophysical sensitivities and vulnerabilities of freshwater systems to climate variability and change. The program focuses on identifying, quantifying, and modelling hydrologic and ecological impacts of climate change and variability. Major activities related to biophysical sensitivities included: developing suitable indicators of hydrological and ecological response; detecting and predicting trends in key hydrologic variables, water resources and aquatic systems sensitive to hydroclimatic extremes and variability; determining and modelling how climatic alterations affect hydrologic, geochemical and ecological processes at local and regional scales. A special focus is also placed on sensitive aquatic systems, such as the bellwether systems identified in the Arctic, or highly valued water resources that are under increasing stress from synergistic effects of resource extraction/consumption and climate variability.

Much of the work on biophysical sensitivities to climate variability and change is regional in nature. In northern and western Canada, researchers have examined the sensitivity of transboundary waters to changes in extreme events such as floods and low flows. Researchers are also examining past trends and variability in hydro-climatology and constructing future climatic scenarios of hydro-climatic conditions. In the Okanagan River basin, the implications for water quality of a projected earlier spring flood and decline in annual flow volume have been examined, in light of ecological needs and growing demand for irrigation and other human uses. In the Prairies, hydrologists are monitoring water balances in wetlands and generating hydrological models that can be used to analyze and predict the impacts of climate change and land use change.

In the Great Lakes basin, groundwater experts are modelling groundwater and climate interaction, and assessing the combined impacts of climate variability, climate change, and water use on groundwater dependent water supplies, in-stream conditions, and aquatic habitat. Scenarios of future climate change also suggest lower water levels in the future for the Great Lakes - St. Lawrence system – a consequence of particular concern for coastal ecosystems such as wetlands, and human activities such as recreation and shipping.

In the Arctic, Environment Canada has led an assessment of climate change impacts on Arctic freshwater ecosystems and hydrology, and on river flow to the Arctic Ocean. In the Mackenzie Delta region specifically, scientists are analyzing the role of climate in catastrophic lake drainage, and analyzing peak spring water levels to determine climate-related variability in the spring break-up flood; they are also working to improve models for climate change impact prediction; establishing surface energy balance over heterogeneous terrain and comparing with tower and aircraft estimates; and conducting analysis of the heat and mass exchanges of lakes.

Research results provided Canadian contributions to major international assessments and/or planning exercises such as those conducted by the Intergovernmental Panel on Climate Change (IPCC), Arctic Climate Impact Assessment (ACIA) project, International Conference on Arctic Research Planning (ICARP) and UNESCO International Hydrological Programme (IHP).

8.4.5 Climate Modelling

Federal Program

Global climate models (GCMs) are the primary tool for making quantitative projections of future climate change. These models are based on mathematical representations of physical processes that include the three-dimensional atmosphere and ocean, along with sea-ice and the land surface (and its vegetation). GCMs are used in two kinds of simulations. The first is a long 'control' run of the model with no change in atmospheric composition or other external forcing. This kind of simulation is used to understand the processes involved in natural climate variability, and to estimate the magnitude of this variability for climate change detection studies. The second kind of simulation involves specified changes in forcing such as GHG concentration and aerosol loading. This kind of simulation is used to understand (and attribute) historical climate change, and to make future climate change projections.

The core Canadian GCM effort is housed within Environment Canada, at the Canadian Centre for Climate Modelling and Analysis (CCCma) in Victoria, British Columbia. This group has been developing and applying an increasingly comprehensive progression of GCMs since the 1970s. In addition, the CCCma plays a central role in collaborative climate research with Canadian university partners and other government departments, notably DFO, who contribute expertise in ocean carbon cycle modelling. The CCCma global climate model is highly regarded internationally and CCCma scientists serve on a variety of national and international steering committees and working groups.

The CCCma's current model, CGCM3, has been used to provide the Canadian contribution to the IPCC coupled model archive, results of which will constitute a significant component of the upcoming IPCC Fourth Assessment Report. The Canadian contribution includes results from two versions of CGCM3: one with a resolution of T47 (approximately 3.8° lat/lon atmosphere and 1.9° lat/lon ocean); and one with a resolution of T63 (approximately 2.8° lat/lon atmosphere and 0.9°x1.4° lat/long ocean). A more complete description is available on the CCCma website. Results from both versions have been extensively used in model intercomparisons.

CCCma has also collaborated with the university community on the development of the CRCM. This model is used to provide higher resolution climate change information for Canada, and is driven at its boundaries by output from the CCCma global model.

Output from both the global and regional models is available to the public via the CCCma website. This website allows a user to select specific model variables, from all or part of the model domain, and download it for use in climate change research, impact assessments and the like. There are almost 1900 registered users of this website, and, on average, there are over 350 data downloads per month.

A new version of the Canadian Global Climate Model, CGCM4, is currently under development. Drawing on research undertaken over the past few years, it includes improved representation of radiative transfer, cloud processes, ocean mixing and numerical computation methods. In addition, it includes an explicit representation of the sulphur cycle and hence the direct and indirect sulphate aerosol effects. A parallel effort to develop of a model version with an interactive carbon cycle has culminated in the first comprehensive climate model in Canada with representation of terrestrial and ocean carbon cycle processes. Future efforts are expected to lead to development of an increasingly comprehensive 'Earth System Model', with interactive carbon, sulphur and nitrogen cycles, along with dynamic vegetation.

A new version of the CRCM is also under development, taking advantage of the improved representation of physical processes in the CGCM, and the availability of a new, and more flexible, dynamical core developed for operational numerical weather prediction. This new CRCM will be used to provide higher resolution downscaling of future climate change projections.

The gap between Numerical Weather Prediction and Climate Modelling is steadily narrowing through the use of coupled (atmosphere-ice-ocean) forecast systems and ensemble forecasts at seasonal to interannual time scales. In Canada, work is progressing on improving our seasonal forecast capability by using coupled models with some form of data assimilation, and by embarking on an effort to produce extended range weather forecasts with a coupled forecast system.

Finally, the Canadian research community will be devoting considerable effort to improved understanding and modelling of high-latitude climate as part of a dedicated contribution to the International Polar Year.

Other Collaborative Programs

Climate modelling research in Canada is undertaken in both federal government research facilities and in universities. A large portion of this research is done in collaboration under various national research networks. With funding from CFCAS and NSERC, a number of networks have recently been established that investigate various aspects of the research necessary to improve both the Canadian regional and global climate models:

- **CGCM3** is the Canadian Global Coupled Climate Carbon Model network that is developing terrestrial and oceanic ecosystem models to allow the CCCma climate model to represent the global interactive carbon cycle.

- **MOC2** is concerned with Modelling Clouds and Climate and is improving our ability to represent cloud and aerosol processes in the CCCma climate model.
- **GCC** is a project on Modelling of Global Chemistry and Climate and involves an upwardly extended version of the CCCma atmospheric model with a sophisticated chemistry package to represent climatically relevant processes (such as ozone depletion) in the upper atmosphere.
- **CRCM** is a network aimed at developing an improved capability for regional climate ‘downscaling’ in Canada, making use of a regional model that is physically consistent with the CCCma global model.
- **CSHD**, the Climate System History and Dynamics Network is a multidisciplinary collaborative effort that made use of paleoclimate reconstructions to evaluate climate model response to past climate forcing, particularly conditions during the last glacial maximum.

Canadian scientists are also extensively engaged in research collaborations with international colleagues, working on projects to improve the representation of various physical processes in global climate models. For example, Canadian scientists with the CCCma participate in the WCRP Working Group on Climate Modelling and the WCRP Observation and Assimilation Panel, and on the WCRP Working Group on Seasonal to Inter-annual Prediction. In addition, Canadian scientists continue to play an important leadership role in international climate research coordination and assessment bodies, such as the International Geosphere-Biosphere Programme (IGBP), WCRP and IPCC.

8.4.6 Climate Scenarios

Research into the sensitivities and vulnerabilities of ecosystems and socio-economic activities to climate change can take different approaches. On the one hand, it is instructive to understand how sensitive systems are to current climate variability in order to understand the ways in which systems could become stressed in the future with a changing climate. On the other hand, in order to consider how climate may change in the future, when past norms no longer provide appropriate guidance, insight is sought from climate change scenarios, which are developed at the appropriate time and space scale, for the system in question. Several federal government departments have recognized the value in facilitating the provision of climate change scenarios to those in Canada engaged in impacts and adaptation work.

The Third National Report described the establishment of a dedicated facility to provide domestic climate change scenarios – the Canadian Climate Impacts Scenario Project (CCIS). The Canadian Climate Impacts Scenarios Facility was originally established in 1999 with CCAF resources, after which the facility was supported by CCAF and Environment Canada through to March 31, 2005. Over 800 users were registered with the Scenarios Facility, which provided, in accordance with IPCC guidelines, climate change scenarios from over 40 projections from seven international modelling centres, as well as training on two freely available pieces of downscaling software. The CCIS project was extremely useful in improving the access of Canadian researchers and decision-makers to relevant scenario information and the need for an ongoing mechanism to continue this function was recognized. In February 2005, the GoC launched the Climate Change Scenario Network (CCSN) to expand this service and improve the links to the impacts and adaptation’s research community.

In developing a new model for development and delivery of Canadian climate change scenarios, it was deemed desirable to embed the facility within the impacts and adaptation research community and to better engage undergraduate and graduate students. The CCSN was therefore established as a national network, coincident and co-located with Environment Canada’s Adaptation and Impacts Research Division (AIRD) with nodes in each region of the country, located within universities, with the exception of Quebec, where the regional node is housed with the Ouranos Consortium (Quebec’s flagship impacts and adaptation partnership.) AIRD manages the network, and AIRD researchers located with the regional nodes facilitate scientific support to the network. The CCSN will provide climate change scenarios, bioclimatic interpretations of scenarios, tools for scenario construction, access to recent vulnerability, impacts and adaptation research and tools and improved linkages among impacts and adaptation researchers and those who use such information for decision-making.

Scenarios research supported by CCAF included projects to develop climate change scenarios for the agricultural sector across much of Canada, for the Saguenay River System in Quebec and for water basins in Western Canada. The latter two projects were designed specifically to provide projections of changes in extreme precipitation events. A one year project was funded which allowed for a dialogue between the paleoclimate community and the scenario user community in terms of the value and limitations of paleoclimate data for impacts and adaptation research. A website has been established that presents maps and other databases of paleoclimatic and paleoenvironmental data.

A GoC report that provides more information on climate scenarios is *Climate Variability and Change in Canada: Past, Present and Future*, published by Environment Canada in 2004 with funding from the CCAF. The report presents results on past and recent trends in Canada's climate and describes plausible climate futures for the country.

8.4.7 Climate Science Assessment

Formal scientific assessments of the state of understanding on complex scientific issues have become a fundamentally important way for scientists to convey advice to decision-makers on matters requiring policy decisions. Canada recognizes the value of such activities, and continues to support Canadian involvement in international assessments, and undertake national, regional and sectoral assessments of climate change. Furthermore, to support such activities, and to provide ongoing science advice on climate change (and other atmospheric issues) to Canadians and to the GoC, Environment Canada maintains an atmospheric science assessment and integration (ASAI) group. Assessment of the scientific literature on climate change is a core ongoing activity for this group, and weekly as well as annual reviews of the literature are published on-line. A review of the literature over the period 2003-2005 will soon be available on the website. The group also maintains the educational site on the science of climate change for Environment Canada.

Environment Canada's National Water Research Institute (NWRI) leads and publishes scientific assessments of priority freshwater issues in Canada, including stresses on water availability in Canada, an issue tightly linked to climate change.

NRCan manages the federal CCIAP under which a new national-scale assessment of climate change vulnerability, impacts and adaptation has been launched (see chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*).

Canada continues to support the involvement of Canadian experts in assessments by the IPCC, including the two most recent Special Reports (*Carbon Dioxide Capture and Storage*; and *Safeguarding the Ozone Layer and the Global Climate System*) as well as the upcoming Fourth Assessment Report (AR4). Twenty-eight Canadian experts from the federal government as well as Canadian universities are playing substantial roles in the AR4 as Coordinating Lead Authors, Lead Authors and Review Editors. Environment Canada also supports the Canadian IPCC Secretariat, which is within the Environment Canada-ASAI group referred to above. The GoC also hosted two meetings of the IPCC in September 2005: the Eighth Session of IPCC's Working Group III, at which the Special Report on CO_2 Capture and Storage was approved, and the 24th plenary session of the IPCC.

Canadians were also substantially involved in the ACIA, a project of Arctic Council and the International Arctic Science Committee that was completed in November 2004. Funding for Canadian experts was provided through CCIAP of NRCan, while the Canadian ACIA Secretariat was hosted by Environment Canada's ASAI group.

Two GoC reports provide information on climate science assessment. The first is a NWRI report, *Threats to Water Availability in Canada*, which was published in 2004. The report includes a number of chapters that address the impacts of climate variability and change on Canadian water resources, including one that provides a cryospheric perspective on threats to water availability in Canada. The second is an Environment Canada-ASAI report entitled *An Introduction to Climate Change*, available electronically on the group's website. It introduces the Canadian public to the subject of climate change and to the impacts of climate change both in Canada and globally.

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Chapter 9 Education, Training and Public Awareness

9.1 INTRODUCTION

Public education, training and awareness activities have been a key part of Canada's response to climate change since the late 1990s. Canada's efforts are guided in part by its international obligations. The United Nations Framework Convention on Climate Change (UNFCCC) recognizes the important role of education in the international response to climate change. Article 4(1)(i) 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(a) of the UNFCCC expands this requirement, indicating that the Parties shall "promote and facilitate:

(i) The development and implementation of educational and public awareness programmes on climate change and its effects;
(ii) Public access to information on climate change and its effects;
(iii) Public participation in addressing climate change and its effects and developing adequate responses; and,
(iv) Training of scientific, technical and managerial personnel."

This chapter will explain how education and awareness components have been built into a broad range of Canadian climate change programs, thus enhancing Canadians' recognition and understanding of the issue.

9.2 EVOLUTION OF CANADA'S PUBLIC EDUCATION AND OUTREACH

9.2.1 Historic Development: 1998-2001

The *Public Education and Outreach Issue Table* was formed as part of a 1998 process to develop *Canada's National Implementation Strategy* on climate change. It recommended a long-term, integrated and sustained public education strategy to build awareness and understanding, as well as encourage and motivate Canadians to take personal action to reduce greenhouse gas (GHG) emissions.

The Government of Canada (GoC) established the Climate Change Action Fund (CCAF) in 1998, allocating $150 million over three years. The CCAF aimed at supporting a wide range of activities to address climate change, including education, training and public awareness. It concentrated on building capacity and taking advantage of early opportunities to raise awareness. Between 1998 and 2001, the CCAF's Public Education and Outreach (PEO) component was the catalyst for more than 150 innovative climate change projects across Canada, backed with national advertising and awareness activities. CCAF's Science, Impacts and Adaptation (SIA) component also contributed to the education of Canadians and the training of scientific and other personnel.

These and other Canadian efforts were outlined in Chapter 9 of *Canada's Third National Report on Climate Change*, in 2001. In response, the UNFCCC in-depth review team recognized that Canada had successfully enhanced the general public's awareness and understanding of climate change issues.

9.2.2 Themes and Priorities: 2001-2005

Canada's work in education and training continued to sustain awareness and educate Canadians about climate change. Efforts were increasingly focused on encouraging and helping individual Canadians to reduce their GHG emissions, and on promoting market transformation – helping to embed adaptation considerations and a low-emissions mindset into government, industrial, business and institutional operations, as well as into consumer, business and institutional markets for goods and services.

Canadian governments (federal, provincial/territorial and municipal) have been working closely together and within their respective jurisdictions on these fronts and have built partnerships with stakeholders in business and industry, environmental non-government organizations (ENGOs), community organizations, youth groups, education organizations and other groups. As a result, Canada has increasingly integrated and cross-promoted the education, training and awareness efforts of all partners, creating a unified approach from the grassroots level up to the national stage.

Canada recognizes that changing behaviours permanently and instilling a low-emissions mindset throughout society is a long-term process. Canada's approach between 2001 and 2005 involved:

- building on successes and lessons learned from past activities, combined with research to help determine future needs/next steps;
- working collaboratively by building networks and partnerships with all levels of government, the private sector, the education system, youth, ENGOs and others;
- designing a wide spectrum of mutually reinforcing activities to reach Canadians in several ways, and providing tools, encouragement and support, as well as direction, to programs to help them take practical action; and,
- increasing the emphasis on measurable objectives, tracking and performance measurement tools.

9.3 BROAD FEDERAL MEASURES

During the period 2001 to 2005, the GoC introduced actions to enhance climate change awareness and understanding in all sectors of Canadian society in an effort to reduce GHG emissions. The broad GoC activities undertaken within the CCAF and the One-Tonne Challenge (OTC) are described below, and other departmentally-based programs are described in the subsequent section.

9.3.1 Climate Change Action Fund

The GoC renewed the CCAF for 2001 to 2004 with a further $150 million. CCAF had two components relevant to education, training and public awareness: Public Education and Outreach; and Science, Impacts and Adaptation. Since inception, the CCAF has funded over 600 projects, which are described in its on-line Project Database.

Given that Phase I of the CCAF was thoroughly covered in *Canada's Third National Report on Climate Change*, the description that follows will focus on Phase II of the CCAF.

9.3.1.1 Public Education and Outreach

In Phase II of the CCAF, the PEO component focused on two general activities: GoC Outreach and Partnered Outreach. In response to an evaluation of Phase I, several changes were introduced to refine the program and increase partnership and local delivery. Phase I's original eight project streams were reduced to four to reach key target groups: Communities, Youth and Educators, Business and Industry, and the General Public. The renewed CCAF-PEO program made the transition from a broad approach to a targeted investment that built on successes, filled gaps, and created and supported critical links with other GoC initiatives.

Government of Canada Outreach

Phase II of the CCAF continued to undertake national awareness activities directed towards the general public. Activities included public opinion research, a national four-page newspaper supplement that was distributed through 127 newspapers, exhibits (direct contact with more than 29,000 Canadians), publications and information (700,000 pieces of information disseminated), and a website. In addition, more emphasis was placed on supporting Climate Change Hubs (see Partner Outreach) and partners, such as the production of a teacher's kit and a toolkit.

In partnership with provincial and territorial agencies, private industry and non-governmental organization (NGOs), the GoC produced seven *Climate Change Impacts and Adaptation Posters* on the regional impacts of climate change in Canada. The original funding was provided by CCAF-PEO, but funding for reprints was shared by the OTC and the *Climate Change Impacts and Adaptation Program (CCIAP)*. All posters provide basic information about the science of climate change, highlight anticipated impacts for the region, introduce the need for adaptation and encourage individual action to improve energy efficiency in an effort to reduce GHG emissions. The series, first published in 2000/01, has been reprinted three times and more than 145,000 copies had been distributed by October 2005. The majority of recipients were education-affiliated.

The CCAF-PEO ended in March 2004. Evaluations and lessons learned from the program fed into the design of the subsequent OTC (see section 9.3.2.) This new initiative retained and built on several elements of the CCAF-PEO.

Partner Outreach

Many CCAF-PEO projects were supported by federal funding, but benefited from management by regional associations, non-profit organizations, educators and communities. Canada's *First National Climate Change Business Plan (FNBP)* recognized that the 'Enhancing Awareness and Understanding' theme would be implemented primarily though a network of outreach hubs. *Climate Change Hubs* were multi-stakeholder climate change centres that provided coordination and a focal point for public outreach projects. Hub pilots were established in ten provinces and two territories. They served as a tool for local coordination and delivery of activities, bringing together all levels of government, business, academia, environmental groups and other stakeholders. Hubs were linked nationally through a Hub Pilot Advisory Team. A CCAF evaluation concluded that hubs played a significant role in increasing awareness and motivation, and were successful in bringing together all stakeholders and uniting the climate change community.

9.3.1.2 Science, Impacts and Adaptation

The SIA component of the CCAF was designed to assist in advancing knowledge of the magnitude, rate and regional distribution of climate change and its impact on Canada, and to increase the country's capacity to adapt. CCAF-SIA was divided into two sections: Science, and Impacts and Adaptation. The Phase II CCAF-SIA science section targeted the themes of climate system processes, climate modelling, climate scenarios, and assessment/evaluation. Meanwhile, the CCAF-SIA impacts and adaptations section placed its focus on understanding the impacts of a changing climate, the process of adaptation, and disseminated the results to a diverse group of stakeholders. The latter section in particular contributed to education, training and public awareness. CCAF also continued to support university and government-based Canadian scientists involved in the work of the Intergovernmental Panel on Climate Change (IPCC).

Federal impacts and adaptation activities with education, training and public outreach components are described in detail in Chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*. However, the CCIAP, a GoC program managed by Natural Resources Canada (NRCan), is outlined with respect to these components later in this chapter.

Respondents to a CCAF evaluation survey and impact studies confirmed that users of the project outputs substantially or moderately improved their knowledge and awareness of climate change, its impacts and mitigation actions.

9.3.2 One-Tonne Challenge

The OTC was designed to encourage Canadians to take personal action to reduce their GHG emissions by one tonne, or about 20%. It aimed at market transformation by raising awareness about mitigation measures, largely through energy efficiency and energy conservation across all sectors. The program was jointly managed by Environment Canada and NRCan, with support from Transport Canada.

The OTC program consisted of two mutually-reinforcing components:

- a national marketing initiative; and,
- partnerships with key sectors.

The national campaign was supported by exhibits, e-marketing, point-of-sale co-promotions, an on-line employee awareness campaign kit, a website with tools such as an emissions calculator, and promotional tools such as an *OTC Tips Guide* to help Canadians reduce their emissions. The OTC banner was linked to appliance selection, transportation, fuel choices, home heating practices, composting and recreational choices. This program was terminated in 2006.

9.4 OTHER FEDERAL MEASURES

In addition to broad GoC activities, individual federal departments have been investing in education, training and public awareness activities. Several of the measures have a mitigation or impacts and adaptation focus, with an education or outreach component. Such measures are described in detail in Chapter 4, *Policies and Measures*, or in Chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*, while they are only briefly referenced in this chapter with a short description of their PEO component.

9.4.1 Environment Canada

Environment Canada's mandate is to preserve and enhance the quality of the natural environment, including water, air and soil quality; conserve Canada's renewable resources, including migratory birds and other non-domestic flora and fauna; conserve and protect Canada's water resources; carry out meteorology; enforce the rules made by the Canada - United States International Joint Commission relating to boundary waters; and coordinate environmental policies and programs for the federal government.

9.4.1.1 Broad Programs

Environment Canada's website provides up-to-date resources, information and ideas on climate protection, as well as approaches that enable individual Canadians to be part of the solution.

Environment Canada disseminates information on current environmental issues of interest to Canadians through a monthly on-line newsmagazine. *Envirozine*, launched in December 2000, frequently presents articles on climate change, how it is affecting Canada and what Canadians can do to take action. It also provides links to more detailed information on Environment Canada's website and other websites. Envirozine attracts users from over 58 countries, has received favourable reviews from science magazines, and was voted Yahoo! Canada's Pick of the Year for 2001 in the Environment category.

Working alongside local groups through the *Let's Drive Green (LDG) Vehicle Emissions Inspection Clinic Program*, Environment Canada not only enhanced awareness about vehicle emissions in communities across the country, but also promoted the OTC by distributing OTC guides. Results of the free tailpipe emissions and tire pressure tests were explained to drivers, as were their vehicles' approximate annual CO_2 emissions, based on their weekly fuel consumption. A pamphlet of tips was distributed to help participants learn more about actions they could take to reduce their impact on air pollution and climate change. These clinics informed drivers of the harmful effects of vehicle emissions on both health and the environment and encouraged them to change their behaviours as they relate to their personal transportation choices and practices. The LDG program was discontinued in November 2005.

Environment Canada supports local action on environmental issues such as climate change through their *EcoAction Community Funding Program*. Non-profit organizations are funded to conduct community-based projects that result in positive, measurable impacts on the environment, and/or build capacity to take action on the environment. Half of the EcoAction funds are now spent in support of climate change initiatives, and in the last several years the program has supported more than 300 projects, as described on-line. Some EcoAction Community Projects are featured in Table 9.4.1.1.

Environment Canada also supports a number of community initiatives focusing on actions that can address both clean air and climate change. Environment Canada coordinates Canada's Environment Week, held in the first week of June each year to celebrate activities that care for and nurture our environmental legacy. Environment Week incorporates Clean Air Day, a national day of events and activities to increase public awareness of and action on air quality and climate change issues.

9.4.1.2 Research and Analysis

Environment Canada is the national source for meteorological information. The service provides weather forecasts and climate information, monitors water quantity and conducts research on climate, atmospheric science, air quality, ice and other environmental issues. Environment Canada's Climate Research Branch conducts and supports scientific research to advance understanding of the climate system, explain its past and current state and behaviour, and predict and simulate its future state.

Environment Canada has produced several products to help inform the public about the science of climate change. For example, Environment Canada has produced a CD for public distribution that contains recent graphics and reports on the science and impacts of climate change in Canada.

Environment Canada also provides more technical products. It analyzes and makes available to Canadians information on the state of the Canadian cryosphere, trends in snow cover in Canada, and snow and ice data. Weekly analyses of snow cover and snow mass for Western Canada are distributed to a variety of users in water resources and agricultural agencies, hydropower companies and weather offices.

Table 9.4.1.1: Environment Canada-Funded EcoAction Community Projects

Wha Ti Sustainable Community Energy Project: This initiative was a collaborative effort by the community of Wha Ti, Ecology North, Arctic Energy Alliance, an Elders' Advisory Committee and a team of local youth to improve the sustainability of the community's energy use. A 10% reduction in GHG emissions was achieved following home energy audits and retrofits of the community's municipal and commercial buildings. The resulting *Wha Ti Community Energy Plan*, the Northwest Territories' (NWT) first comprehensive community energy plan, envisions a $10 million run-of-river mini-hydro facility on the nearby La Marte River to supply enough electricity to meet the community's energy needs for the next 20 years. Ecology North and the Community of Wha Ti are sharing the successes of this project by offering one-day community energy planning events in communities across the NWT.

Toronto Environmental Alliance's Social Housing Tenants as Environmental Leaders Project: This project aims to reduce energy use and emissions from Toronto's social housing by promoting the OTC objectives. The program, implemented in conjunction with the Toronto Community Housing Corporation's (TCHC) energy-efficiency retrofit projects, trains tenants to be community facilitators, develops educational materials and outreach tools, and creates an incentive program for inter-building competitions in energy-use reductions and for tenant success in meeting the OTC. Building retrofits, in combination with the tenant education program, are expected to reduce energy consumption in the buildings by approximately 20%.

Youth Action on Climate Change Project: Partners for the Saskatchewan River Basin manage the Youth Action on Climate Change project, a hands-on program in which 6,000 youth and 1,200 adults learn about the role of GHGs in climate change. *Youth Action on Climate Change* kits were distributed to participants across the Prairie Provinces. These kits include information and activities for measuring current contributions to GHGs and for reducing these contributions through energy efficiency, waste management and water conservation.

Environment Canada monitors, analyzes and documents Canadian and global climate trends and variations. The Canadian Centre for Climate Modelling and Analysis, within Environment Canada, develops and uses climate models to examine how the climate may change in the future. Projections of the potential effects of global warming on the climates of Canada and the world are produced with Canada's state-of-the-art climate model. These projections are used extensively across Canada and abroad by students, researchers, policy makers and many others to develop regional climate change scenarios, which are used to quantify the future impacts of climate change on a variety of sectors such as hydro-power, agriculture, forestry, natural ecosystems and urban infrastructure. Environment Canada's research helps in the training of scientific and other personnel about climate change impacts and adaptation requirements.

9.4.2 Natural Resources Canada

NRCan has a mandate to promote the responsible development and use of Canada's resources, with specialization in energy, minerals and metals, forests, and earth sciences. NRCan supports more than 20 initiatives that promote action on energy efficiency, alternative fuels and renewable energy. These include education, training and public awareness activities in all sectors of the Canadian economy. NRCan's website provides information on the department and its climate change activities.

9.4.2.1 Office of Energy Efficiency (OEE)

Many of NRCan's climate change-related programs are coordinated through the OEE, established in 1998 to be Canada's centre of excellence for energy efficiency and alternative fuels information. Some OEE program highlights are provided in Table 9.4.2.1. In addition to programs aimed at the residential, equipment, commercial/institutional, industrial and transportation sectors, the OEE also distributes more than five million copies annually of over 300 energy efficiency and alternative energy publications to individuals and organizations.

The OEE gathers and publishes a wide range of energy efficiency data, such as trends in Canadian energy use and the GHG intensity of various energy sources, and makes this information available to public- and private-sector organizations as well as to the Canadian public. This raw data forms the basis for energy use and efficiency and GHG calculations for climate change studies and reports, as well as for materials intended for the public, such as the OTC Tips Guide and on-line GHG calculator.

The OEE's energy efficiency and alternative fuels programs are described in depth in Chapter 4, *Policies and Measures*. Most of the programs include substantial public outreach and education components, targeting builders, home owners, households, trades people, real estate agents, and other stakeholders. They are designed to inform the target audiences so that they can make wise construction, purchasing and retrofitting decisions.

In the commercial and institutional sectors, OEE coordinates training in energy management techniques and promotes best practices in energy efficiency through programs designed to engage companies in setting targets for reduced energy use and lowered GHG emissions.

In both the residential and commercial/institutional sectors, OEE also manages programs that encourage homeowners, businesses and others to switch to energy-efficient equipment (including appliances).

OEE's transportation programs encourage improved energy efficiency of the personal, commercial and federal vehicle stocks and seek to influence driver behaviour, vehicle maintenance practices and fleet management. Extensive educational material is found on the OEE's programs website.

OEE partners with Transport Canada on some freight efficiency programs, discussed later in this chapter. It also has programs that promote the use of alternative transportation fuels.

Working with the industrial sector, the *Canadian Industry Program for Energy Conservation* (CIPEC), described in Chapter 4, *Policies and Measures*, continues to be the OEE's main industry outreach program. CIPEC training and awareness initiatives encourage energy efficiency so as to improve industrial productivity, cut costs and contribute to the government's climate change goals.

Table 9.4.2.1: OEE Program Highlights

EnerGuide: EnerGuide labels increase public awareness of the link between energy and the environment, and promote the opportunities opened up by energy-efficient technology. The labels, which can be affixed to the product alone or be part of its price label, have a standardized design and provide a measurement of energy performance. They help and encourage consumers to make energy-wise choices when buying a wide variety of products, from homes to vehicles, appliances and equipment.

ENERGY STAR: The international ENERGY STAR ® symbol takes the EnerGuide concept one step further, by identifying for consumers the products that are among the most energy-efficient ones on the market.

Auto$mart Driver Education: In partnership with the Canadian driver education industry, this program promotes energy-efficient vehicle operating techniques. Since its inception in 1997, Auto$mart training courses have reached approximately one million new drivers. Officially launched in February 2005, the updated, expanded and redesigned Auto$mart resource package now also includes train-the-trainer workshops for instructors to show them how to use and incorporate these new materials into their regular curricula. As of August 2005, nearly 500 driving instructors had received this comprehensive fuel efficiency training.

FleetSmart: This program offers free practical advice to both public sector and commercial vehicle fleets on how energy-efficient vehicles and business practices can reduce a fleet's operating costs, improve productivity and increase competitiveness. The program directs participants to fuel-saving information, Smart Driver training, a Commercial Transportation Energy Efficiency Rebate, publications on bench marking and success stories, and other materials. OEE has provided training in fuel-efficient practices to more than 315,000 professional fleet drivers since 2001.

Dollars to $ense Workshops: Under CIPEC, more than 9,000 representatives from over 4,500 organizations from across Canada have enrolled in these energy management workshops. The one-day workshops are designed to disseminate energy-saving tips to industry representatives so as to benefit their organizations and facilities through lower operating and production costs, an improved competitive position, reduced GHG emissions, increased operational efficiency, and a better work environment.

Employee Awareness Program: This program is intended to help companies get their employees on board with energy management programs by increasing the employees' awareness and understanding of energy efficiency and their ability to achieve energy management goals. OEE has produced an employee awareness toolkit to help companies bring home the idea of energy conservation. The toolkit includes a guidebook to assist companies in getting started and several off-the-shelf tools (e.g. posters, fact sheets, slide show presentations) to help them develop an Employee Awareness Program.

9.4.2.2 Canadian Forest Service (CFS)

NRCan's CFS investigates how forests interact with climate and the role they occupy in the issue of climate change. It plays a key role in developing skilled workers, publishing scientific findings, increasing public awareness of climate change and its impacts on forests, and translating its findings into information relevant to partners. CFS works with industry, universities, NGOs and other federal and provincial government departments on several aspects of climate change.

From 2001 to 2004, CFS produced 146 climate change publications and 121 scholarly articles. CFS engages in training researchers and industry personnel on the application of the climate change related models it has developed, such as an operational-scale carbon budget model and a simulation model of insect outbreaks under various climate change scenarios.

CFS, in partnership with the *Natural Sciences and Engineering Research Council* (NSERC) and the *Social Science and Humanities Research Council* (SSHRC), supports graduate student research through the Graduate Supplement Program. This program allows students to conduct research in collaboration with CFS research centres. The Program has supported 68 graduate students from 2001 to 2006, some of whom have done research related to climate change.

CFS is also a partner in the *Fluxnet Canada Research Network* (FCRN). FCRN was created in 2002 as a network of university and government scientists, including researchers from the five CFS centres, who study the interactions between climate disturbances and carbon cycling in Canadian forest and peatland ecosystems. FCRN has also supported 58 graduate students and postdoctoral fellows.

CFS has made an operational-scale version of its Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3), which is publicly available at http://carbon.cfs.nrcan.gc.ca, and supports it through training workshops. Analysts from industry and provincial and territorial resource management agencies can use the model to evaluate the impacts of alternative forest management strategies on carbon emissions and removals.

Finally, CFS has been leading Canadian participation in the North American Carbon Program (NACP), a US-initiated tri-lateral research program that plans to provide continental-wide estimates and maps of carbon sources and sinks using state-of-the-art approaches. The program involves collaboration of public sector and university-based researchers in Canada, the United States and Mexico.

9.4.2.3 Minerals and Metals Sector (MMS)

NRCan's Minerals and Metals Program is working with partners to reduce GHG emissions through enhanced mineral and metal processes and practices. The program, described in detail in Chapter 4, *Policies and Measures*, aims to improve awareness and transfer knowledge to stakeholders, be they industrial representatives, owners, architects, engineers, or municipal and provincial decision-makers. This is accomplished through seminars and workshops for the exchange of information, as well as the development of networks. Information products include videos, brochures and technical articles.

9.4.2.4 Earth Sciences Sector (ESS)

Housed within ESS, the *Climate Change Impacts and Adaptation Directorate (CCIAD)* oversees the CCIAP, which has several education and public outreach components. CCIAP is described in detail in Chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*. Since 2001, CCIAP has organized six national workshops and conferences to disseminate information to decision-makers and the scientific community. In addition, CCIAP has provided financial support for 14 national and regional events, aimed at disseminating knowledge of impacts and adaptation issues. It informs the public on initiatives through a Project Database on its website.

An important awareness-building output of CCIAP was the publication of *Climate Change Impacts and Adaptation: A Canadian Perspective*, released in 2004. It provides an overview of research in the field of climate change impacts and adaptation as it relates to Canada. The publication has been used by students, educators and libraries, and is included in information kits such as the *Climate Change Tool Kit for First Nations Communities*.

CCIAD coordinates operations and facilitates interaction between stakeholders and researchers through the national *Canadian Climate Impacts and Adaptation Research Network* (C-CIARN) program. Since its inception in 2001, C-CIARN has held over 130 workshops among researchers, industry, governments and NGOs that have increased understanding of climate change impacts and adaptation across

Canada. Chapter 6, *Vulnerability Assessment, Climate Change Impacts and Adaptation Measures*, discusses C-CIARN in greater detail.

ESS also has several other activities that integrate public outreach. Of particular note is the Climate Change Show, a collaborative initiative by NRCan and the Canadian Association of Science Centres, which is on a five-year, cross-country tour to inform and educate Canadians about the impact of a changing climate and how to adapt to it. The centrepiece of the show is the Climate Explorer, an interactive computer system housed in a helicopter shell, which teaches visitors about climate change through Mt. Logan ice cores, information on forest fires, bio-fuels and lightweight metals. The show is expected to reach more than one million Canadian citizens.

The results of the ESS expedition to extract ice cores from Mt. Logan have also been publicized through popular lectures by the Yukon Science Institute and Kluane National Park Visitor Centre and a multi-media, interactive exhibit by the Canadian Museum of Nature. These outreach efforts demonstrate to Canadians the relevance of paleo-climate data in reconstructing past climates for climate change impact analysis.

9.4.3 Transport Canada

Transport Canada has undertaken steps to better understand the transportation system's vulnerabilities to climate change and to develop effective strategies to respond to negative impacts. Programs and initiatives are described on Transport Canada's environment website.

In accordance with the federal government's policy framework, Transport Canada has implemented programs and participated in initiatives to reduce GHG emissions from all modes, while focusing on three areas: vehicles and fuels, passenger transportation, and goods transportation. Public awareness has been a key feature of these initiatives. Programs aim to influence supply of, and consumer demand for, integrated transportation strategies and advanced technology in terms of equipment and vehicles. Transport Canada also works closely with the lead departments on the OTC, bringing partners like Via Rail to the program.

Some of the Transport Canada programs that have an education, training or public awareness component include:

- Advanced Technology Vehicle Program;
- Urban Transportation Showcase Program;
- Moving On Sustainable Transportation Program;
- Freight Efficiency Program; and,
- Freight Efficiency and Technology Initiative (including a Freight Sustainability Demonstration Program and other training and awareness campaigns).

These programs are described in Chapter 4, *Policies and Measures*.

In 2003, Transport Canada hosted the National Workshop on Impacts of Climate Change on Transportation in Canada, which brought together industry, academia, governments and other organizations. The goal of the workshop was to identify current and potential impacts of climate change on transportation infrastructure and operations in Canada, and to provide advice to government and industry on preliminary steps towards adaptation planning, including research needs. To fill these research needs, Transport Canada has been actively involved in reviewing research proposals under CCIAP.

9.4.4 Health Canada

As the federal lead department on issues that intersect climate change and health, Health Canada facilitates the development of interdisciplinary research. It encourages multi-disciplinary efforts to develop sound science to support climate change adaptation actions and policies at various levels of government.

C-CIARN Health is a network made up of external scientists and policy makers that promote interdisciplinary research and disseminate information to increase understanding of priority health concerns associated with climate change. The information helps governments, communities and individual Canadians prepare to adapt to climate change.

Health Canada's *Climate Change and Health: Research Report*, released in 2004, provides an overview of climate change-related health concerns, highlights the work of C-CIARN Health, and profiles the accomplishments of selected Canadian researchers. It also encourages additional researchers and practitioners to become engaged.

To support future assessments of health impacts associated with climate change, Health Canada, the World Health Organization (Europe), in association with the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), published *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change* in 2003. It is intended for use in both developed and developing countries. It presents flexible methods and tools for governments, health agencies and environmental and meteorological institutions to use in assessing the health impacts of climate variability and change at regional, national and local levels.

9.4.5 Agriculture and Agri-Food Canada (AAFC)

AAFC is mandated to provide information, research and technology, and policies and programs to achieve security of the food system, health of the environment and innovation for growth. *Agriculture in Harmony with Nature II: AAFC's Sustainable development strategy 2001-2004* promotes partnership among government, industry and communities, through which AAFC can share information on environmentally sound products, practices and technologies, and encourage adoption of these innovations by the agriculture sector through adaptation and stewardship initiatives. With AAFC resources, research and technology development has taken place that informs sectoral actors of sources of GHGs, best practices to reduce emissions of methane and nitrous oxide, and methods to increase carbon sequestration in soils and shelterbelts.

9.4.6 Department of Foreign Affairs and International Trade (DFAIT)

DFAIT's Clean Development Mechanism and Joint Implementation (CDM and JI) Office enhances Canada's capacity to achieve GHG emissions targets through international partnerships with developed and developing nations. The office conducts outreach to Canadian industry and host-country project proponents through meetings and workshops, trains officers at Canadian missions abroad, develops communication products, participates in trade shows and workshops, and assists less developed countries with the technical aspects of CDM and JI office or focal point start-up. DFAIT also manages international Sustainable Development activities that include knowledge-sharing and training in developing countries. A more detailed description of DFAIT's climate change-related activities is presented in Chapter 7, *Financial Resources and Transfer of Technology*.

9.5 PROVINCIAL AND TERRITORIAL ACTIVITIES

In addition to working in partnership with the GoC on climate change initiatives such as the Hubs, provincial and territorial governments have made increasing investments in climate change awareness, training, and education since 2001. Some jurisdictions have undertaken climate change education, training and public awareness activities as they broadly relate to regional issues, from air quality to adaptation to sea level rise, while others have moved forward on activities specific to climate change. Considerable provincial action is driven by an interest in demand-side management.

Many provinces and territories work with the federal government to enhance or expand federal initiatives. For example, in Quebec, Hydro-Québec matched two to one the incentives provided by EnerGuide for Houses. In addition, several provinces and territories, such as Prince Edward Island, Quebec, Alberta and British Columbia, have developed their own climate change actions plans, some of which feature education, training and public awareness activities.

British Columbia's 40-point action plan on climate change reflects its interests in forestry, water management and clean energy production. Its education and awareness activities include community information on adaptation measures, such as flood preparation, a GHG Action Guide for municipal governments, and workshops on adaptation measures for forest sector and protected-area managers.

Public awareness activities in Quebec's *Action Plan on Climate Change* (2000-2002) focused on providing financial assistance to: non-profit organizations, for the publication of educational documents; awareness-raising events targeting schoolchildren and the general public; promotion of non-automobile transportation modes; and, demonstrations of the benefits of sustainable agriculture.

Alberta has taken a multi-stakeholder approach to education, training and awareness in its climate change plan. Alberta's *Climate Change Central* is a unique partnership among Alberta businesses, governments and the environmental community, aimed at reducing GHG emissions. Its multi-stakeholder programs focus on innovation, technology, education and public participation to strengthen Alberta's environmental energy advantage.

Manitoba's *Climate Change Connection* takes a different approach, focused on individual Manitobans. It seeks to build awareness and empower Manitobans to take action and reduce their GHG emissions, both individually and as a community. It offers information and tools to help Manitobans make the changes necessary to live more climate-friendly lifestyles.

A number of provincial activities are geared towards the formal education system, which falls under provincial jurisdiction in Canada. Saskatchewan, for example, has developed climate change curriculum modules for kindergarten to grade 12 and holds workshops for teachers on how to deliver this new material. Saskatchewan is also integrating climate change curriculum into university-level teacher-training courses, so that teachers will graduate with climate change curriculum already included in their basic curriculum.

Ontario has also added climate change to its education system. The province's *Partners in Air* program includes lesson plans on climate change. *Partners in Air* is a hands-on classroom initiative to give high school students an opportunity to study air quality and discuss their findings with students and scientists everywhere via the internet. Both British Columbia and Ontario are incorporating energy-efficient driving and vehicle maintenance tips into provincial student driving programs.

For some provinces and territories, it is more cost-effective to direct resources to shared, rather than individual public awareness, education and training efforts. As a consequence, these jurisdictions are focusing their support on their provincial climate change hub or on related NGOs. This is particularly the case in Atlantic Canada and the North. For example, Prince Edward Island's *First Business Plan* (2000-2003) recognizes that a unified national strategy for education and awareness is a more effective approach than a fragmented approach delivered by each territorial and provincial jurisdiction. Other jurisdictions support the work of NGOs to raise public awareness on climate change issues, as detailed in section 9.6.

9.6 OTHER CANADIAN ACTIVITIES

Municipalities, environmental groups, NGOs, businesses, industry and individual Canadians play an important role in raising awareness of climate change and encouraging action by all parts of society. Like the provinces and territories, many municipalities are supporting and expanding upon federal initiatives, such as the idle-free campaigns. They also organize their own education and outreach programs, such as those described below.

Municipalities are key players in the climate change training, education and public awareness network. The Federation of Canadian Municipalities (FCM) has spearheaded a number of programs to build community capacity to embed a low-emissions approach into municipal operations and community action. For example, the Partners for Climate Protection (PCP) program, funded in part by the FCM-administered *Green Municipal Fund (GMF)*, guides more than 132 Canadian municipal governments to reduce GHG emissions and act on climate change. PCP is the Canadian component of ICLEI's Cities for Climate Protection (CCP) network that comprises more than 600 communities worldwide making the same efforts. Municipal participants and their milestone status are provided on the FCM website.

A wide range of environmental organizations, institutes and non-profit groups work hard to raise awareness and educate the Canadian public about climate change. These include national organizations, such as the David Suzuki Foundation, the Sierra Club, Pollution Probe, the Pembina Institute, Friends of the Earth, the World Wildlife Fund and Greenpeace. As well, there are numerous smaller organizations that focus on a particular region or community, or on a single set of climate change issues, such as energy efficiency.

Communities in Canada's North are particularly concerned about the impacts of climate change and ways to adapt. The *Northern Climate ExChange*, a program governed by the Northern Research Institute at Yukon College and funded by the CCAF and the Government of Yukon, works to build understanding of the impacts of climate change on the northern economy, environment and social fabric. Among other activities, it supports the contributions of indigenous peoples to the climate change knowledge base by promoting the acceptance of traditional knowledge and aboriginal expertise.

Similarly, the *Arctic Energy Alliance*, a partnership of the Northwest Territories government and other groups, is the Northwest Territories' foremost source of information and expertise on renewable energy use, energy efficiency and reducing the causes of climate change.

In Atlantic Canada, the *Conservation Corps of Newfoundland and Labrador* is a not-for-profit organization dedicated to providing youth with training and employment in environmental and cultural heritage conservation. Its Green Teams have completed upwards of 250 environmental and cultural projects, including climate change projects, in more than 100 communities across the province.

Clean Nova Scotia is a non-profit ENGO that works with Nova Scotians to help them understand the importance of environmental responsibility, focusing on climate change and other environmental issues.

9.7 RESULTS

Today, almost all Canadians (94%) have heard about climate change, and there is a much better understanding of its causes and impacts. As an illustration, in 1989, about 40% of Canadians thought that ozone layer depletion was a cause of climate change. By 2005, research showed that only 13% of Canadians attributed climate change to depletion of the ozone layer.

While the greatest shift in awareness and understanding occurred in the late 1990s, we are now seeing a major shift in Canadians' sense of responsibility to take personal action. In 1998, 54% of Canadians who had heard about climate change felt there was something they personally could do about it. That number had jumped to 68% by 2001, and was at 78% as of 2004.

While progress has been made, changing behaviours permanently and embedding a low-emissions mindset throughout society is a long-term process.

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* Except Ontario

Appendix 1 - Summary of Policies and Measures

Table of Content

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
POLICY STATEMENTS						
Government of Canada						
Action Plan 2000 on Climate Change	This $500 million climate change plan announced in 2000 aimed at reducing GHG emissions by 65 megatonnes annually during the period 2008 to 2012. It included measures to reduce emissions from the transportation, energy and industrial sectors, as well as from buildings, agriculture and forestry. It also comprised initiatives related to science, adaptation, technology and international cooperation.	all	Policy	Terminated	Various departments	
Climate Change Action Fund (CCAF)	This Fund was initially announced in 1998 with funding of $150 million over three years. It was extended for an additional three years in 2000, at the same level of funding. The CCAF supported early actions to reduce GHG emissions and to increase understanding of the impact, cost and benefits of the Protocol implementation, as well as identify implementation options available to Canada.	all	Policy	Implemented	Various departments	
Climate Change Plan for Canada	Released in 2002, this plan built on existing federal measures and proposed a range of new initiatives to see GHG emissions in Canada reduced by 180 megatonnes annually during the period 2008 to 2012. It also proposed measures to improve climate science and to prepare to adapt. A number of measures contained in this Plan were implemented through an investment of $1.3 billion announced in 2003.	all	Policy	Planned / Implemented	Various departments	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Project Green – Moving Forward on Climate Change – A Plan for Honouring our Kyoto Commitment	This climate change plan released in 2005 was built on six key elements: • Competitive and sustainable industries for the 21st century; • Harnessing market forces; • A partnership among Canada's governments; • Engaged citizens • Sustainable agricultural and forest sectors; and, • Sustainable cities and communities.	all	Policy	Planned	Various departments	
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
Albertans & Climate Change: Taking Action	Released in February 2002, this plan provided the framework - targets, goals and milestones - that will ensure challenging and effective actions are taken to reduce GHG emissions in Alberta. This plan includes actions in the following areas: • Government Leadership • Energy Conservation • Carbon Management • Technology and Innovation • Renewable and Alternative Energy • Enhancing Carbon Sinks • Adaptation	CO_2, CH_4, N_2O	Information/ Awareness/ Fiscal/ Research	Implemented	Government of Alberta / Alberta Environment	Objective is to reduce GHG relative to GDP by 20% below 1990 levels, in the province, by 2010.
Climate Change Action Plan 2005	In July 2005, the Government of Newfoundland and Labrador released a plan that outlined action items to reduce GHG emissions and initiatives to help the province adapt to the impacts of climate change. The plan includes 40 action items that relate to education, transportation, energy efficiency, resource industries, municipalities, industry and the building sector.	CO_2, CH_4, N_2O	Information/ Awareness/ Fiscal/ Research	Implemented	Government of Newfoundland and Labrador	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Making it Work: A Saskatchewan Perspective on Climate Change Policy	In October 2002, Saskatchewan released a perspective that outlined past actions on climate change. Saskatchewan has established a climate change program that is undertaking projects in five major areas: • development of public education initiatives; • development of new technology to dispose of carbon dioxide; • development of strategies to assist in adapting to potential climate change; • development of biological sinks for carbon dioxide in agricultural soils and forests; and • implementation of energy conservation and alternative energy projects.	CO_2, CH_4, N_2O	Information/ Awareness/ Fiscal/ Research	Implemented	Government of Saskatchewan	
Curbing Climate Change – Prince Edward Island Climate Change First Business Plan	In 2001 Prince Edward Island released its climate change business plan. The plan included actions on climate change related to capacity building, research, technology development and government leadership.	CO_2, CH_4, N_2O	Information/ Awareness/ Fiscal/ Research	Implemented	Government of Prince Edward Island	
Kyoto and Beyond	In October 2002, Manitoba released its climate change plan. The plan highlights some actions to be undertaken in a variety of sectors, with the majority of planned emissions reductions coming from renewable electricity and targeted measures in agriculture and other industrial sectors.	CO_2, CH_4, N_2O	Information/ Awareness/ Fiscal/ Research	Implemented	Government of Manitoba	Reduce emissions by up to 18% by 2010 and up to 23% by 2012.
NWT Greenhouse Gas Strategy	In March 2001, the Northwest Territories (NWT) government released its climate change strategy aimed at mitigating or controlling GHG emissions by: • increasing awareness; • engaging all northerners to take action to control GHG emissions; • identifying and implementing achievable and practical actions; • identifying economic opportunities that may arise from the use of cleaner, more efficient equipment and technology; and, • identifying potential sources of funding that may be utilized to implement the actions identified.	CO_2, CH_4, N_2O	Information/ Awareness/ Fiscal/ Research	Implemented	Government of the Northwest Territories (GNWT)	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Québec Action Plan on Climate Change 2000-2002	The October 2000 Plan established a series of measures that will aim at preserving what has been gained thus far, obtaining additional reductions from the principal GHG emitters, and leveling off the ascending curve of transport-related emissions in Quebec.	CO_2, CH_4, N_2O	Information/ Awareness/ Fiscal/ Research	Implemented	Government of Québec	
Weather, Climate and the Future: B.C.'s Plan	The December 2004 Plan outlined 40 actions that will shape the efforts of British Columbia as it works with the federal government, industry, local government and individuals to address climate change. The plan's target is to maintain the province's ranking of third-lowest per-capita GHG emissions.	CO_2, CH_4, N_2O	Information/ Awareness/ Fiscal/ Research	Implemented	Ministry of Environment / Government of British Columbia	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - CROSS-SECTORAL						
Government of Canada						
Aboriginal and Northern Community Action Program (ANCAP)	ANCAP facilitates the engagement of Aboriginal peoples and Northerners in climate change activities and undertakes specific initiatives to address the energy needs of Aboriginal and northern communities, with an emphasis on capacity building, use of alternative energy sources and energy best practices.	CO_2, N_2O	Outreach / Education / Fiscal	Implemented	Natural Resources Canada / Indian and Northern Affairs Canada	Generated 60 projects by the end of March 2005.
CANMET Energy Technology Centre (CETC)	As Canada's leading S&T organization, CETC works with private and other public sector partners to develop and demonstrate energy efficient, alternative and renewable energy technologies and processes for virtually all sectors of the Canadian economy. CETC is funded primarily from PERD and T&I R&D, which are described below. Technology development activities are performed on cost-shared basis through either in-house R&D work at their laboratories or by providing funding support to their technology partners.	CO_2, CH_4, N_2O	Research / Economic	Implemented	Natural Resources Canada	
EcoAction Community Funding Program	This broadly-focused program provides financial support to community groups for projects that have measurable, positive impacts on the environment (including with respect to climate change) such as projects that have an action focus, a community capacity building focus, or a combination of both objectives. It is delivered by a network of regional offices across Canada. Each office maintains a website that caters to its region.	CO_2, CH_4, N_2O	Economic	Implemented	Environment Canada	
Federal House in Order (FHIO)	To show leadership and contribute to achieving Canada's overall goals, the 11 federal departments that account for 95% of all GoC GHG emissions have committed to reduce those emissions to 31% below 1990 levels by 2010. FHIO is supported by three associated programs: the *Federal Buildings Initiative (FBI)* and the *Energy Technology Applications Group's (ETAG's)* are described in the "Buildings" sector, while the *Federal Vehicles Initiative (FVI)* is described in the "Transportation" sector.	CO_2, N_2O	Fiscal / Voluntary Information	Implemented	Natural Resources Canada	The GoC has already achieved a 24% emissions reduction, since 1990.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Gas Tax Fund (GTF)	This fund provides annual allocations over a five-year period to all municipalities across Canada to fund environmentally sustainable municipal infrastructure that improve the quality of the air and water, and reduce greenhouse gas emissions. It includes a component to address the infrastructure needs of First Nations Communities.	CO_2, CH_4, N_2O	Fiscal / Economic / Outreach	Implemented	Infrastructure Canada	
GHG Verification Centre (The Centre)	The Centre is an assistive program intended to help domestic climate change initiatives to better quantify their GHG emissions and emission reductions. The Centre has addressed this by building a database and resource centre of GHG-related literature and tools, developing quantification and verification protocols, providing technical support and initiating a process whereby private sector companies could become accredited to verify GHG emissions and emission reductions.	CO_2, CH_4, N_2O, SF_6, HFC, PFC	Education / Information / Outreach	Implemented	Environment Canada	Six training sessions are scheduled for 2006.
Green Municipal Fund (GMF)	The GMF supports partnerships, leveraging both public and private sector funding to encourage municipal actions to improve air, water and soil quality, and to reduce GHG emissions. Prior to April 1, 2005, the fund was subdivided into the following two funds:	CO_2, CH_4, N_2O	Fiscal / Economic / Outreach	Implemented	Federation of Canadian Municipalities (FCM)	Since its inception in 2000, 522 feasibility studies, projects and field tests have been approved.
Green Municipal Enabling Fund (GMEF)	The Green Municipal Enabling Fund (GMEF) provided grants for cost-shared feasibility studies to improve the quality of air, water and soil through greater energy efficiency, the sustainable use of renewable and non-renewable resources and more efficient water, waste and waste water management.					
Green Municipal Investment Fund (GMIF)	The Green Municipal Investment Fund (GMIF) was a permanent revolving fund that supported the implementation of innovative environmental projects whereby a municipal government could borrow at preferred interest rates. Partners were also eligible for loans at attractive rates. The Fund also provided grant funding for pilot projects with significant environmental impact and replication on a regional or national basis.					

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Hydrogen Early Adopters (h2EA) Program	Designed to demonstrate integrated hydrogen and hydrogen-compatible technologies in real-world settings, the program encourages the awareness and acceptance of these groundbreaking technologies through their installation and demonstration in transportation, residential and commercial power generation applications. In addition, it seeks to attract and retain world class talent as well as domestic and foreign investment.	CO_2, N_2O	Research / Information / Awareness	Implemented	Industry Canada	As of March 2005, awarded $13.3 million to four projects across Canada involving 33 organizations in partnership.
Infrastructure Funds	The GoC provides funding to support the development of infrastructure in Canada. Climate change-related projects are eligible. Key funds are described below.	CO_2, CH_4, N_2O	Fiscal / Economic / Outreach	Implemented	Infrastructure Canada	
Canada Strategic Infrastructure Fund (CSIF)	This Fund is directed to projects of major federal and regional significance in areas that are vital to sustaining economic growth and enhancing the quality of life of Canadians.					
Infrastructure Canada Program (ICP)	This Fund enhances infrastructure in Canada's urban and rural communities and improves quality of life through investments that protect the environment and support long-term community and economic growth.					
Municipal Rural Infrastructure Fund (MRIF)	This Fund supports smaller scale municipal infrastructure projects that improve the quality of life, sustainable development and economic opportunities, particularly of smaller communities. It includes a component to address the infrastructure needs of First Nations communities.					
Innovation Excellence Initiative	This initiative aims to advance Canada's leadership, through support for research, development and proof-of-concept demonstrations in hydrogen technologies. Its objectives are to reduce costs and improve the reliability, durability and longevity of hydrogen technologies, including production, distribution and storage technologies and those involving different energy pathways. The *Canadian Fuel Cell Commercialization Roadmap* will provide strategic direction for these investments.	CO_2, N_2O	Research / Information / Awareness	Implemented	Industry Canada / Natural Sciences and Engineering Research Council of Canada (NSERC)	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Northern Ecosystem Initiative (NEI)	This broadly-focused initiative enhances the health and sustainability of communities and ecosystems in the Canadian North. The initiative is guided by the principle of sustainable development and follows an interdisciplinary scientific approach that also seeks to assimilate local and traditional knowledge. Initial efforts have concentrated on four priority issue areas: biodiversity; climate change in the North; contaminants in northern ecosystems; and, impacts of development.	CO_2, N_2O	Research / Information / Awareness	Implemented	Environment Canada	Developed 14 focus projects.
NRC Fuel Cell and Hydrogen Program	This program provides R&D aimed at delivering the breakthroughs needed to reduce fuel cell costs, improve reliability and increase durability. It aims at facilitating the transition to the hydrogen economy and fostering a globally competitive industry in Canada by expanding the knowledge base as well as new and improved technologies for climate change mitigation related to a hydrogen economy.	CO_2, N_2O	Research / Information / Awareness	Implemented	National Research Council Canada (NRC)	Funded 11 research projects in 2004/05. Also produced 27 peer-reviewed scientific papers and filed five patent applications.
Opportunities Envelope (OE)	Provided funding to the provinces and territories as they continued to develop solutions that meet their specific needs and circumstances, and support national climate change goals at the same time. The OE also allowed the GoC to contribute to cost-effective emissions reduction initiatives brought forward by its provincial and territorial partners.	CO_2, CH_4, N_2O	Fiscal / Economic	Terminated	Natural Resources Canada / Environment Canada	29 initiatives have been approved for funding.
Pilot Emission Removals, Reductions and Learnings (PERRL)	Provided Canadian companies and organizations with an economic incentive to reduce GHG emissions through projects in areas such as methane emissions from landfills, renewable energy and carbon sinks. Through this initiative, the GoC purchased GHG emissions reductions and removals from qualified projects on a lowest-cost-per-tonne basis.	CO_2, CH_4, N_2O	Fiscal / Economic / Outreach	Terminated	Environment Canada	Total emission reductions for 2004-2007 is 1.7 Mt.
Program of Energy Research and Development (PERD)	This federal, interdepartmental program funds research and development (R&D) designed to ensure a sustainable energy future for Canada in the best interests of both the economy and the environment. It directly supports 40% of all non-nuclear energy R&D conducted in Canada by the federal and provincial governments, and is concerned with all aspects of energy supply and use.	CO_2, CH_4, N_2O	Research / Economic	Implemented	Natural Resources Canada	Currently funds 26 energy R&D programs.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Sustainable Development Technology Canada (SDTC)	This not-for-profit foundation, established by the GoC in 2001, draws from an investment fund of $550 million. It finances and supports the development and demonstration of clean technologies that provide solutions to issues of climate change, clean air, water quality and soil. SDTC-funded projects are active in all major Canadian economic sectors.	CO_2, CH_4, N_2O	Research / Economic	Implemented	Natural Resources Canada / Environment Canada	Completed six funding rounds and allocated a total of $126 million to 60 projects.
Technology and Innovation Research and Development (T&I R&D) Initiative	This initiative, established in 2003 to advance promising GHG technologies through R&D, provides funds directly to partner departments and agencies, which then team up with provinces, the private sector and/or universities. Nine Expert Groups have been set up under the following technology areas: i) Cleaner fossil fuels; ii) Advanced end-use efficiency iii) Distributed energy production iv) Biotechnology v) Hydrogen economy.	CO_2, CH_4, N_2O	Research / Economic	Implemented	Natural Resources Canada	Currently funds 11 energy R&D programs.
Technology Early Action Measures (TEAM)	Identifies, develops and supports technology late stage development and demonstration projects, and technology transfer opportunities in support of early action to reduce GHG emissions, domestically and internationally, while sustaining economic and social development. TEAM investments are aligned with the T&I R&D initiative. Its unique approach brings together industry, community, and international partners to encourage additional investment in innovative technology.	CO_2, CH_4, N_2O	Research / Economic	Implemented	Natural Resources Canada	As of March 2005, supported 98 projects in 64 Canadian cities. Also supported projects in 14 other countries.
Technology to Market (T2M) Program	Established to improve the commercialization process from federal R&D onward, this program funds market studies to analyse the domestic market potential and expected barriers to uptake or technology transfer. The program also evaluates whether technologies are ready for hand-off to demonstration and deployment programs managed by other departments and agencies, or directly to industry.	CO_2, CH_4, N_2O	Research / Economic	Implemented	Natural Resources Canada	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Conservation Fund (formally Conservation Partnerships Program)	The Fund aims at promoting the development of conservation awareness in as many sectors of the Ontario economy as possible, by directly engaging stakeholders through conferences, workshops, and other activities. Over $1 million was invested in a range of replicable, sector-specific outreach and pilot projects. Projects funded supported conservation initiatives in social housing, agriculture, schools, home construction and small business.	CO_2, CH_4, N_2O	Education / Information / Outreach	Implemented	Ontario's Conservation Bureau	
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
CSA Climate Change Services	The Canadian Standard Association (CSA) offers the unique, multi-functional perspective and resources needed to develop products and services to drive development, commercialization and verification of practical and effective climate change solutions. As a membership organization, draws on the expertise of more than 9,000 professionals representing 54 technology areas for the development of standards for technology, products, procedures and management systems to manage, reduce, monitor, report and measure GHG emissions.	CO_2, CH_4, N_2O	Information / Policy / Standards	Implemented	Canadian Standards Association (CSA)	
House-in-Order (HIO) Strategy	This initiative to reduce GHG emissions from Government operations includes activities such as the establishment and reporting of GHG reduction targets for government operations, energy efficiency improvements for buildings and vehicles, the development of a green procurement program and employee education.	CO_2, N_2O	Fiscal / Voluntary Information	Planned	The Government of Newfoundland and Labrador/ The Department of Environment and Conservation	
Leading by Example	Governments in Saskatchewan are showing leadership by putting their own houses in order, including their buildings and their fleets. They are sharing their experiences and best practices with others who can benefit from them.	CO_2, N_2O	Awareness	Implemented	Government of Saskatchewan	
New Brunswick Environmental Trust Fund (ETF)	The Fund provides assistance for action-oriented projects with tangible, measurable results, aimed at protecting, preserving and enhancing the natural environment of New Brunswick, including energy efficiency and climate change undertakings.	CO_2, CH_4, N_2O	Economic	Implemented	New Brunswick Department of Environment	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Saskatchewan Municipal Energy Efficiency Program	This program provides low-cost energy saving initiatives to encourage and assist municipalities in Saskatchewan in reducing their conventional energy use. Through collaborative purchasing arrangements, municipalities can reduce the capital cost of energy-efficient equipment, allowing for replacement of aging, less-efficient equipment. Program examples include: • Lighting Purchase Program • Solar Energy Pool Incentive.	CO_2, CH_4, N_2O	Economic / Information	Implemented	Government of Saskatchewan / Office of Energy Conservation (OEC), Saskatchewan Research Council	
Sustainable Development Innovations Fund (SDIF)	This broadly-focused Fund provides funding for the development, implementation and promotion of environmental innovation and sustainable development projects delivered by local governments, industry, community and youth groups, Aboriginal organizations, and First Nation communities in Manitoba.	CO_2, CH_4, N_2O	Economic	Implemented	Manitoba Conservation	
Tax Exemption for Material and Equipment Used to Conserve Energy	In British Columbia, the *Social Service Tax Act* provides an exemption from social service tax, also called provincial sales tax (PST), for prescribed energy conservation materials and equipment that prevent heat loss from a building, for prescribed residential energy efficient furnaces, boilers and heat pumps, for prescribed alternative energy sources, and for natural gas and propane conversion kits for internal combustion engines.	CO_2, N_2O	Fiscal	Implemented	British Columbia Ministry of Small Business and Revenue	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - BUILDINGS						
Government of Canada						
Accelerated Standards Action Program (ASAP) and Enhanced Equipment Market Transformation (EEMT)	To accelerate the penetration of existing high-efficiency products into appliance and equipment markets, ASAP will deploy a series of "market-based" actions that address market barriers arising from the lack of information. By promoting the Energy Star labeling, it will encourage consumers to purchase best-in-class efficient products and thereby set the stage for the future enhancement of current standards.	CO_2, N_2O	Regulatory / Information	Implemented	Natural Resources Canada	This effort is expected to result in about 2.8 fewer megatonnes of GHG emissions per year by 2010.
Commercial Buildings Incentive Program (CBIP) and Improved Efficiency of New Commercial Buildings	Promotes the construction of buildings at least 25% more energy efficient than the minimum energy efficiency standards of the Model National Energy Code for Buildings. The program offers a financial incentive of up to $60,000, which is intended to help offset the incremental design costs associated with designing energy efficient buildings.	CO_2, N_2O	Information / Economic	Implemented	Natural Resources Canada	Accounted for 18% of new construction floor space in 2004/05, averaging 35% better performance than the MNECB.
EnerGuide for Equipment Labelling and HVAC	Under the *Energy Efficiency Act*, the Program encourages consumers to compare products and purchase the most energy-efficient equipment on the market according to their needs. Labelling helps consumers obtain consistent and reliable information to enable them to compare the energy efficiency performance of each model to others of the same size and class.	CO_2, N_2O	Regulatory / Information	Implemented	Natural Resources Canada	Over 50% of Canadians are aware of the EnerGuide label.
EnerGuide for Existing Building (EEB)	Offers funding to organizations in the commercial and institutional sectors (such as hotels and schools) for retrofit planning activities and implementation projects in existing buildings that become more energy efficient and reduce their GHG emissions through a variety of tools and services including information, incentives, training and advice.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	Natural Resources Canada	Retrofitted buildings save an average of 20% in energy consumption each year.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
EnerGuide for Houses (EGH) and Retrofits of Existing Houses (REH)	Encouraged Canadians to improve the energy performance of their houses. Homeowners received advice from independent energy efficiency experts on how to improve home comfort and reduce heating and cooling costs when making home improvements. They could then apply for grants after completing their energy efficiency renovations.	CO_2, N_2O	Information / Economic	Terminated	Natural Resources Canada	Average annual savings of 28% on energy bills and reduced emissions by 4 tonnes, per retrofitted home.
Energy Efficiency (EE) Standards and Regulations	The program, created by regulation authorized under the *Energy Efficiency Act*, entails the development, application and enforcement of prescribed minimum energy efficiency performance levels for a set of energy-using equipment so as to eliminate inefficient energy-using equipment from the Canadian market.	CO_2, N_2O	Regulatory	Implemented	Natural Resources Canada	Estimated energy savings of 178 PJ per year, by 2010.
Energy Technology Applications Group (ETAG)	A component of the cross-cutting FHIO initiative, provided technical and project services related to energy reduction and sustainable development of facility heating, cooling and ventilating systems and overall energy consumption at federal government departments and agencies.	CO_2, N_2O	Fiscal / Voluntary Information	Terminated	Natural Resources Canada	GHG emissions are reduced by an average of 4.7 kt/yr per year, or approximately 1,150 terajoules in 2004/05.
Federal Buildings Initiative (FBI)	A component of the cross-cutting FHIO initiative, assists federal organizations implement energy efficiency improvements in their facilities to reduce energy costs and GHG emissions through public-private partnerships with energy management firms. These energy management companies provide a turnkey service that includes engineering, third-party savings financing, comprehensive training packages and occupant awareness programs. The FBI provides an implementation model, supporting documents, information and advice to facilitate the development of such projects.	CO_2, N_2O	Voluntary Information	Implemented	Natural Resources Canada	Initiated and registered retrofits of 7,500 federal buildings and facilities, generating annual savings of $33 million.
R2000 Standard (R-2000) and EnerGuide for New Houses (EGNH)	Uses a quality assurance process to ensure that certified houses meet the voluntary performance standard for energy efficiency, indoor air quality, and environmental sustainability. The program is delivered provincially by more than 30 industry partners and provides technical support, builder training, and industry infrastructure.	CO_2, N_2O	Voluntary Information	Implemented	Natural Resources Canada	R-2000 homes consume 40% less energy than typical new house and EGNH houses are 19% better.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Refrigeration Action Program for Buildings (RAPB)	Supports the development and the adoption of innovative refrigeration technologies that reduce energy consumption, synthetic refrigerant use and GHG emissions in commercial and institutional buildings.	CO_2, N_2O	Voluntary Information	Implemented	Natural Resources Canada	Completed five demonstration projects with 14 more under construction. New system is 20% to 50% more energy efficient.
Renewable Energy Deployment Initiative (REDI)	Focuses on promoting renewable energy systems for space and water heating and cooling, such as active solar hot water systems, active solar air heating systems, high efficiency biomass combustion systems, and ground-source heat pump or earth energy systems.	CO_2, N_2O	Economic / Information	Implemented	Natural Resources Canada	Influenced the deployment of 741solar and biomass systems as of March 31, 2006.
Super E™ House Program	Brings energy-efficient, economical, environmentally responsible, Canadian-built housing to international markets. Natural Resources Canada (NRCan) initially developed the Super E™ House Program to provide comfortable, energy efficient homes to the Japanese market. Now, the program has expanded to match qualified UK builders with Canadian experts, who facilitate the building process in the UK.	CO_2, N_2O	Research / Information	Implemented	Natural Resources Canada / Canada Mortgage and Housing Corporation	Since the program started in 1998 over 30 Japanese companies have partnered with ten Canadian companies to build homes in every region of Japan.
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
Alberta Consumer Incentive Programs	Homeowners can receive rebates when replacing their old appliances with new, ENERGY STAR-qualified high-efficiency appliances. Manufacturers may supplement the rebates with offers of their own. The time-limited programs often come back for new funding opportunities. Examples include: • The Alberta Furnace Replacement Program – began in 2004 and was back in July 2005. • Soak Up The Savings – Alberta Clothes Washer Replacement Program • Mow Down Pollution Program – to rid Canadian backyards of two-stroke mowers.	CO_2, N_2O	Economic	Implemented	Climate Change Central / The Alberta Government / Natural Resources Canada	Replaced 5,900 old furnaces. Can improve the average efficiency of a typical home's heating system by 30%, and save the consumer about $400 a year.

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Better Buildings Partnership	Promotes and implements building renewal and energy-efficiency retrofits of industrial, commercial, institutional and multi-residential buildings. The public-private partnership was developed to assist in the City of Toronto's commitment to reduce CO_2 emissions by 20% with respect to 1990 levels. The initiative includes many components, such as: • The Residential Energy Awareness Program, • The Large Office Building Program, • The Small/Medium Commercial Buildings Program, • The Multi-Residential Non-Profit Buildings Program, • The In-House Energy Efficiency Program, and • The BBP Loan Recourse Fund.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	City of Toronto	To date, retrofitted 39 million sq.ft. in 440 buildings resulting in operating cost reductions of $19 million.
Bright Ideas	Offers rebates and financing to all electric heat customers to upgrade existing and newly-constructed homes to reduce heating costs and improve comfort. This initiative is delivered through various programs, such as the *Wrap-Up For Savings Program*, and the *Thermostat Rebate Program*. Also provides practical advice for residential and commercial customers to help them with the wise and efficient use of electricity through tips on their website and their *Saving Energy Makes Sense!* campaign.	CO_2, N_2O	Information / Economic	Implemented	Newfoundland Power	
BuildSmart Program	Created in January 2003 to be a resource for the design and construction industry, helping designers make smart, sustainable choices when crafting the future of the constructed environment. Encourages the use of green building strategies and technologies; supports green building efforts by offering tools and technical resources; and educates the building industry on sustainable design and building practices.	CO_2, N_2O	Voluntary Information /	Implemented	Greater Vancouver Regional District	
Commercial Energy Management Program (CEMP) and Residential Energy Management Program (REMP)	Helps to reduce the demand for electricity during the winter and peak periods for diesel generation by assisting municipalities, First Nations, private building owners, tenants and residential consumers to implement energy-efficient renovations, including lighting retrofits and heating system improvements. The program also provides energy audits, general information and financial incentives, which are determined through an audit process.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	Yukon Housing Corporation	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Destination Conservation (DC)	An innovative school based conservation program where students, staff, school district staff and utility companies interact to initiate environmental education and conservation activities. The program includes an educational and a technical component. Technical changes are based on a comprehensive energy audit and the development of plans to reduce consumption through retrofits and lifestyle changes. School jurisdictions from Alberta, British Columbia, Ontario, New Brunswick, Quebec and Saskatchewan take part in this program.	CO_2, CH_4, N_2O	Education / Information / Outreach	Implemented	Tomorrow Foundation for a Sustainable Future	
Energy Conservation Program (ECP)	Provides financial assistance to territorial and community funded departments, boards, and agencies, and non-profit organizations, to undertake capital projects that will result in long-term reductions in the usage of electricity and heat energy, and water. Eligible projects must relate to purchased electricity, fuel or water supplies.	CO_2, N_2O	Fiscal / Economic	Implemented	Northwest Territories Department of Environment and Natural Resources	Estimated reduction of 529,537 kWh from April 2001 to March 2004.
Energy Efficiency Fund	Provides funding for different energy conservation programs Involving Gaz Métro natural gas consumers or those about to become so. It is meant to carry out energy efficiency programs that cover shells of buildings or aim at new or emerging technology on the market, including: • 10 programs for residential customers; • 6 programs for sociocommunity organizations, non-profit housing (OSBL) and coop housing; and, • 6 programs for the commercial, institutional and small industrial sectors.	CO_2, N_2O	Fiscal / Economic	Implemented	Régie de l"énergie du Québec / Société en commandite Gaz Métro	

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Energy Efficiency Program	Promotes energy-saving measures and tips to assist its customers in reducing their energy consumption through various sub-programs, such as: • Residential Energy Efficiency Program – offers free energy efficiency material to every customer using a natural gas water heater in a home build before 1990. • Boiler Replacement Incentive Program – provides an incentive to install an energy-efficient condensation boiler. • Building Design Incentive Program – covers up to 50% of costs related to a computer modeling of a commercial building's energy plan. • Implementation Assistance Incentive Program – provides a $\$0.05/m^3$ rebate to institutions that implemented energy efficiency upgrades after having received an accredited energy inspection and assessment.	CO_2, N_2O	Information / Awareness / Economic	Implemented	Gazifère Inc.	
Energy Efficient Buildings: A Plan for B.C.	Launched in September 2005, will deliver social, environmental and economic benefits by encouraging increased energy efficiency and market transformation in homes and buildings across the Province.	CO_2, N_2O	Information / Awareness	Adopted	British Columbia Ministry of Energy, Mines and Petroleum Resources	
Energy Management and Awareness Program	Works with government, municipal and private-sector clients in the Northwest Territories to reduce their energy consumption, thereby reducing their energy costs and associated environmental impacts. Promotes and facilitates the implementation of energy management strategies and energy efficiency retrofits. Specific services provided include energy assessments and audits, workshops and seminars, technical advice, assistance in locating funding and general project facilitation.	CO_2, N_2O	Information / Awareness	Implemented	Arctic Energy Alliance	
Energy Management Plan for Government Buildings and Schools Pilot	Cost-effective energy management measures are being implemented to reduce energy cost in government buildings and to produce additional benefits such as decreased emissions from reduced heating fuel use and increased hydro-generated electricity use.	CO_2, N_2O	Information / Economic	Implemented	Government of Yukon	

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Energy Management Revolving Fund	This $30 million revolving fund was created to finance energy retrofits of city facilities to reduce environmental impacts from energy use and to reduce utility costs. Utility savings are used to repay the fund and are then re-invested in further energy efficiency upgrades.	CO_2, N_2O	Information / Economic	Implemented	City of Edmonton	
ENER*info* Energy Advisory Services	Provide homeowners and the construction industry with a source of unbiased technical advice on energy related issues. The toll free line provides Nova Scotians with personalized advice on improving energy efficiency, energy conservation and home heating options. Includes support for R-2000 Home program, housing demonstrations projects as well as publications and videotapes on energy efficiency.	CO_2, N_2O	Information / Awareness	Implemented	Clean Nova Scotia / Nova Scotia Department of Energy	
EnVest® Environmental Stewardship Program	Helps commercial and industrial customers manage and reduce their energy and water consumption, resulting in environmental and financial benefits. The program is made up to two key components: • EnVest Renewable Energy – allows customers to purchase blocks of energy generated from low impact/renewable sources, such as small hydro, wind, biomass and solar. Green Power is sold in bundles called ECO-PACKS that represent a percentage of an average customer's monthly consumption. • EnVest Energy Efficiency Program – highlights ways to improve the energy efficiency of customer operations. Individual parts of the program include Initial Assessments, Detailed Audits, Project Management, Metering Solutions, and Financing Options.	CO_2, N_2O	Information / Awareness / Economic	Implemented	EPCOR Merchant and Capital L.P.	
Envision	Envision™ is a proprietary, open-standards, energy-management software-based solution designed to collect, monitor, analyze and manage data from utility meters for the purpose of generating information pertaining to the consumption of energy by commercial and industrial entities. Envision makes it possible for consumption data for electricity, natural gas, water, compressed air, steam, and nitrogen, among others, to be automatically totaled and compared against user-defined cost centres, to find efficiencies in how they can buy and use utilities.	CO_2, N_2O	Information / Awareness	Implemented	Ontario Power Generation (OPG)	

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Energy Wise	Hydro-Québec several initiatives to provide awareness and/or financial incentives to empower both their residential and business customers to improve the energy efficiency in their buildings.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	Hydro-Québec	
Exemption of the Provincial Sales Tax (PST) Paid on Appliances	Provides an exemption to Saskatchewan residents who purchase EnergyStar® refrigerators, freezers, clothes washers, and dishwashers purchased since October 1, 2003.	CO_2, N_2O	Fiscal	Implemented	Saskatchewan Finance	
Government House-in-Order Program	Works with government, industry and organizations through partnerships, sponsorship, and contracted program funding to improve energy efficiency and encourage energy conservation throughout the province. Actions include programs such as the Province's Public Buildings Initiative (PBI) – first block of retrofits initiated; and adoption of the procurement policy for the Department of Energy – a stepping stone to province-wide involvement.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	Nova Scotia Department of Energy	
Government In-House Energy Management Program	Aims to reduce energy cost in buildings that house various government departments. The program entails a computerized energy accounting system, energy engineering studies, staff information and awareness activities, and an energy retrofit program. Activities using the energy performance contracting approach to energy management have also been initiated. Greater effort was put in the recent past on Energy Performance Contracting activities.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	Newfoundland and Labrador Department of Works, Services and Transportation	
Government of Ontario Conservation Targets	In April 2004, the government announced a plan to reduce consumption of electricity in buildings it owns by 10 per cent – or 62 million kilowatt-hours – by 2007. The government's conservation action plan involves: building upgrades; deep lake water cooling; employee education; and, extreme weather response.	CO_2, N_2O	Regulation / Awareness / Economic	Implemented	Ontario Ministry of Energy	By December 2005, the Ontario Realty Corporation (ORC), had reduced electricity demand in ORC-managed buildings by as much as 7.8%.

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Green Buildings BC	Accelerating the transformation of BC's education and health care facilities into high performance buildings without increasing capital demands on the province. Contributes to the transformation of both new and existing facilities by enabling local agencies with planning support and capital procurement tools, at no charge, to simplify the process while protecting the interests of both the agency and the province. Delivered through two programs: • News Buildings Program – provides tools and resources to help build high performance (green) buildings. • Retrofit Program – provides tools and resources to help in the undertaking of comprehensive portfolio-wide retrofits of facilities to significantly improve energy and water efficiency, and reduce GHG emissions and waste generation.	CO_2, N_2O	Voluntary Information /	Implemented	British Columbia Buildings Corporation	
GreenHome Mortgage Program	Offers reduced interest rate mortgage financing of up to $200,000 for homes built or upgraded to the Yukon Housing Corporation's energy-efficient *GreenHome* standard. Also supports the R-2000 initiative.	CO_2, N_2O	Economic	Implemented	Yukon Housing Corporation	
Home Repair Program	Provides low-cost loans to homeowners to undertake all types of repairs, including energy efficiency upgrading of housing units so that homeowners can bring their homes up to current standards.	CO_2, N_2O	Economic	Implemented	Yukon Housing Corporation	
ME *first!* Program	Launched in September 2003, this four-year, $100 million interest-free loan program is designed to help municipalities achieve energy savings; reduce GHG emissions; and, replace conventional energy sources with renewable or alternative sources.	CO_2, N_2O	Economic	Implemented	Climate Change Central / Alberta Municipal Affairs and Alberta Environment	
NB Existing Homes Energy Efficiency Upgrades Program	Provides New Brunswick owners of single-family homes with financial assistance to make their houses more energy efficient in order to conserve energy. These improvements will allow homeowners to reduce their energy use and, in turn, save money.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	New Brunswick Energy Efficiency and Conservation Agency	
Nova Scotia Energy Efficient Housing Program	Provides for low income home owners, seniors and family public housing, non-profit and community groups, and working families to achieve the permanent reductions in energy use through energy efficiency improvements and strategic use of renewable energy. Also supports those building and purchasing new homes to ensure they are as energy efficient as possible.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	Nova Scotia Department of Energy	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Novoclimat	Enables consumers to purchase a house that provides maximum comfort, better indoor air quality and superior energy efficiency. The program focuses on training for contractors and certification of the home's energy performance and compliance with technical requirements.	CO_2, N_2O	Fiscal / Economic	Implemented	Agence de l'efficacité énergétique du Québec	
Ontario Conservation Legislation	Legislation is used as a tool in creating a conservation culture in Ontario. For example: • The *Energy Conservation Responsibility Act* – requires that ministries, agencies and broader public sector organizations prepare energy conservation strategies on a regular basis, and report on energy consumption, proposed conservation measures, and progress. It also provides the framework for the government's commitment to install 800,000 smart meters in Ontario homes and businesses by 2007 and to have them installed in all homes and businesses by 2010. • The *Energy Efficiency Act* – prohibits the sale or lease of specified inefficient energy-using appliances or products from the Ontario marketplace. The Ministry also gets involved in the development of standards.	CO_2, N_2O	Regulation	Implemented	Ontario Ministry of Energy	
Power Sales Incentive Program	Gives eligible Yukon businesses the option of using hydro power to heat their facilities instead of diesel fuel or propane. There are some stipulations: the business' existing heating system must be maintained and fully operational so that it can be re-activated on 24 hours notice. A second electrically fired heating system must be added in order to use the secondary sales electricity as a heating source. The business must also be located in an area that is served by hydro-generated power.	CO_2, N_2O	Economic	Implemented	Yukon Energy Corporation	Customers save 10% or more on their heating bills.

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PowerSense Program	Encourages customers to reduce their energy consumption through education and awareness initiatives, and by offering rebates and other incentives. It is recognized as one of Canada's leading energy efficiency programs, earning provincial and national recognition. This initiative is promoted through the following two components, which are further broken-down into sub-programs: • The residential programs – promotes the efficient use of electrical energy within the home through various sub-programs including home improvement; new homes; heat pump; and compact fluorescent lights. • The commercial programs – offers many ways for commercial and industrial operations to conserve energy and save, from building and process improvements to energy efficient lighting, pumps and fans.	CO_2, N_2O	Voluntary Information / Economic	Implemented	FortisBC	Resulted in annual water savings of 16 million litres and cumulative energy savings of over 200 million kW.h, since 1989.
Power Smart Programs – BC	Helps customers be more energy efficient by identifying opportunities to reduce their energy consumption. This initiative is divided into "At Home" and "For Business" components, which are further broken-down into sub-programs, including: • Fridge Buy-Back Program – offers to buy, pick-up and recycle old refrigerators. • Windows Rebate Program – offers rebates to homeowners and builders for installing ENERGY STAR® labeled windows. • New Homes – Encourages home buyers to purchase new homes equipped with Power Smart packages of energy-efficient products. • Analyze My Home – An online interactive tool that helps homeowners save money by determining where they can save electricity. • Product Incentive Program – provides financial incentives to business customers who replace existing inefficient products with energy-efficient technologies. • Power Smart Partner Program – provides eligible organizations with the opportunity to partner with BC Hydro and gain access to a variety of tools and resources to become more energy efficient. • Other Programs and Tools – help businesses and homeowners reduce their energy consumption through various other initiatives including awareness programs.	CO_2, N_2O	Information / Economic	Implemented	BC Hydro	Achieves savings of 4,000 GWh of electricity each year. To date, customers saved over $1 billion.

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Power Smart Programs – Manitoba	Designed to assist customers in using energy more efficiently. Its objective is to meet energy needs through efficiency improvements rather than through new sources of generation. Power Smart initiatives promote a wide variety of energy efficient products, services and programs, which deliver energy savings to Manitobans. Power Smart products last longer, reduce maintenance and labour costs, and improve living and working environments. The various programs create awareness of how customers can get more for their energy dollar. With a focus on customer service, Power Smart programs are available to customers through the following components: • Power Smart for Your Home – provides a broad array of educational materials, ranging from how to retrofit a home to energy efficient products and practices, as well as financial assistance to customers making home efficiency improvements. • Power Smart for Business – supports its commercial customers maximize the performance, comfort and visual appeal of their facilities by offering electric and natural gas programs and information. • Power Smart for Business – provides technical expertise and financial incentives to industrial customers of all sizes and in all sectors, to improve their energy efficiency. • Earth Power Program - Geothermal – provides a convenient *Residential Earth Power Loan* to assist qualifying homeowners with the cost of installing a geothermal heat pump system.	CO_2, N_2O	Information / Economic	Implemented	Manitoba Hydro	In 2003-04, the Power Smart Industrial programs saved 214.5 GW.h in electricity savings and reduced electricity demand by 58.4 MW. Expected to save 237 MW and 988 Gwh by 2011/12.
PowerWISE	Six of Ontario's largest local electricity distribution companies, cooperatively deliver this multi-year, initiative designed to promote energy conservation to consumers and reduce the demand for electricity in their respective service areas.	CO_2, N_2O	Information / Economic	Implemented	Ontario Ministry of Energy	In 2005, delivered over 110.6 million Kwh of electricity savings.
Provincial Buildings Initiative NB	The objective of the Provincial Buildings Initiative (PBI) is to retrofit all provincially-owned government facilities for improved energy efficiency. The PBI is a government-wide initiative that assists departments and hospital corporations to use third-party financing to implement energy improvements in provincially-owned buildings through energy management service contracts.	CO_2, N_2O	Voluntary Information	Implemented	New Brunswick Department of Energy	

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Renewable Energy Technology Conversion Assistance Program (RETCAP)	This two-year program, initiated in 2001, provided funding to assist in the installation of eligible renewable energy technologies that did not enjoy some form of financial incentive and focused on market-ready renewable technologies. Eligibility required that the equipment be installed at year-round residences or wilderness lodges, that they achieved quantifiable reductions in energy cost and/or GHG emissions	CO_2, N_2O	Economic / Fiscal / Information / Awareness	Terminated	Northwest Territories Department of Resources, Wildlife and Economic Development (RWED)	Predicted savings of 164,632 litres of fuel per year from the 35 RETCAP systems.
Residential Energy Assistance Plan	The PEI Government has created a $1.4 million energy assistance plan that includes direct assistance to low-income Islanders in the form of a home energy efficiency upgrade; and low interest loans, as well as a provincial sales tax exemption, on alternative heating systems such as wood stoves, pellet stoves, solar panels and geothermal units.	CO_2, N_2O	Economic / Fiscal / Information / Awareness	Implemented	Prince Edward Island Department of Environment, Energy and Forestry	
Saskatchewan Building Energy Management Program	Carries out customer energy assessments in order to determine the areas of greatest energy use and opportunities for improvements. It is directed primarily at commercial buildings and small industrial businesses and offers follow-up support by providing financing option information and names of companies that provide energy management products and services.	CO_2, N_2O	Awareness / Information	Implemented	Saskatchewan Research Council	
Saskatchewan Home Energy Improvement Program (SHEIP) for Low-Income Households	This $16.5 million dollar program is intended to help low-income homeowners and rental property owners housing low-income tenants, undertake energy retrofits that will make housing more affordable and reduce GHG emissions that contribute to climate change. It provides financial assistance to defray the cost of retrofits, such as heating system upgrades, insulation, and draft proofing.	CO_2, N_2O	Economic	Implemented	Saskatchewan Housing Corporation	
Smart Energy Choices	Offers householders rebates and incentives on a variety of energy-saving initiatives, such as solar water heating system for residential or commercial use; certified wood or wood pellet stoves; retrofits of existing houses, including furnace replacement; and, EnerGuide for new houses. The program also provides energy saving kits as well as public information and promotion of energy efficiency.	CO_2, N_2O	Information / Fiscal / Economic	Implemented	Nova Scotia Department of Energy	

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MEASURES AFFECTING GHGs - TRANSPORTATION						
Government of Canada						
Advanced Technology Vehicles Program (ATVP)	Encourages the supply and consumer demand for advanced technology vehicles in Canada and assesses vehicles with advanced and alternate technologies to measure their impact on safety, energy efficiency and the environment.	CO_2, N_2O	Information / Education / Other	Implemented	Transport Canada	102 events held as of March, 2005.
Biodiesel Initiative	A component of CTEEFI, supports research and provides incentives for industrial-scale biodiesel pilot plants, and supports demonstrations of its effectiveness to encourage broader use of this cleaner-burning alternative to conventional diesel.	CO_2, N_2O	Research / Information / Economic / Fiscal	Implemented	Natural Resources Canada	Developed a national fuel standard and two pilot plants are now in commercial production.
Canadian Transportation Fuel Cell Alliance (CTFCA)	Demonstrates and evaluates options for the production of hydrogen and its delivery to fuel-cell vehicles. It will also establish safety standards for fuelling stations, and develop training and certification programs for the people who install and maintain those stations.	CO_2, N_2O	Fiscal / Economic / Outreach / R&D	Implemented	Natural Resources Canada	There are currently 8 fuelling stations in operation, as well as 4 fuel cell passenger vehicles and a delivery van being tested.

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Commercial Transportation Energy Efficiency and Fuels Initiative (CTEEFI)	Complements existing energy-efficiency efforts under FETI by focusing on increasing the market penetration of efficiency enhancing technologies in all modes of commercial and freight transportation. This initiative is promoted through *FleetSmart*, which offers free practical advice on how energy-efficient vehicles and business practices can reduce fleet's operating costs, improve productivity and increase competitiveness. Also promotes the *Idle-Free Quiet Zone* campaign, which was conceived to raise awareness in the trucking sector about the harmful effects of unnecessary engine idling.	CO_2, N_2O	Information / Education / Economic / Fiscal	Implemented	Natural Resources Canada / Transport Canada	Trained transit drivers save on average 10% in fuel consumption.
Freight Efficiency Program (FEP)	A component of CTEEFI, aims to reduce GHG emissions by Canadian private companies and not-for-profit organizations in the rail, air and marine freight-transportation industries. The FEP: • administers the Freight Incentives Program (FIP); • provides funding for marine-shore power pilots at suitable locations across Canada, based on a facility's activities, potential for GHG reductions, and potential to operate marine-shore power cost-effectively; and, • delivers awareness programs for shippers and freight forwarders to increase awareness of the environmental, economic and other benefits of different transportation choices for people who buy transportation services for themselves or for clients. Also identifies barriers to the adoption of environmentally friendly alternatives.				Transport Canada	Completed feasibility study for three marine-shore power pilot projects and developed concept papers for shippers and freight forwarders.
Freight Incentive Program (FIP)	Administered by the FEP, provides financial support to enable the purchase and installation of GHG-reduction technology and equipment, including those demonstrated under the FSDP, by companies in the rail, marine and aviation freight transportation sectors.					Thirteen projects have been approved, one of which will save as much as 53% in company's fuel consumption.
Ethanol Expansion Program (EEP)	Provides contributions toward the construction financing of new or expansion fuel ethanol production facilities in Canada in order to increase the proportion of our gasoline that is blended with ethanol.	CO_2, N_2O	Fiscal / Economic / Information	Implemented	Natural Resources Canada / Agriculture and Agri-Food Canada	11 new plant projects will produce an additional 1.2 billion litres of ethanol by 2007.

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Excise Tax Exemptions for Lower Carbon / Renewable Fuels	Encourages the development and marketing of lower carbon fuels such as natural gas and propane, as well as renewable fuels such as ethanol and methanol made from biomass, when it is blended with gasoline or diesel fuel, by providing an exemption from the excise tax on transportation fuels.	CO_2, N_2O	Fiscal / Economic	Implemented	Canada Revenue Agency / Finance Canada	
Federal Vehicles Initiative (FVI)	A component of the FHIO, this initiative assists GoC departments, agencies and Crown Corporation to increase the efficiency of federal fleets, cut costs, increase the use of alternative fuels and lessen the negative environmental impacts associated with their operations.	CO_2, N_2O	Fiscal / Economic / Information	Implemented	Natural Resources Canada	As of the end of March 2003, achieved a 31% reduction in GHG emissions since 1990.
Freight Efficiency and Technology Initiative (FETI)	Designed to help transform Canada's freight transportation system by engaging the freight industry in efforts to reduce growth in their GHG emissions via technology uptake and innovative operational practices.	CO_2, N_2O	Information / Education / Economic / Fiscal	Implemented	Transport Canada / Natural Resources Canada	
FETI – Training and Awareness	A component of FETI, organizes a series of events, such as conferences and workshops, to increase awareness of strategies to improve energy efficiency and reduce GHG emissions in Canada's freight sector. These are of interest to the freight carrier, shipping and freight forwarding communities; manufacturers & suppliers; regulators; and environmental NGOs.					Trained truck operators achieve a 10% improvement in fuel use on average
FETI – Voluntary Performance Agreements	A component of FETI, voluntary performance agreements are being established between the federal government and industry associations within each freight mode - rail, marine, aviation and trucking - to outline concrete initiatives for reducing GHG emissions. Agreements will include an emission reduction target, an action plan to achieve that target, and reporting on progress.					One voluntary agreement will result in a 24% reduction in GHG emissions by 2012, compared to 1990.
Freight Sustainability Demonstration Program (FSDP)	A component of FETI, supports the demonstration and evaluation of tools, technologies and best practices that could help the freight-transportation sector in all modes reduce GHG emissions.					34 projects being implemented.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Future Fuels Initiative (FFI)	Aims to boost Canada's annual ethanol production and use as well as provide market information to retail consumers.	CO_2, N_2O	Fiscal / Information / education	Implemented	Natural Resources Canada	Currently, 7% of all gasoline sold in Canada is ethanol-blended.
Green Commute Program	A function of the FHIO initiative, engages employers to promote commuter options for their employees and help them to become conscious of all of their travel patterns and make changes to reduce their overall vehicle use.	CO_2, N_2O	Information / Education /	Implemented	Transport Canada	Developed the Commuter Options Guide for employers and implemented the Transit Pass Pilot Project.
Intelligent Transportation Systems (ITS)	Creates an environment that will stimulate the collaborative development and deployment of a broad range of diverse technologies, applied to ground transportation, across urban and rural Canada to improve safety and maximize the use and efficiency of the existing multimodal transportation system.	CO_2, N_2O	Information	Implemented	Transport Canada	
Marketing of Efficient Vehicles (MEV) and Personal Vehicles Initiative	Promote energy-efficient practices among Canadian motorists by providing helpful tips on buying, driving and maintaining their vehicles to reduce fuel consumption and GHG emissions. Specific activities include: • EnerGuide for Vehicles (EGV) labeling – labels providing fuel consumption ratings are affixed to all new light-duty vehicles sold in Canada for comparison purposes; • Auto$mart Fuel-Efficient Driving campaign – promotes energy-efficient practices through publications, events, joint projects, and a Student Driver Kit; • Idle-Free campaign – encourages motorists to stop unnecessary engine idling as well as groups and organizations to build their own anti-idling campaigns; • Vehicle maintenance – provides motorists with helpful tips on driving and maintaining their vehicles to reduce fuel consumption.	CO_2, N_2O	Information / Education	Implemented	Natural Resources Canada / Transport Canada	Over 300,000 guides distributed in 2004-05, 16 masters trainers qualified to train other driver educators on the Auto$mart kit in 2005, and over 100 municipalities and/or communities joined the idle-free campaign.
Motor Vehicle Fuel Efficiency Initiative (MVFEI)	Designed to influence the supply and penetration of more fuel-efficient vehicles as well as the demand for, and use of, these vehicles by Canadians. It is delivered through collaborative agreements with vehicle manufacturers and aims at promoting improvements in motor vehicle fuel efficiency, including introduction of fuel efficiency technologies in new vehicles. Also conducts consumer education and awareness campaigns.	CO_2, N_2O	Voluntary / Negotiated Agreement	Implemented	Natural Resources Canada / Transport Canada	Reached agreement with auto industry to reduce annual GHG emissions of light duty vehicles by 5.3 Mt by 2010.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Moving On Sustainable Transportation (MOST)	Supports projects that produce the kinds of education, awareness and analytical tools needed to make sustainable transportation a reality.	CO_2, N_2O	Information / Education / Economic	Implemented	Transport Canada	By the end of March 2005, 84 projects had been approved.
National Biomass Ethanol Program (NBEP)	Encourages firms to invest in the Canadian ethanol industry and encourages the production and use of renewable fuels where it is environmentally sound and economically viable. It is designed to minimize the cash flow impact of a future federal government decision to reduce or eliminate the 10.0 cent/litre excise tax exemption on fuel ethanol produced for sale and use in Canada.	CO_2, N_2O	Fiscal / Economic / Information	Implemented	Farm Credit Canada / Agriculture and Agri-Food Canada	
Natural Gas Vehicle Market Transformation Program	Focuses on reducing the up-front cost of targeted natural gas vehicles (NGV) in urban applications, increasing the demand for these vehicles and improving economies of scale for vehicle manufacturers.	CO_2, N_2O	Fiscal / Economic / Information	Implemented	Natural Resources Canada	
Off-Road Vehicles and Equipment Initiative	Aimed at improving the availability of information and compiling a GHG inventory for the off-road sector, as well as increasing awareness of users of off-road machines.	CO_2, N_2O	Fiscal / Outreach / Policy	Terminated	Environment Canada	Disseminated five technical papers and conducted eight targeted studies.
Urban Transportation Showcase Program (UTSP)	The Program demonstrates and evaluates the impacts of integrated strategies and disseminates this information to reduce GHG emissions from urban transportation in communities across Canada.	CO_2, N_2O	Information / Education	Terminated	Transport Canada	Increased use of more energy efficient modes of transportation.
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
AirCare	This Motor Vehicle Emissions Inspection and Maintenance Program aims at reducing emissions from cars and light trucks in the Lower Fraser Valley, by identifying and requiring the repair of vehicles with defective emission controls. Although not specifically designed to address climate change, the improved fuel economy that results from AirCare repairs accounts for a significant reduction in the amount of fuel burned by light-duty vehicles, which translates into a reduction in GHG emissions.	CO_2, N_2O	Regulatory	Implemented	TransLink / British Columbia Ministry of Water, Land and Air Protection / Greater Vancouver Regional District	More than 11 million vehicles inspected. Credited for a 35% reduction in vehicle emissions between 1992-2002.

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Alternative Fuel Vehicles	Investigating the feasibility of using alternative fuel vehicles in the government fleet. Their efforts to reduce the use of fossil fuels began with downsizing vehicle engines in 1993. They have purchased and tested propane vehicles and an electric car but have not been satisfied with the performance of these vehicles. The next step is to purchase a hybrid vehicle for testing.	CO_2, N_2O	Research / Information / Education	Implemented	Yukon Government Services	
Alternative Fuel Vehicles and Alternative Motor Fuel (AMF) Tax Concessions – BC	Encourages the alternative motor fuel (AMF) use and the development of AMF production and supply infrastructure in BC. Provides tax concessions for motor vehicles that qualify as alternative fuel vehicles, including vehicles converted to alternative fuel use, and hybrid electric vehicles as well as AMF and the AMF portions of blended gasoline or diesel fuels. A fuel qualifies as an AMF if it provides a reduction in vehicle air emissions that meet the reduction criteria, compared to gasoline or diesel.	CO_2, N_2O	Economic / Fiscal	Implemented	British Columbia Ministry of Finance / British Columbia Ministry of Small Business and Revenue	
Alternative Fuels Program	Demonstrates the effectiveness of alternative fuels on reducing emissions by replacing conventional vehicular fuels with natural gas and hydrogen. SRC has also been developing technology for fuelling vehicles with natural gas and has unveiled the world's first modified pickup truck fueled by a combination of hydrogen and diesel fuel. On January 31, 2005, unveiled a truck fueled by a combination of hydrogen and gasoline.	CO_2, N_2O	Information / Awareness / Outreach	Implemented	Saskatchewan Research Council (SRC) / SaskEnergy	
BIOBUS and *BioMer*	The scale of this one year project was the largest undertaken in North America in the field of urban mass transit, supplying a fleet of 155 buses serving Montréal's downtown. It demonstrated, under actual operating conditions, that using biodiesel is viable, especially in cold weather, and that it is feasible to continuously supply an urban transit company the size of the STM. The project, which was completed at the end fo March 2003, also assessed the economic and environmental impact of using this fuel. The *BioMer* project was the logical sequel to the *BIOBUS* project and ran from May to October, 2004. Rather than fuelling a fleet of city buses, however, biodiesel was tested on a fleet of 12 cruisers to demonstrate that biodiesel is a viable alternative for fuelling boats of various sizes and types in very tourist-intensive areas.	CO_2, N_2O	Research / Pilot Project	Implemented	Société de transport de Montréal (STM) / Maritime Innovation / Institut maritime du Québec	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Clean Technology for Vehicles and Fleets	Encourages municipalities to purchase Clean Technology Vehicle, such as alternative fuel vehicles. With regards to alternative fuel vehicles, the objective is to purchase manufactured vehicles (OEM) instead of retrofits whenever possible, for better efficiency and performance.	CO_2, N_2O	Information	Implemented	Greater Vancouver Regional District	
Cool Down the City	Educates the public about climate change and what they can do to reduce the impact on the climate and reduce their energy use. Encourages local action, such as the *Commuter Challenge*, the *CarPool* event and *Vehicle Emissions Clinics*, to dramatically reduce GHG emissions.	CO_2, N_2O	Information / Awareness / Outreach	Implemented	City of Regina, Saskatchewan	To reduce GHG emissions with the community of Regina by 6% of 1990 levels by 2012.
Energy Efficiency in Ferry Fleet	An audit and inspection program to determine the efficiency of the ten marine ferries and to indicate whether there are cost-effective options available to increase efficiency, in an effort to reduce fuel consumption and GHG emissions.	CO_2, N_2O	Information / Awareness	Planned	Newfoundland and Labrador Department of Transportation and Works	
Ethanol Blend Tax Relief	Provides a reduction in the gasoline tax of 2.5 cents per litre for gasohol containing a 10% blend of ethanol. The ethanol must be derived from biomass materials and must be produced and consumed in Manitoba.	CO_2, N_2O	Fiscal / Economic	Implemented	Government of Manitoba	Passed legislation to mandate ethanol blends in gasoline by 2007
Ethanol Fuel Grant Program	Saskatchewan has mandated the use of ethanol-blended fuel, providing a 15 cent per litre grant to distributors who blend ethanol within Saskatchewan. Husky Energy has announced construction of a 130 million litre facility in Lloydminster, and NorAmera BioEnergy has announced a 25 million litre facility in Weyburn.	CO_2, N_2O	Fiscal / Economic	Implemented	Government of Saskatchewan	
Ethanol in Gasoline	A new regulation, requiring that all gasoline sold in Ontario, by January 1, 2007, will contain an average of 5% ethanol. This may be accomplished through the actual blending of ethanol, or through the trading of renewable fuel credits.	CO_2, N_2O	Regulatory	Adopted	Ontario Ministry of the Environment	Will be equivalent to removing 200,000 cars off the road.
Ethanol Tax Credit	The Quebec government will introduce a temporary refundable tax credit for the production of ethanol fuel in Quebec by an eligible corporation. The ethanol must be produced from renewable materials and sold in Québec. A tax exemption is also applicable to biodiesel in the mass transit sector.	CO_2, N_2O	Fiscal / Economic	Implemented	Ministère des Finances / Quebec Government	

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Fuel Reduction Initiatives	Examines advanced technologies to reduce fuel use and environmental emissions in the 830e haul trucks at the Diavik and Ekati diamond mines.	CO_2, N_2O	Research	Implemented	Diavik Diamond Mines Inc. / BHP Billiton , Northwest Territories	
Leaders in Greening Canadian Fleets	Helps on-road vehicle fleets in improving fuel efficiency as well as reduce smog and GHG emissions that contribute to climate change. Each of the five regions – British Columbia, Alberta, Saskatchewan, Ontario and Québec – hosts programs with activities that include the promotion of alternative fuels like biodiesel, ethanol and hydrogen; the creation of a network for fleets to share experiences and knowledge; and, support in implementing fleet management best practices.	CO_2, N_2O	Economic / Information / Awareness	Implemented	Fleet Challenge Canada	
Manitoba Biodiesel Production Program	Supports the development of smaller, community-based biodiesel production facilities, while reducing GHG emissions, by promoting the development of new or expanded facilities in the province of Manitoba, each capable of producing at least 2 million litres of biodiesel annually.	CO_2, N_2O	Fiscal / Economic	Implemented	Government of Manitoba	
Natural Gas for Vehicles Program	This program is locally administered to provide incentives to customers choosing NGVs. It encourages the purchase of vehicles running on natural gas, or after-market conversion of gasoline, or diesel, vehicles. SaskEnergy also operates natural gas vehicle-refueling facilities located in seven municipalities.	CO_2, N_2O	Economic / Information	Implemented	SaskEnergy	
Natural Gas Vehicle Business Development	To increase sales of natural gas in the vehicle marketplace by designing and selling vehicle conversion systems as well as designing and installing vehicle-refueling stations. It is also involved in the development of codes and standards, research and development, marketing programs, government relations and other strategic issues. The program is focused on increasing sales of original equipment manufacturer (OEM) natural gas vehicles (NGVs).	CO_2, N_2O	Economic / Information / Awareness	Implemented	Enbridge Gas Distribution Inc., Ontario	
Ontario Ethanol Growth Fund (OEGF)	This 12-year, $520 million Fund was established in June 2005 to support the production of ethanol fuel in Ontario. It will provide: • capital assistance to help meet financial challenges; • operating assistance to address changing market prices; • support for independent retailers selling ethanol blends; • a research and development fund to pursue opportunities for research and innovation.	CO_2, N_2O	Economic / Fiscal / Research	Implemented	Ministry of Agriculture, Food and Rural Affairs	

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Sustainable Transportation Empowerment Program (STEP!)	Educates, encourages and rewards residents in Greater Victoria on the benefits of using active (cycling, walking, running, in-line skating) and sustainable (ridesharing, transit) transportation options. For example, STEP! promotes initiatives and programs that reduce single occupancy vehicle use. It also offers *Go Green Choices* training for local workplaces and promotes local active transportation events.	CO_2, N_2O	Information / Awareness / Economic	Implemented	City Green / Better Environmentally Sound Transportation / British Columbia Ministry of Communities	
Transit Enhancement	Provides municipalities with additional funds for public transit through the new provincial allocation of fuel tax revenue. This funding will be used to implement two measures – bus renewal and light rail transit (LRT) expansion – aimed at increasing transit use in urban centres.	CO_2, N_2O	Economic	Implemented	Government of Alberta	
Transportation Greenhouse Gas Strategy and Action Plan	Continues with initiatives to green the 2,250 vehicle provincial fleet. A recent policy encourages ethanol use by fleet drivers. Sport utility vehicle use remains low, with SUVs comprising only 2.67% of the fleet.	CO_2, N_2O	Economic / Regulatory	Implemented	Manitoba Transportation and Government Services	Added 116 E85 cars and 11 hybrid vehicles to fleet since 2000.
Transportation Plans	Tools used to plan and prioritize, for all modes of transportation, the interventions most likely to respond for the long term to needs related to the transport of passengers and goods within a given territory, while respecting land use planning and the environment. In the short term, the implementation of the plans will take the form of cooperation, studies, transportation infrastructure work and programs of support for transportation partners. Transportation plans have been devised for the Greater Montreal Area, the Estrie region, and the Nord-du-Québec region.	CO_2, N_2O	Economic / Fiscal / Research / Awareness	Implemented	Ministère des Transports du Québec	
TravelSmart	Integrates land-use and transportation system planning management. The City's land use pattern was shaped to make optimum use of present and future transportation facilities. This included shifting development to appropriate geographic areas, and increasing densities in selected locations.	CO_2, N_2O	Information / Research	Implemented	City of Kamloops, British Columbia	
TRAX	Aims to reduce GHG emissions, enhance air quality, and promote the health of all citizens. Works to promote sustainable transportation – public transit, cycling, walking, carpooling, rollerblading, vanpooling, or a combination of modes – in Nova Scotia through: workplace trip reduction programs, infrastructure improvement, and public education and outreach.	CO_2, N_2O	Economic / Information / Awareness	Implemented	Ecology Action Centre / Nova Scotia Department of Energy	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Trucking Partnership Program	Provides an opportunity for companies to improve the efficiency of their operation through negotiated agreements. For example, allowing loads in excess of weights and/or lengths that can be legally hauled on the provincial highway system. The companies must meet specific operational requirements including the sharing of haul savings with the Department.	CO_2, N_2O	Information / Awareness	Implemented	Saskatchewan Department of Highways and Transportation	
Vehicle/Driver and Awareness Program	This pilot driver training (fuel efficiency) project for the Government of Alberta employees was implemented in January 2002. The program covers all aspects of vehicle/equipment ownership and operation relating to energy efficiency. In addition to vehicle/equipment maintenance operation and driver behaviour issues, this program encourages lease renewal decision-makers to select the most fuel-efficient vehicles in their class.	CO_2, N_2O	Information / Awareness / Education	Implemented	Alberta Infrastructure and Transportation Ministry	
Vehicle Scrappage Programs	These voluntary programs, developed and run by local organizations in communities across Canada and supported by partners, including Environment Canada, are designed to improve air quality and help reduce smog–forming and climate change emissions by permanently removing older, high emitting vehicles from Canadian roads. Financial incentives and rewards are offered to encourage and enable motorists to trade in their qualifying vehicles, which are recycled according to environmental guidelines. Participating programs include: • Car Heaven – BC, Alberta, Ontario, and Atlantic Canada; • Bye Bye Beaters Program – Manitoba; • The Scrap-It Program – BC Lower Mainland; • Fredericton Scrappage Program – Greater Fredericton Area, New Brunswick; • The Cash for Clunkers Clean Air Rewards Program – Central Okanagan Regional District; • Kidney Car Program – BC, Saskatchewan; • Faites de l'air! – Montréal, Québec	CO_2, N_2O	Economic / Information	Implemented	The Clean Air Foundation / British Columbia Ministry of Environment / Manitoba Lung Association / New Brunswick Lung Association / City of Kelowna / The Kidney Foundation of Canada / Assocation québécoise de lutte contre la pollution atmosphérique	Over 34,000 vehicles retired Nationwide, since June 2000, from Car Heaven Program alone.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
www.carpool.ca program	As Canada's leading rideshare program, actively promotes the development of rideshare programs; promotes the responsible use of automobiles by individuals; and, raises public awareness of the environmental and economic benefits of rideshare programs. Many large cities have regional car and vanpool programs. A marketing component encourages communities/partners to host promotional events, which include *Go Green* in the spring and *Rideshare Week* in the fall.	CO_2, N_2O	Information / Awareness	Implemented	Trans Canada Carpool.ca (formerly Commuter Connections Society)	Used by over 120 employers and institutions

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - INDUSTRIAL (CROSS-CUTTING)						
Government of Canada						
Canadian Industry Program for Energy Conservation (CIPEC)	Helps Canadian industry be more energy efficient thereby improving their economic performance and reducing their GHG emissions. CIPEC is an umbrella organization overseeing a unique government-industry voluntary partnership that addresses barriers to planning, implementing and tracking energy efficiency projects at the sector and company levels. While CIPEC operates at the sector level, direct company involvement occurs through the Industrial Energy Innovators (IEI) component and is supported by five sub-programs. IEI are companies that make a written company-level commitment to CIPEC to become more energy efficient, thus being eligible to gain access to CIPEC products and services, including: • Awareness Building; • Emissions Benchmarking; • Energy Efficiency Audits; and, • Improved energy/emissions tracking and reporting.	CO_2, CH_4, N_2O	Economic / Awareness / Information	Implemented	Natural Resources Canada	Increased energy use among CIPEC participants (more than 800 IEI) is about half that of non-participants. The mining, manufacturing and construction sectors improved their energy intensity by an average of 1.7% per year (0.7% for all CIPEC industries) since 1990.
EnerGuide for Industry	Encourages the use of more energy-efficient off-the-shelf industrial equipment. Its goal is to strengthen Canada's economic competitiveness while reducing GHG emissions that contribute to climate change. Building on the trusted EnerGuide name, it offers comprehensive Web-based information that enables equipment buyers to compare the energy performance of products and select the most energy-efficient model that meets their needs.	CO_2, N_2O	Awareness / Information	Implemented	Natural Resources Canada	
Environmental Supply Chain Management (ESCM) Pilot Project	Explores how supply chain management can be used to raise awareness of climate change and encourage activity to reduce GHG emissions among Canada's small and medium-sized enterprises (SMEs). The pilot host industries are exploring methods for influencing suppliers to measure, track, manage and reduce GHG emissions through changes in business/production processes and the use of new technologies.	CO_2, CH_4, N_2O	Information / Awareness	Terminated	Industry Canada / Canadian Standards Association (CSA)	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Industrial Building Incentive Program (IBIP)	IBIP is to transform the design on industrial buildings by modifying the expectations that owners have for their buildings and how designers think about addressing those expectations. It also aims to achieve the construction of more energy efficient buildings in the industrial sector so that energy performance is at least 25% better than the *1997 Model National Energy Code for Buildings (MNECB)*.	CO_2, N_2O	Economic / Information	Implemented	Natural Resources Canada	Average performance of IBIP buildings is 55% better than the MNECB.
Regulatory Action	The Government intends to propose regulations to reduce air emissions from key industrial sectors including fossil-fuel fired electricity generation, upstream oil and gas, downstream petroleum, base metal smelters, iron and steel, cement, forest products, and chemicals production. Together, these sectors contribute about half (47%) of Canada's GHG emissions.	CO_2, N_2O	Economic / Policy	Planned	Environment Canada	
Support for Co-Generation and District Energy Systems	This measure examined the technical and economic potential for co-generation and district energy systems in Canadian industry. A preliminary potential study identified barriers to co-generations and district energy systems and explored ways to remove them.	CO_2, N_2O	Economic / Information	Terminated	Natural Resources Canada	
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
GHG Registries	The registries constitute a universally accepted, fully functional and cost effective platform for reporting GHG emissions, removals, and reductions. They are designed to encourage organizations from all sectors of the economy to voluntarily develop and implement GHG reduction plans. GHG Registries maintains two primary integrated registries: • the Canadian GHG Challenge Registry is an entity-based registry of voluntary GHG Emissions Reduction Action Plans; and, • the Canadian GHG Reductions Registry is a project-based registry of GHG reductions projects and their annual registered emissions reductions (RERs).	CO_2, CH_4, N_2O	Information / Policy	Implemented	Canadian Standards Association (CSA)	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
The Renewable Power Sales Incentive Program	Encourages the consumption of available surplus hydro electricity to displace fossil fuels used for space and water heating for general service, government and industrial customers. The program guarantees a return on investment to customers who install the equipment necessary to purchase secondary power. It also provides technical services such as feasibility planning and building design, financial assistance like interest abatement, loans and capital contributions, electronic power dispatch and a building energy management reporting service.	CO_2, N_2O	Economic / Information	Implemented	Yukon Development Corporation / Yukon Energy Corporation	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - UPSTREAM OIL AND GAS						
Government of Canada						
CO_2 Capture and Storage (CO_2 C&S)	This program was to advance the understanding of the optimum use of CO_2 in geological formations, as a means to reduce GHG emissions and to promote its future commercialization. An incentive encouraged oil and gas producers to incur higher costs of production in order to stimulate reductions in CO_2 emissions.	CO_2	Economic / Research and Development / Information	Implemented	Natural Resources Canada	Signed five contribution agreements, leading to five CO_2 C&S demonstration projects.
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
Canadian Oil Sands Network for Research and Development (CONRAD)	An R&D network that was established with the objective of encouraging, initiating, and supporting collaborative research in oil sands that will permit new grass-root development, while improving the performance of existing operations. CONRAD has the following three goals: • Improve the performance of the Oil Sands Industry through superior new technologies; • Improve the effectiveness and quality of Oil Sands Research; and, • Develop technologies that will further improve Industry's environmental performance.	CO_2, N_2O	Research and Development / Information / Outreach	Implemented	Alberta Research Council	
CAPP's Stewardship Initiative	Actively encourages members to engage in open communication with stakeholder groups to develop policies and procedures that build a better, cleaner environment for their communities. Stewardship core publications, such as the Basic Environmental Program, can provide member companies with the tools to develop their company specific environmental management programs and performance measurements.	CO_2, N_2O	Policy / Research and Development / Information / Outreach	Implemented	Canadian Association of Petroleum Producers (CAPP)	
Gas Market Development Fund	Put aside by the partners in the Sable Offshore Energy Project, these funds will help offset the costs of converting to energy-efficient space heating and hot water appliances for this clean, convenient energy alternative.	CO_2, N_2O	Economic	Implemented	Nova Scotia Department of Energy	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Innovative Energy Technology Program (IETP)	This $200 million commitment over five years is designed to encourage the development of innovative technologies that will increase resource recovery. It provides royalty adjustments to a number of specific pilot and demonstration projects that use innovative technologies to materially increase recoveries from existing reserves and encourage responsible, development of oil, natural gas and in situ oil sands reserves. The program is also designed to assist industry to find commercial technical solutions to the gas over bitumen issue that will allow efficient and orderly production of both resources.	CO_2, N_2O	Economic / Fiscal / Research and Development / Information	Implemented	Alberta Department of Energy	
Otherwise Flared Solution Gas Royalty Waiver Program" (OFSG)	Encourages the reduction in the volume of solution gas being flared in the province. The department will waive the royalty on otherwise flared solution gas and associated by-products when used in a manner that would have normally required payment of royalty (ie. conserved). The waiver will last for ten years from the month that the application is received.	CO_2, N_2O	Economic / Fiscal	Implemented	Alberta Department of Energy	
Technology for Emission Reduction and Eco-efficiency (TEREE)	Facilitates technologies that will reduce the industry's impact on the environment, while improving profitability and eco-efficiency. Objectives. Launched in 2003, its objectives are to facilitate: • recognition and understanding of key emission reduction issues; • identification and evaluation of existing eco-efficient technology and best practice solutions to address these key issues; • development of new technologies and best practices that address identified gaps; • transfer into practice new and existing technology and best practice based solutions; and, • verification of actual emission reductions achieved.	CO_2, N_2O	Economic / Research and Development / Information	Implemented	Petroleum Technology Alliance Canada (PTAC)	Currently has six projects underway.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - ELECTRICITY GENERATION						
Government of Canada						
Government Purchases of Electricity from Renewable Resources (PERR)	Intends to displace the 20% of federal electricity purchases from carbon-intensive sources such as coal and petroleum products with purchases of electricity from emerging renewable energy sources (ERES) that are certified by a third party as having low environmental impact, thus reducing GHG and other air pollution emissions associated with federal electricity consumption. The program is intended to expand the renewable energy industry in Canada by supporting promising climate-friendly technologies in the expectation that their total costs will come down as a result of the expanding market created by the federal leadership. Electricity from ERES includes wind, water, biomass and the sun.	CO_2, N_2O	Policy / Economic / Information	Implemented	Natural Resources Canada / Environment Canada / Public Works and Government Services Canada	147.5 GWh/year have been purchased with a target of purchasing 450 GWh/year, by 2010.
Market Incentive Program	The intent of the program was to stimulate the emerging markets for renewable electricity by seeking proposals from electricity distributors interested in developing market-based projects that would increase the sales of electricity from emerging renewable energy sources in residential and small-business sectors.	CO_2, N_2O	Fiscal / Economic / Information	Terminated	Natural Resources Canada	
On-site Generation at Federal Facilities	Promoted the adoption of electricity from emerging renewable energy sources for on-site electricity generation in federal operations. The program had two sub-objectives: • to develop a sustainable market in federal facilities for reliable and cost-effective applications, which are found essentially in off-grid locations; and, • to create awareness of these systems among Canadians through installations in high-visibility buildings, mostly in on-grid locations.	CO_2, N_2O	Fiscal / Economic / Information	Terminated	Natural Resources Canada	Total of 17 projects for total installed power of 857.5 kW, generating capacity of approximately 5.27 GWh/yr.

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Reducing Barriers to Inter-provincial Trade and Transmission of Electricity	This three year program, which commenced in fiscal year 2001/02, was intended to work with interested jurisdictions on issues pertaining to access to electricity grids for generating plants that emit zero or low levels of GHGs, and on reducing the barriers to inter-provincial transmission and trade that would permit electricity from such sources to reach markets in neighbouring provinces.	CO_2, CH_4, N_2O	Policy / Outreach	Terminated	Natural Resources Canada	
Tax Incentives	The GoC offers two significant tax incentives to encourage the development of energy conservation and renewable and alternative energy projects: • The accelerated capital cost allowance (CCA), available on Classes 43.1 and 43.2 provides an accelerated rate of write-off for investments that produce heat for use in an industrial process, or electricity by using fossil fuel efficiently or by using renewable energy sources. • The Canadian Renewable and Conservation Expenses (CRCE) allow investors to fully write-off certain, mostly intangible, costs associated with investments in renewable energy and energy conservation projects. These expenditures can also be renounced to shareholders through a flow-through share agreement, which is particularly beneficial for companies not otherwise able to use a current tax deduction.	CO_2, N_2O	Fiscal	Implemented	Canada Revenue Agency / Finance Canada	
Wind Power Production Incentive (WPPI)	Intended to encourage electric utilities, independent power producers and other stakeholders in the development of wind energy, which does not produce emissions. The incentive will also help establish wind energy as a full-fledged competitor in the electricity marketplace. It was intended to help stimulate the installation of 1,000 MW of wind capacity.	CO_2, N_2O	Economic / Information	Implemented	Natural Resources Canada	As of June 2006, 19 projects were commissioned with a total capacity of 769 MW and 3 other wind projects (155 MW) signed for a total commitment of 22 projects and 924 MW.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
Alternative Energy (Wind)	This program supports the installation, monitoring and assessment of wind turbines. Two types of small (50 - 80 kW) wind turbines are being installed on isolated diesel systems in three communities.	CO_2, N_2O	Research and Development	Implemented	Northwest Territories Power Corporation	
Energy Technologies Development Assistance Program (ETDAP)	Contributes to energy resource diversification, to support new technologies for which research costs cannot be covered entirely through private investment, to promote the export of Quebec's technology and know-how, to improve the competitiveness of Quebec's industry by enhancing energy efficiency, and to develop technologies to reduce pollution caused by the use of energy. Priority is given to research and development in hydrogen, biomass, and wind energy.	CO_2, N_2O	Economic / Research and Development	Implemented	Ministère des Ressources naturelles du Québec	
Green Power Initiative	Encourages renewable energy production in an environmentally sustainable manner. Its objectives are to displace diesel electricity production and reduce greenhouse and other gas emissions, especially in communities only served by diesel generation; to provide consumers with a green power option; to expand the technical capability to develop green power alternatives; and to improve the long-term cost effectiveness of green power energy sources. The program will achieve these goals through research and development, demonstration projects, targeted technical information, development of standards and youth education projects.	CO_2, N_2O	Research and Development / Information / Outreach	Implemented	Yukon Energy Corporation (YEC)	
Haeckel Hill Wind Monitoring	Monitors the performance of two wind turbines – one of which is a 150-kW commercially available wind turbine – in Yukon's northern climate in an attempt to overcome technical barriers primarily associated with ice accumulation. YEC also monitors wind at Haines Junction and Old Crow.	CO_2, N_2O	Research and Development	Implemented	Yukon Energy Corporation (YEC) / Yukon Electrical Company Ltd.	
Manitoba Energy Development Initiative	Implements and co-ordinates government-wide economic development strategies encompassing the province's hydro-electric and alternative energy development opportunities; develops, analyzes and implements the provincial government's energy policies; and, monitors the implementation of energy-related climate change initiatives.	CO_2, CH_4, N_2O	Economic / Information	Implemented	Manitoba Energy, Science & Technology	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Power Connect	Provides technical and regulatory support to the manufacturers of alternate energy (i.e. photovoltaic, wind, fuel cells, clean combined heat and power) technologies concerning the implementation of distributed energy resources in a competitive electricity market. It will help address many of the barriers that customers and project developers face when they try to implement and interconnect renewable and distributed generation in Canada. This includes the need to study the cost-benefit of distributed energy resources integration into the electrical network, address urgent issues concerning net-metering, reverse-metering, time-of-day pricing to improve peak-shaving value, and standard integration procedures and contracts.	CO_2, CH_4, N_2O	Policy / Outreach	Implemented	Electro-Federation Canada (EFC) / Natural Resources Canada / Industry Canada	
Prince Edward Island's Renewable Energy Act	Requires utilities to acquire at least 15% of electrical energy from renewable sources by 2010. This Act ensures the economic viability of community or wind cooperative systems by guaranteeing a selling price to the utility of up to 85% of the retail residential rate.	CO_2, N_2O	Policy	Implemented	Prince Edward Island Government	
Quebec's Request for Proposal	Encourages the development of 990 MW of wind energy through a tendering process. A total of 660 wind turbines will be installed and operating by 2012. Local content requirements outlined in the request for proposal have led the participating wind developer to establish a nacelle assembly and component manufacturing operation in the Gaspésie/Matane region of Quebec.	CO_2, N_2O	Policy	Implemented	Hydro Quebec	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - MINING AND MANUFACTURING						
Government of Canada						
Enhanced Emission Reductions for Minerals and Metals	This program aims to reduce GHG emissions by examining processes where improved understanding could lead to new emission-reduction opportunities in the Canadian minerals and metals industry sector. It also works to promote increased use of Supplementary Cementing Materials (SCMs) in concrete to displace Portland cement, thereby reducing the GHG intensity of concrete production. The program was created in February 2004, as a result of combining the three initiatives described below.	CO_2, N_2O	Economic / Research and Development / Information / Outreach	Implemented	Natural Resources Canada	At least 15% of cement is now replaced by SCMs, with a goal of reaching 25% by 2012.
Concrete Roads Program	Provided education and information about the benefits of concrete roads as well as expert advice to engineers, builders and others. The program also reviewed current analyses of the fuel economy benefits of concrete roads, and facilitated such analyses for specific potential concrete-road projects.			Terminated		
Supplementary Cementing Materials (SCM) Program	Developed and disseminated information on the benefits and costs of SCMs, and on appropriate design, engineering and construction techniques. The program helped develop standards and specifications for concrete with SCMs in various applications, and developed networks of stakeholders to share knowledge and experience regarding SCMs.			Implemented		
Studies and Monitoring for Greenhouse Gas Reduction Potential	Aimed to improve the level of knowledge with respect to selected areas of research by gathering data and other information needed on potential approaches to reducing GHG emissions.			Terminated		
Enhanced Recycling	Designed to stimulate recycling activities within Canada by seeking like-minded partners to participate in projects that take current recycling activities to higher levels. Through national consultations, workshops and seminars, the program has raised the awareness of key issues that are limiting sustainable recovery efforts.	CO_2, CH_4, N_2O	Economic / Information / Outreach	Implemented	Natural Resources Canada	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
Advanced Manufacturing Initiative (AMI)	The AMI will consist of the delivery of “Lean Manufacturing” programs, such as consortia; best practice tours; creating awareness for lean thinking and diagnostic tools; and, human resources programs, such as lean manufacturing certificate programs, training, delivery and communications. Lean thinking focuses on the reduction and removal of waste from manufacturing processes, but it also results in improvements in productivity, customer satisfaction, employee morale and overall enterprise success.	CO_2, CH_4, N_2O	Economic / Information / Awareness	Implemented	Canadian Manufacturers & Exporters (CME) - Manitoba Division	
$mart Energy Management Program	Assists manufacturers and processors in reducing their energy costs through energy efficiency. Includes energy efficiency workshops, development and distribution of an interactive CD-ROM on energy efficiency for the sector, and an energy auditing service.	CO_2, N_2O	Outreach / Information	Implemented	Prince Edward Island Department of Environment, Energy and Forestry	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - AGRICULTURE						
Government of Canada						
Agricultural Policy Framework (APF)	A combined federal-provincial-territorial strategic agriculture initiative designed to support agriculture and agri-food. Though not directly designed as a climate change strategy, the environmental component of the APF has several programs that focus on improving environmental performance on farms (e.g. the *Environmental Technology Assessment for Agriculture (ETAA)* program, the *Greencover Canada* initiative.) Within these programs, reducing GHGs is part of the goal to improve the quality of air.	CO_2, CH_4, N_2O	Economic / Awareness / Policy / Research & Development	Implemented	Agriculture and Agri-Food Canada (AAFC)	
Energy Co-Generation from Agricultural and Municipal Waste (EcoAMu)	Establishes model demonstration pilot plants that demonstrate innovative technologies for the co-generation of energy from the use of agricultural and municipal wastes. Data collected at the sites is being used to assist the international Offset Protocol Partnership group (OPPs) to develop standardized protocols for the measurement of GHG emission reductions from anaerobic digestion of manure.	CO_2, CH_4, N_2O	Research and Development	Implemented	Agriculture and Agri-Food Canada (AAFC)	Five projects are well underway.
Environmental Technology Assessment for Agriculture (ETAA)	Assesses the performance of innovative technologies to improve the Canadian agriculture sector economically and environmentally. ETAA also facilitates the adoption of new technologies, production systems, bio-processes and bioproducts. The knowledge and information generated through ETAA is communicated and shared with stakeholders to support on-farm action and resource management decisions.	CO_2, CH_4, N_2O	Economic / Awareness / Research and Development	Implemented	Agriculture and Agri-Food Canada (AAFC)	Thirteen projects implemented
Greenhouse Gas Mitigation Program for Canadian Agriculture (GHGMP)	Works towards reducing agricultural GHG emissions and creating sustainability for the industry. It aims to: 1) prepare suites of GHG beneficial management practices (BMPs); 2) build awareness and involve producers in fostering the adoption of practices that reduce GHG emissions; and, 3) quantify the impact of BMPs on GHG reductions. The program measures are targeted at soil, nutrient and livestock management; and, increasing carbon sinks.	CO_2, CH_4, N_2O	Economic / Awareness	Implemented	Agriculture and Agri-Food Canada (AAFC)	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Model Farm Program	The model farm was intended to demonstrate the most efficient and orderly layout of farm buildings, although its primary functions included pure and applied scientific agricultural research and practical farming. The rational was to provide better estimates of the carbon sequestration and net reduction of GHG emissions for whole farming systems, and to identify practices that best reduce whole-farm emissions.	CO_2, N_2O	Research / Awareness	Implemented	Agriculture and Agri-Food Canada (AAFC)	
Shelterbelt Enhancement Program (SEP)	Designed to reduce GHGs through increased shelterbelt plantings on agricultural lands across the Prairies, by working in partnership with farmers, livestock producers and rural organizations to plant 8,000 kms of shelterbelts by 2006 in addition to the annual planting commitments. As part of the program, clients are supplied with weed-controlling materials and specialized mulch application equipment.	CO_2, N_2O	Economic / Awareness	Implemented	Agriculture and Agri-Food Canada (AAFC)	As of March 31, 2005, 2,895 kms of shelterbelt had been planted.
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
Agricultural Development Fund and the Technology Adaptation Fund	Over the last ten years, SAFRR has directed approximately $4.8 million in climate change research funding for 29 projects through the Agricultural Development Fund and the Technology Adaptation Fund. These efforts have produced dramatic improvements in soil management practices in Saskatchewan.	CO_2, N_2O	Fiscal	Implemented	Saskatchewan Agriculture, Food and Rural Revitalization (SAFRR)	
Alberta Environmentally Sustainable Agriculture Processing-Based Program	This program aims to reduce environmental impacts of agri-food processing on the environment and build industry environmental stewardship and consumer confidence through awareness, extension and education programs. AESA Processing-Based Program may provide grants on cost-shared basis for eligible projects to a maximum of $20,000 per project.	CO_2, N_2O	Financial Incentives	Implemented	Alberta Agriculture, Food and Rural Development	
BC Agriculture Council Best Management Practices	The program's goal is to ensure that farmers and ranchers use the best management practices, to minimize environmental risk and maximize benefits.	CO_2, N_2O	Information	Implemented	Government of BC / BC Agricultural Council	
Covering New Ground (CNG)	Provides funds to Manitoba producer groups and provincial commodity organizations to carry out sustainable agriculture demonstration or technology transfer projects throughout the province. Eligible projects must offer solutions to the challenges of sustainable development with an emphasis on improving the environmental performance of the agricultural industry.	CO_2, N_2O	Economic / Information / Awareness	Implemented	Manitoba Agriculture, Food and Rural Initiatives	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - FORESTRY						
Government of Canada						
Feasibility Assessment of Afforestation for Carbon Sequestration (FAACS)	This initiative evaluated the feasibility of afforestation, undertook information collection and land assessment research on privately owned lands, and contributed to establishing Canada's carbon measurement and accounting infrastructure for reporting internationally on afforestation. Research focused on: landowner consultations; cost-benefit modelling; carbon science development; and, land suitability assessment.	CO_2	Policy / Research & Development / Awareness	Terminated	Natural Resources Canada	
Forest 2020 Plantation Demonstration Assessment (PDA)	Building upon the work of the FAACS initiative, this initiative examined the economics of fast growing tree plantations and potential options to attract investment into future Canadian plantations, by taking advantage of the combined benefits of wood fibre, carbon values and other environmental services. Forest 2020 PDA approached these goals through: tree plantation demonstration sites; further carbon research; cost-benefit analysis of afforestation; and, private sector investment analysis.	CO_2	Policy / Research & Development / Awareness	Terminated	Natural Resources Canada	
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
Forest Enhancement Program	This program supports tree planting projects that endeavor to establish healthy, long-term forests or community tree stands; and forest education projects that improve school children's or the public's appreciation and understanding of the nature, role and importance of trees, forests and sustainable forest management in communities, agricultural areas and forest covered areas of Manitoba.	CO_2, N_2O	Economic / Information /Awareness /	Implemented	Manitoba Hydro	
Ontario Large Scale Forest Carbon Project	Determines the current and future forest carbon balance of Ontario using provincial forest resources inventory (FRI) information and the planned forest management unit silvicultural activities set out in the Strategic Forest Management Model (SFMM), a forest management planning computer model.	CO_2, N_2O	Research	Implemented	Ontario Forest Research Institute	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES AFFECTING GHGs - WASTE						
Government of Canada						
The Waste Prevention Program	Focuses on the sustainable management of solid non-hazardous waste by: • developing, implementing and coordinating national programs that foster waste prevention and sustainable waste management; and • working with governments, municipalities and the private sector to identify and promote further opportunities for landfill gas capture and utilization, which can result in the reduction in environmental impacts, energy consumption and the optimization of energy recovery.	CO_2, CH_4, N_2O	Policy / Regulations / Information / Research & Development	Implemented	Environment Canada	
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
Beverage Container Program	Aluminum, tin/bi-metal cans; plastic, glass bottles; milk jugs and juice boxes are collected and recycled.	CO_2, CH_4, N_2O	Pilot Project	Implemented	Government of NWT	
Environmental Management Act	EMA now provides a more flexible authorization framework, increases enforcement options and uses modern environmental management tools to protect human health and the quality of water, land and air in British Columbia. EMA also enables the use of administrative penalties, informational orders and economic instruments to assist in achieving compliance.	CO_2, CH_4, N_2O	Regulations	Implemented	Government of BC	
EnviroVista	The program officially recognizes facilities that have a minimum history of five years of exemplary emissions performance, a comprehensive, publicly-accessible, third-party audited environmental management system and five years without any prosecutions under Alberta's Environmental Protection and Enhancement Act (EPEA).	CO_2, CH_4, N_2O	Information/ Awareness	Implemented	Government of Alberta	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Extended Producer Responsibility (EPR) Workshop	This workshop provided testimony on issues of EPR from experts across Canada and around the world. The workshop also provided participants with an opportunity to discuss program performance, to learn of emerging approaches and technologies, and to help in the planning of EPR programs in their area of responsibility.	CO_2, CH_4, N_2O	Information / Awareness	Implemented	Government of Nova Scotia	
Manitoba Water Services Board (MWSB)	Assists rural residents outside Winnipeg in developing safe and sustainable water and/or sewerage facilities. The Board's primary objectives are to ensure that public health and/or environmental concerns are alleviated by supporting and promoting sustainable community development activities.	CO_2, CH_4, N_2O	Information / Awareness	Implemented	Manitoba Water Stewardship Department	
Multi – Materials Stewardship Board (MMSB)	To encourage participation in provincial recycling and waste management initiatives, MMSB coordinates and delivers a province-wide education campaign for all Newfoundlanders and Labradorians. This information campaign focuses on Green Depots, schools, businesses, government, fundraising groups, retailers, households, and youth.	CO_2, CH_4, N_2O	Information / Awareness	Implemented	Government of Newfoundland	
Nova Scotia Solid Waste-Resource Management Strategy	A comprehensive waste reduction plan that includes: Disposal Bans, Industry Stewardship, Bottle deposit/refund system, Curbside Recycling, Regional Cooperation and Disposal Sites	CO_2, CH_4, N_2O	Fiscal / Economic	Implemented	Government of Nova Scotia	
Pollution Prevention Pledge Program	This program acknowledges facilities that develop and achieve pollution prevention goals that exceed existing government standards.	CO_2, CH_4, N_2O	Fiscal	Implemented	Government of Ontario	
Product Stewardship	Product Stewardship (IPS) is a government strategy of using regulations to place the onus for end of life product management on the producer and consumers of a product in order to achieve waste reduction and promote recycling.	CO_2, CH_4, N_2O	Regulations	Implemented	Government of BC	
Recycling Club	The Recycling Club is a program that helps children establish community recycling depot and programs and allows participants to win prizes in return for their effort.	CO_2, CH_4, N_2O	Information / Awareness	Implemented	Yukon Environment	
Resource Recovery Grant Program	This program provides grants to municipalities to develop a resource recovery/recycling infrastructure. There are over 100 municipalities currently operating recycling programs in the province.	CO_2, CH_4, N_2O	Fiscal Incentives	Implemented	Government of Alberta	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Reusing and Recycling in Saskatchewan	The Saskatchewan government maintains a resource center on waste reduction and other environmental issues. It has information on a wide range of topics and responds to information requests from businesses, municipalities and community groups about recycling and waste reduction. Specific sub-programs include: • Beverage Container Collection and Recycling Program; • Pesticide Container Collection Program; • Paint Disposal and Recycling Program; • Scrap Tire Management Program; and, • Used Oil Material Recycling Program.	CO_2, CH_4, N_2O	Information / Awareness	Implemented	Saskatchewan Environment	
Waste Diversion Act	This Act, passed on June 27, 2002, created Waste Diversion Ontario (WDO), a permanent, non-government corporation, which is run by a board of directors comprised of industry, municipal and NGO representatives. The Act gave WDO the mandate to develop, implement and operate waste diversion programs-to reduce, reuse or recycle waste.	CO_2, CH_4, N_2O	Regulation	Implemented	Government of Ontario	
Waste Management Assistance Program	This program has been providing technical and financial assistance to groups of municipalities to address their waste management needs. Assistance covers regional waste management planning studies and up to 75 % of capital and engineering costs associated with the design and construction of regional waste management systems.	CO_2, CH_4, N_2O	Economic / Information	Implemented	Government of Alberta	
Waste Management Trust Fund	Plays an integral role in supporting waste management projects that guide the province toward modern waste management, and support the overall implementation of the Provincial Waste Management Strategy. This funding has benefited more than 300 community and environmental groups, municipalities, and schools, and has funded dump site closures, waste management studies, school recycling initiatives, and environmental education and recycling.	CO_2, CH_4, N_2O	Economic	Implemented	Government of Newfoundland	
Waste Reduction and Diversion – An Action Plan for New Brunswick	A comprehensive waste reduction plan that includes: • Legislated Waste Diversion Standards; • Green Procurement Policy for Government; • Public Education Campaigns; and, • Industry Stewardship Programs such as the *Beverage Container Program* and the *Used Oil Program*.	CO_2, CH_4, N_2O	Policy	Implemented	New Brunswick Land, Properties and Environment Department	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Waste Reduction and Pollution Prevention (WRAPP) Fund	Established in 2000 to support improved waste reduction and pollution prevention practices in the Province of Manitoba, it supports projects focusing on waste reduction, pollution prevention and innovative integrated waste management practices.	CO_2, CH_4, N_2O	Information / Awareness Economic	Implemented	Manitoba Conservation	
Waste Watch Program	Provides solid waste management services through a 3-stream source separation based waste management system that is Island-wide.	CO_2, CH_4, N_2O	Information / Awareness	Implemented	Island Waste Management Corporation (IWMC)	Goal of reaching 65% diversion from waste.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
MEASURES ON IMPACTS, ADAPTATION AND CLIMATE SCIENCE						
Government of Canada						
Climate Change Impacts and Adaptation Program (CCIAP)	Provides funding for research and activities to improve our knowledge of Canada's vulnerability to climate change, to better assess the risks and benefits posed by climate change and to build the foundation upon which appropriate decisions on adaptation can be made. The Program also supports the Canadian Climate Impacts and Adaptation Research Network (C-CIARN), which facilitates linkages between stakeholders and researchers, promotes new research techniques and methodologies, disseminates information, and provides a voice for an emerging impacts and adaptation research community.		Research / Economic	Implemented	Natural Resources Canada	Funded 130 research projects since 2001.
Health Policy Research Program	This broadly-focused program examines the capacity of Canada's health sector to adapt to issues such as climate change by funding extramural policy research in order to improve the evidence base available for health policy decisions and to promote informed debate and public understanding of health policy issues.		Research / Economic	Implemented	Health Canada	Supported 22 research papers/workshops as at the end of December 2005.
Reducing Canada's Vulnerability to Climate Change (RCVCC)	This program aims to improve understanding of the vulnerability of Canada's landscape and coastal areas, infrastructure, and communities to climate change via research. Research being conducted by the portfolio of program projects includes the monitoring of Canada's landscape and coastal areas through satellite observation and in-situ measurements; paleo reconstructions for understanding historical climate and landscape evolution; spatially explicit, process-based modelling of landscape dynamics; and simulations and assessments of landscape changes in response to climatic, socio-economic and policy scenarios.		Research / Awareness	Implemented	Natural Resources Canada	Conducts six projects that are linked by common themes. Created a series of land cover maps.

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Science Impacts and Adaptation component of the Climate Change Action Fund (CCAF-SIA)	This component of the CCAF supported a number of activities, such as: climate monitoring and studies of GHG sources and sinks; arctic climate studies; studies of extreme weather; as well as development, assessment and implementation of adaptation responses.		Research	Terminated	Climate Change Secretariat	
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
ArcticNet	This initiative contributes to the development and dissemination of the knowledge needed to formulate adaptation strategies and national policies to help Canadians face the impacts and opportunities of climate change and globalization in the Arctic. A major goal is to engage Inuit organizations, northern communities, universities, research institutes, industry as well as government and international agencies as partners in the scientific process and the steering of the Network. Over 100 ArcticNet researchers from 27 Canadian universities and 5 Federal departments collaborate with research teams in the USA, Japan, Denmark, Sweden, Norway, Poland, the United Kingdom, Spain, Russia, Greenland and France.		Research / Economic	Implemented	Networks of Centres of Excellence (NCE)	
Ouranos Consortium	The mission of Ouranos is to acquire and develop knowledge on regional climate change, on related socioeconomic and environmental vulnerabilities and on potential impacts, in order to inform decision makers of the probable evolution of the climate and advise them in identifying, promoting, implementing and evaluating local and regional adaptation strategies.		Research / Awareness	Implemented	Government of Québec / Hydro-Québec / Environment Canada	
Prairie Adaptation Research Collaborative (PARC)	This partnership is mandated to pursue climate change impacts and adaptation research in the Prairie Provinces. Its objective is to generate practical options to adapt to current and future climate change. It is also charged with fostering the development of new professionals in the emerging science of climate change impacts and adaptation.		Research / Awareness	Implemented	Governments of Canada, Alberta, Saskatchewan and Manitoba	Since inception in 2000, has been involved in dozens of interdisciplinary projects to address climate change impacts and adaptation issues.

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Transportation and Permafrost Impacts Initiatives	Develops the necessary knowledge, capacity, and experience to address impacts on the transportation system in the NWT, including: • proactively building bridges on all crossings on the Mackenzie winter road; • increased maintenance and rehabilitation efforts on all-weather roads and airport runways; and, • study the effects of climate change on the NWT transportation system.	CO_2, N_2O	Research / Economic / Information	Implemented	Government of the Northwest Territories	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
PUBLIC EDUCATION AND OUTREACH INITIATIVES						
Government of Canada						
Clean Energy Portal	Designed to inform Canadian and non-Canadians about Canada's clean energy expertise and innovative clean energy industry, it actively promotes Canadian companies to foreign businesses, investors, and governments through the Portal, at trade shows, and in brochures and presentations. The Portal uses Internet services and information technology advancements to enhance communication links and activity between individuals, institutes, industry, and government stakeholders, which accelerates and promotes the commercialization and technology transfer of climate and clean energy-related technologies.		Information / Awareness	Implemented	Natural Resources Canada / Industry Canada	Contains a directory of over 600 Canadian technology providers.
One-Tonne Challenge (OTC)	The OTC was a social marketing program that promoted and supported action on climate change by individual Canadians. Through information, interactive tools and partnerships with provinces and territories; business and industry; communities; and, youth and educators, the OTC linked Canadians to programs and actions that helped them in achieving a one-tonne reduction of GHG emissions each year.		Education / Information / Outreach	Terminated	Natural Resources Canada / Environment Canada	
Public Education and Outreach component of the Climate Change Action Fund (CCAF-PEO)	This component of the CCAF supported activities to raise Canadians' awareness to the issue of climate change and to promote individual and collective action.		Awareness / Outreach	Terminated	Various departments	
Other levels of government and Non-Governmental Organizations						
BC Climate Exchange	The Exchange facilitates interaction between the various government, civil society and private sector organizations in British Columbia engaged in public education and outreach on climate change, impacts and solutions.		Information / Outreach	Implemented	Fraser Basin Council / Canadian Institute for Climate Studies	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Building Bridges	This community engagement program brings together youth and community leaders in New Brunswick in a united effort to encourage people to reduce their GHGs. High school and university-age youth first educate community leaders (teachers, politicians, sports personalities, business owners…) about the causes, impacts and solutions for climate change. Together they make presentations to colleagues of the community leader, and encourage them to make signed commitments to reduce their use of electricity or to drive their car less.		Information / Outreach	Implemented	New Brunswick Lung Association	
Climate-Air Connections	This partnership between the public sector, environmental NGOs, and industry, helps senior governments and Ontario's PEO practitioners: share knowledge of activities underway in Ontario; share information on best practices; identify gaps in Ontario's initiatives to address those gaps, and; foster cooperative relationships to extend programs and improve effectiveness.		Information / Outreach	Implemented	Clean Air Foundation	
Climate Change Central	Founded in 1999 as a non-profit organization, Climate Change Central is focused on accelerating innovative solutions to reducing GHG emissions in Alberta within all sectors.		Fiscal / Economic / Outreach	Implemented	Government of Alberta / Alberta Environment	
Climate Change Centre (CCC)	The Centre increases awareness and motivate groups throughout Nova Scotia to develop and implement climate change activities. It is designed to reflect local/regional needs and include the input of stakeholders in industry, academia, government and environmental movement.		Information / Outreach	Implemented	Clean Nova Scotia (CNS)	
Climate Change Connection	This initiative aims at building awareness and at empowering Manitobans to take action and reduce their GHG emissions - both individually and as a community.		Information / Outreach	Implemented	Manitoba Eco-Network (MEN) / The University of Winnipeg	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Climate Change Education and Action Program (CCEAP)	This program encourages all members of Scouting to actively reduce GHGs. A Climate Change Crest has been developed, which includes an age-appropriate version of the One Tonne Challenge. Through earning the crest, youth learn about climate change and the ways in which they and their families can reduce GHG emissions. They also conduct a home energy audit. An electronic calculator is available to calculate their achievements. In addition, a special program introducing the role that trees play in reducing GHGs was introduced in the Spring of 2004 to complement Scoutrees projects.		Education / Information / Outreach	Implemented	Scouts Canada	
Climate Change Education Centre	The Centre provides education tools and facts on the impacts and adaptation that climate change will have on Newfoundland and Labrador. It raises awareness about the serious effects of Climate Change and how the people of Newfoundland and Labrador can do something to better their own environment.		Information / Outreach	Implemented	Conservation Corps of Newfoundland and Labrador (CCNL)	
Climate Change Saskatchewan	This initiative improves information available to residents of Saskatchewan to build awareness and understanding of climate change in context of Saskatchewan; to motivate action; and to develop support for change.		Information / Awareness	Implemented	Office of Energy Conservation	
Climate-Smart Program	This program is a leading edge collaborative partnership involving both the public and private sectors. Its goal is to help municipalities integrate GHG emission reduction and climate change impact and adaptation issues into the decision-making process for policy makers, practitioners and vulnerable communities. With Halifax Regional Municipality as the prototype municipality, lessons learned can be replicated in other municipalities across Canada and overseas.		Research / Information	Implemented	ClimAdapt / Nova Scotia Environmental Industry Association	
Environmental Awareness Fund	This broadly-focused Fund provides support to assist registered NGO's with efforts to inform and educate the public by promoting environmental education or awareness, resource planning and sustainable development in the Yukon. Funds can be used for a range of qualifying projects including educational camps, workshops, brochures, surveys, video productions, public lectures, conferences, web site development and similar kinds of activities.		Economic / Education / Awareness	Implemented	Yukon Department of Environment	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Green Street	This broadly-focused initiative endeavors to provide opportunities to actively engage students and teachers in environmental learning and sustainability education by inking schools in Canada to reputable Environmental Education organizations across the country. It aims to deliver credible, accessible and affordable programs that are relevant to students' concerns, curriculum-linked, encourage a sense of personal responsibility for the environment, foster a commitment to sustainable living, and promote an enduring dedication to environmental stewardship.		Education / Information / Outreach	Implemented	The J. W. McConnell Family Foundation	
New Brunswick Climate Change Hub	The Hub facilitates the exchange of ideas, information and resources between government, private sector, and community-based organizations. Through workshops, projects and various activities, raises awareness of individual and corporate citizens of New Brunswick on the impacts of climate change, and motivates them to reduce GHG emissions in their communities and daily lives.		Information / Outreach	Implemented	Government of New Brunswick	
Northern Climate ExChange	The ExChange provides a credible independent source of information, develops shared understanding and promotes action on climate change in northern Canada.		Information / Awareness	Implemented	Northern Research Institute of Yukon	
Ontario EcoSchools	This environmental education program combines what is taught in the classroom (curriculum) with how schools operate. Action-oriented guides are used in schools to conserve energy, minimize waste and green school grounds. Teaching resources (Gr.1-12) linked to curriculum explore climate change and actions students can take to reduce GHG emissions.		Education / Outreach	Implemented	York University	
Partners for Climate Protection (PCP) program	PCP is a network of 133 (and counting) Canadian municipal governments who have committed to reducing the local production of GHG emissions. PCP provides services (advocacy tools, training and workshops, research, networking), and tools and resources (inventory and projection software, model documents, information, case studies) to help Canadian municipalities prepare and implement local climate action plans.		Fiscal / Economic / Outreach	Implemented	Federation of Canadian Municipalities (FCM)	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
PEI Climate Change Hub	Functions as a resource and support center for Climate Change education and outreach on P.E.I. Also supports, encourages and motivates Islanders to take action to reduce GHG emissions.		Information / Awareness	Implemented	Government of PEI	
The Greenhouse Gas Action Guide	A compilation of straightforward, cost-effective actions intended as a resource to assist municipalities in British Columbia in implementing immediate actions to reduce GHG emissions. Recognizing that municipalities have limited resources, the GHG Action Guide identifies adaptations to existing practices that can be implemented through tools that are already available to municipalities, and by specifying resources (organizations, programs and funding) that they can gain immediate access to.		Voluntary Information / Outreach	Implemented	BC Climate Exchange	

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
INTERNATIONAL INITIATIVES						
Government of Canada						
Canadian International Technology Initiative (CITI)	Supports Canadian GHG mitigation technologies by providing market information and deployment assistance through trade missions and technology promotion officers, and generating potential opportunities through feasibility studies and market analyses. It consists of the following sub-programs: • The *Canadian Initiative for International Technology Transfer (CIITT)* provides support for the identification and development of climate-change technology transfer projects headed for developing and developed nations. • The *Climate Change Technology Promotion Officers (CCTPO)* assigns officers to Canadian embassies abroad to help Canadian companies forge business connections and market their climate-friendly technologies, products and services in countries that could benefit strongly from them.	CO_2, CH_4, N_2O	Research / Information / Economic	Implemented	Natural Resources Canada	
Clean Development Mechanism and Joint Implementation (CDM/JI) Office	*Serves as the Government of Canada's official Designated National Authority for CDM activities and the Focal Point for JI activities.* Issues "letters of approval" for projects involving Canadian companies.	CO_2, CH_4, N_2O	Information / Awareness / Economic	Implemented	Department of Foreign Affairs and International Trade (DFAIT)	
Environment and Natural Resource Management Program	This broadly-focused program manages several initiatives, which focus on research that helps reduce environmental burdens and enhance the use of natural resources for the poor in both rural and urban areas of developing countries. Examples include the following initiatives: • Rural Poverty and Environment (RPE) Program Initiative • Urban Poverty and Environment (UPE) Program • Climate Change Adaptation in Africa Research and Capacity Development Programme (CCAA) • The International Model Forest Network (IMFN)	CO_2, CH_4, N_2O	Research / Economic	Implemented	International Development Research Centre (IDRC)	
International Initiative for Technology Development (IITD)	Aims to identify and develop technology transfer projects and facilitate the expansion of market opportunities for climate change technologies.	CO_2, CH_4, N_2O	Research / Economic	Implemented	Natural Resources Canada	Provided funding for 20 feasibility studies.

Name of Policy or Measure	Objective and/or Activity Affected	GHG Affected	Type of Instrument	Status	Implementing Entity or Entities	Output Measure
Trade Team Canada Environment (TTCE)	Works to identify and implement trade promotion activities accessible to the environment industry as a whole by collaborating with private sector associations and companies, federal and provincial government sector experts, as well as the International Trade Posts and geographic desks.	CO_2, CH_4, N_2O	Information	Implemented	Industry Canada	
Other levels of government and Non-Governmental Organizations		(This list is not exhaustive. It illustrates the kind of policies and measures adopted by other levels of governments and non-governmental organizations.)				
International Centre for Municipal Development (ICMD)	The Centre delivers a wide range of international programming related to municipal capacity building and decentralization policy development by strengthening the capacity of overseas municipalities to respond to basic issues in the lives of their citizens; specifically by helping them determine, design and implement efficient solutions to their service delivery needs in areas like water, waste management, local economic development or emergency services.	CO_2, CH_4, N_2O	Awareness / Economic	Implemented	the Federation of Canadian Municipalities (FCM)	