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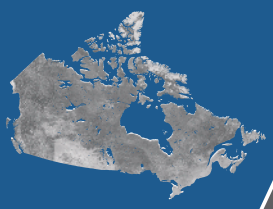
ecoENERGY
an ecoACTION initiative

Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act*
For the Fiscal Year 2006–2007



Canada

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Table of Contents

LIST OF FIGURES AND TABLES

Figures

Tables

Minister's Foreword

I am pleased to introduce this Report to Parliament. Fiscal year 2006/2007 was a year of decisive action on energy policy and programs by our Government.

Canadians have made it clear that the health of our environment is a top priority, and our Government is responding with real action to address key concerns including climate change and air pollution.

Our ecoENERGY Initiatives are achieving real results for Canadians, underlining our commitment to work with our partners in the provinces and territories, in the private sector and with individual Canadians to reduce the emissions that are harmful to both our environment and our health.

Our ecoENERGY Efficiency Initiative is helping Canadians make their homes, buildings, industries and vehicles more energy efficient. We are strengthening and expanding the regulations contained in the *Energy Efficiency Act* to assure Canadians that, whether they are buying a light bulb or a refrigerator, they can be confident it is among the most efficient in the world.

Our ecoENERGY for Renewable Power Initiative will encourage the production of enough clean electricity from renewable sources including wind, biomass, low-impact hydro, geo-thermal, solar photovoltaic and ocean energy, to power about one million homes. We are increasing our supply of cleaner fuels, and creating new economic opportunities for Canada's farmers, with our ecoENERGY for Biofuels Initiative. And, we are supporting the development of new, cleaner-energy technologies with our ecoENERGY Technology Initiative.

These measures, and others like them, are at the heart of our government's practical, balanced approach to addressing climate change and reducing air pollution.

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The largest source of untapped energy is the energy we waste. By investing in real action to increase energy efficiency, increasing our supply of cleaner energy and developing the technologies that will allow us to become cleaner producers and users of conventional energy, we are making real progress toward the results Canadians want; reduced energy costs, cleaner air and a healthier environment for all.

The Honourable Lisa Raitt, P.C., M.P.
Minister of Natural Resources

Executive Summary

Canadians spent approximately $152 billion in 2005 on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes. Several factors contribute to Canadian energy demand: a vast geography, a northern climate with extreme seasonal variations in temperature, and an economy founded on an abundance of natural resources.

Types of Energy Use

The two general types of energy use are primary and secondary. Primary use comprises Canada's total consumption, including energy required to transform one form to another—such as coal to electricity—and energy required to deliver energy to consumers. Secondary use comprises energy consumed for residential, commercial/institutional, industrial, transportation and agricultural purposes.

Key highlights in energy use include the following:

- Between 1990 and 2005, the latest year for which figures are available, primary energy use increased by 27.0 percent.
- In 2005, secondary use accounted for 68.5 percent of primary energy use and produced 66.2 percent (495 megatonnes [Mt]) of Canada's total greenhouse gas (GHG) emissions. This last figure includes emissions produced by utilities in meeting the demand for electricity.
- Without improvements in energy efficiency made to buildings and equipment and the changes in the behaviour of energy users during the past several decades, the increases in energy use would have been much higher.

The industrial sector consumes the most energy, accounting for 37.9 percent of total secondary energy use in 2005. Transportation is second (29.5 percent), followed by residential (16.5 percent), commercial/institutional (13.6 percent) and agriculture (2.5 percent).

Promoting Energy Efficiency

For the past decade, Natural Resources Canada (NRCan) has promoted energy efficiency and the use of alternative energy as a means to reduce GHG emissions and save money. NRCan uses a broad range of policy instruments, including leadership, information, voluntary actions, financial incentives, research and development, and regulation.

The *Energy Efficiency Act*, which came into force in 1992, provides for the making and enforcement of regulations concerning minimum energy performance levels for energy-using products, as well as the labelling of energy-using products and the collection of data about energy use. The *Energy Efficiency Regulations* are described in Chapter 2.

Energy Intensity / Energy Efficiency

As explained in Chapter 1, although aggregate energy intensity is sometimes used as a proxy for energy efficiency, there is a difference between the two terms. Understanding this difference is important when comparing Canada with other countries. Energy intensity is a broader measure, capturing not only energy efficiency but also impacts such as weather variations and changes in the structure of the economy.

Evidence of Change

As explained in this report, recent growth in energy use is primarily due to increased activity in various sectors. However, this growth would have been much greater without improvements in energy efficiency. As reported in Chapter 1, energy efficiency improvements made between 1990 and 2005 are estimated to have reduced GHG emissions by almost 64 Mt and decreased energy expenditures by $20.1 billion in 2005 alone.

Between 1990 and 2005, the residential sector recorded a 24.9 percent increase in energy efficiency. The figures for transportation (18.8 percent), industry (12.8 percent) and the commercial/institutional (8.7 percent) sectors demonstrate that improvements in energy efficiency are being made throughout the economy.

Through improvements in energy efficiency, Canadians can reduce their energy bills and achieve important environmental goals. Over the short term, changes to less GHG-intensive fuels (for example, from coal to natural gas) can help reduce GHG emissions. However, over the long term, reducing GHG emissions further will require more widespread use of alternative energy.

Canada is a world leader in the production of renewable energy with almost 16 percent of its primary energy supply coming from renewable sources in 2005.

Engaging Canadians

To maximize the effectiveness of its initiatives, NRCan engages a growing number of partners from the private and public sectors. Dozens of cooperative agreements are in place with a broad range of businesses, community groups and other levels of government.

These initiatives engage Canadian society, along with every sector of the economy, in new and more efficient approaches to secondary energy use and in the development and deployment of renewable energy sources.

This report provides an overview of the work being done in each sector, highlights NRCan's efficiency and alternative energy (EAE) programs, and lists their key achievements for 2006–2007. All programs are described in the corresponding sector chapter. Program entries for market transformation programs also include quantitative performance indicators in graph or table format (see below). A list of NRCan's EAE initiatives and expenditures appears in Appendix 1.

Performance Indicators Highlighted in the Report

Equipment, Standards and Labelling

- Volume of Monthly Import Documents
- Estimated Impact of *Energy Efficiency Regulations*, 2010 and 2020 (aggregate annual savings)
- ENERGY STAR® Qualified Appliances as a Percentage of Total Category Sales in Canada, 1999 to 2005
- ENERGY STAR Awareness Levels in Canada, 2005

Housing

- Annual Heating Consumption for Houses Constructed to Different Standards
- Number of Households, Average Floor Space of New Houses and Energy Intensity Indexes, 1990 to 2005
- Average Energy Consumption of New Appliances, 1990 and 2005 Models
- Number of Eligible R-2000* Housing Starts, 1990 to 2006
- Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000–2007

Buildings

- Estimated Average Energy Savings by Type of Building Under the Commercial Building Incentive Program, 2006
- EnerGuide for Existing Buildings – Incentive Retrofit Projects, 1998 to 2006

* R-2000 is an official mark of Natural Resources Canada.

Industry

- CIPEC Energy Intensity Index, 1990 to 2005
- Estimated CIPEC Energy Savings, 2001 to 2006
- Industrial Dollars to $ense Participants, 1997 to 2006

Transportation

- Company Average Fuel Consumption (CAFC) versus Canadian Voluntary Standards, 1990 to 2006
- Vehicle Fuel Efficiency Labelling
- Drivers Trained, 1998 to 2005

Renewable Energy

- Electricity Generation Capacity from Renewable Sources (Includes Hydro-Electricity)
- Canadian Wind Power Capacity, 1993 to 2006
- REDI for Business Projects Completed, 1998 to 2005

Federal House in Order

- GHG Emissions Reductions From Federal Operations, 1990 to 2010
- Federal Fleet Size and Fuel Consumption, 1997 to 2005
- Purchases of Alternative Fuel Vehicles (Including Hybrids) for the Federal Fleet, 1997 to 2005

Introduction

NATURAL RESOURCES CANADA'S EFFICIENCY AND ALTERNATIVE ENERGY PROGRAM

Since the early 1990s, Natural Resources Canada (NRCan) has emphasized the promotion of energy efficiency and the use of alternative energy (that is, alternative transportation fuels and renewable energy) as a means to reduce greenhouse gas (GHG) emissions and improve the Canadian economy.

A complete list of NRCan's efficiency and alternative energy (EAE) initiatives in 2006–2007 is in Appendix 1. These initiatives engage Canadian society and all major sectors of the economy in new and more advanced approaches to secondary energy use—that is, to the consumption of energy in the residential, commercial/institutional, industrial, and transportation sectors.

NRCan's EAE initiatives are managed by

- the Office of Energy Efficiency, which delivers market transformation initiatives to improve energy efficiency and the use of alternative transportation fuels
- the CANMET[1] Energy Technology Centre and the Mineral Technology Branch, which deliver EAE research, development and demonstration (R,D&D) initiatives
- the Electricity Resources Branch, which delivers market transformation initiatives for renewable energy
- the Science Branch of the Canadian Forest Service, which undertakes research and development (R&D) in the use of forest biomass for energy

In its efforts to improve energy efficiency and increase the use of alternative energy, NRCan emphasizes partnership and cooperation with stakeholders such as other levels of government, the private sector and non-governmental organizations. With this approach, the demand side of the energy market moves toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels. On the supply side, Canada participates in developing technology for tapping renewable energy resources and alternative transportation fuels as well as for increasing the energy efficiency of energy production.

POLICY INSTRUMENTS

NRCan's key policy instruments are as follows:

- regulation
- financial incentives
- leadership
- information
- voluntary initiatives
- research, development and demonstration

[1] CANMET is the Canada Centre for Mineral and Energy Technology.

FIGURE INT-1

Moving the Market

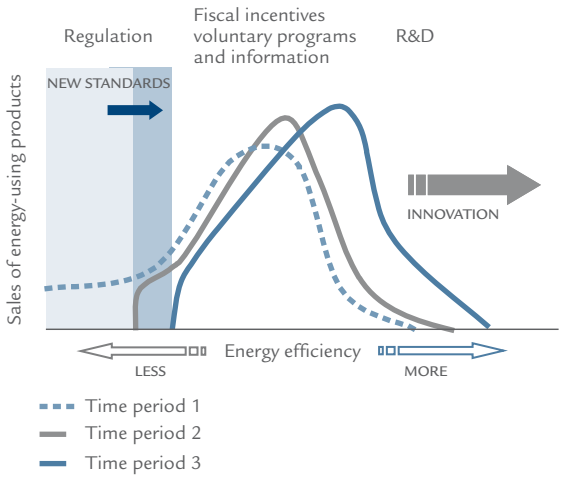


Figure Int-1 shows how these policy tools work together to increase energy efficiency, that is, how they help to reduce the amount of energy needed to obtain a certain level of service. Energy performance regulations eliminate less efficient products from the market. Fiscal incentives, voluntary programs and information increase the take-up of existing opportunities to use energy more efficiently. R&D increases the opportunities for achieving higher levels of efficiency in a particular type of energy use.

Regulation

The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations, primarily for establishing performance and labelling requirements for energy-using products and doors and windows that are imported or shipped across provincial borders.

Financial Incentives

NRCan uses financial incentives to encourage final users of energy to employ energy efficiency and renewable energy technologies and practices. NRCan also offers financial incentives for wind energy, ethanol plants, natural gas vehicles and refuelling infrastructure.

Leadership

Leadership means setting an example for other levels of government and for the private sector by increasing energy efficiency and the use of alternative energy in the Government of Canada's operations.

Information

NRCan disseminates information to consumers, using methods that range from broad distribution to individual consultations with clients, to increase awareness of the environmental impact of energy use and to encourage consumers to become more energy efficient and make greater use of alternative energy sources. Activities include publications, exhibits, advertising, toll-free telephone lines, conferences, Web sites, workshops, training, building design software and promotional products.

Voluntary Initiatives

Companies and institutions work with NRCan voluntarily to establish and achieve energy efficiency objectives. NRCan's voluntary EAE initiatives target large consumers of energy in the commercial/institutional and industrial sectors and organizations whose products are important determinants of energy use. The initiatives involve industry-government agreements and, for groups of large industrial energy users, setting energy efficiency targets. NRCan provides support services to assist and stimulate action by companies and institutions on energy efficiency, including developing standards and training.

Research, Development and Demonstration

NRCan's EAE initiatives support the development and dissemination of more energy-efficient equipment, processes and technologies, and alternative energy technologies. R,D&D also provides the scientific knowledge needed to develop the technologies, codes, standards and regulations required for the sustainable use of energy.

NRCan provides national leadership in energy science and technology (S&T) by undertaking research in its own laboratories, contracting research activities to other organizations and carrying out the federal funding initiatives listed in Chapter 9. These initiatives are the only federal interdepartmental S&T investment funds that focus on the energy sector and its economic and environmental effects.

MEASURING PROGRESS

The primary goal of NRCan's EAE initiatives is to change energy consumption patterns to obtain environmental and economic benefits. Part of assessing program progress and performance involves considering both program delivery and program effectiveness.

NRCan monitors and tracks the following three aspects of program delivery:

- program outputs
- program outcomes
- market outcomes

Program outputs are the items produced regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. Program outputs are designed to lead to **program outcomes**—namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase more energy-efficient appliances than they would have if there were no program. Other important factors that influence consumer behaviour include product price, household income, personal taste and other government and non-government programs.

Since program outcomes can directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable **market outcomes**. Market outcomes ultimately reflect the impacts of NRCan programs on changes in energy efficiency, energy intensity, GHG emissions and the use of alternative energy. In this sense, achievement of a targeted market outcome, or observable progress towards a market outcome, serves as an indicator of program effectiveness. An example of a program outcome leading to a market outcome is a householder's purchase of a more energy-efficient appliance, resulting in reduced use of electricity. Depending on the source of electricity and how the utility changes its electricity-generating methods to meet the change in demand resulting from reduced electricity use, this could also lead to a decline in GHG emissions.

DATA COLLECTION AND ANALYSIS

In 1991, NRCan launched the National Energy Use Database (NEUD) initiative to help the department improve its knowledge of energy consumption and energy efficiency at the end-use level in Canada and to support NRCan's analytical expertise. The NEUD initiative plays a number of crucial roles directly related to NRCan program activities. However, its most important role is to secure the development of a reliable, Canada-wide information base on energy consumption at the end-use level for all energy-consuming sectors.

The NEUD initiative consists of several broad components that typically involve conducting large- and small-scale surveys of energy use in the transportation, industrial, commercial/institutional and residential sectors. The surveys gather information about the stocks and characteristics of energy-using equipment and buildings, observing Canadians' behaviour with respect to energy use, monitoring the adoption of new technologies in the marketplace. In 2006–2007, the NEUD initiative sponsored the collection of energy data in the commercial, transportation and industrial sectors, analyzed this data and produced reports that explain how and where energy is used in each sector. Work was also initiated to collect energy data in

the residential sector in 2007–2008, which will also form the basis for a report. The NEUD initiative also produced a comprehensive energy use database with accompanying publications to explain Canada's overall energy use and energy efficiency trends. All NEUD initiative reports are available to the public, free of charge, both in hard copy and on-line.

The NEUD initiative also has participated in the development of energy end-use data and analysis centres (DACs) across Canada. Three DACs currently exist: the transportation centre at Université Laval in Québec City, Quebec; the industrial centre at Simon Fraser University in Burnaby, British Columbia; and the buildings centre at the University of Alberta in Edmonton, Alberta. The DACs are mandated to improve the accessibility and comparability of existing data about the evolution of energy consumption and its impact on environmental quality.

GHG EMISSIONS AND CLIMATE CHANGE

Climate change is a global challenge arising from the continuing buildup in levels of anthropogenic (human-produced) GHGs in the atmosphere in addition to naturally occurring emissions. GHGs are composed of a number of gases, and the main source of anthropogenic emissions is the combustion of fossil fuels. Substantially reducing GHG emissions is a challenge, particularly given Canada's highly industrialized and resource-based economy. Solutions require a multifaceted, coordinated domestic response and a high level of cooperation among all nations.

IN THIS REPORT

This fourteenth annual *Report to Parliament* focuses principally on EAE initiatives that address secondary energy use. The EAE programs described in this *Report* were operational for the 2006-2007 fiscal year. Some of the programs have continued, while others have since been completed. The ecoENERGY programs described within this document were initiated on April 1, 2007 and will continue for the next four years. Trends in energy use and GHG emissions in Canada are discussed in Chapter 1. Chapter 2 discusses the equipment regulations under the *Energy Efficiency Act* and equipment labelling activities. Chapters 3 to 6 review individual EAE initiatives to improve energy use in housing, buildings, industry and transportation, highlighting their achievements and progress indicators. Chapter 7 deals with renewable energy sources and use. Chapter 8 describes the Government of Canada's actions to improve its own use of energy. Chapter 9 describes general programs that are not specific to the EAE initiatives discussed in Chapters 3 to 7. The final chapter describes domestic and international cooperation in EAE. Appendix 1 contains information about NRCan's EAE expenditures. Appendix 2 contains detailed information about the figure data presented in this report.

ecoENERGY PROGRAMS 2007/2008 – 2010/2011

ecoENERGY for Industry – is designed to improve industrial energy intensity and reduce energy-related industrial GHGs and air pollution. The program is delivered through the long-standing and successful Canadian Industry Program for Energy Conservation (CIPEC), a voluntary partnership between the Government of Canada and industry that brings together industry associations and companies representing more than 98 percent of all industrial energy use in Canada.

ecoENERGY for Biofuels – will invest up to $1.5 billion over 9 years to boost Canada's production of renewable fuels such as ethanol and biodiesel. As a key element of the government's comprehensive strategy on renewable fuels, this program will make investment in production facilities more attractive by partially offsetting the risk associated with fluctuating feedstock and fuel prices.

ecoENERGY for Personal Vehicles – offers easy access to information, including fuel consumption guides and other decision-making tools, to help Canadians choose the most fuel-efficient car or truck for their particular needs. This initiative will also work with communities, provincial and territorial governments and other partners to encourage driving and vehicle maintenance habits that increase fuel efficiency, reduce emissions and save money.

To make sure Canadians continue to enjoy a wide selection of fuel-efficient vehicles, the Government is working directly with automakers to reduce GHG emissions by 2010. This voluntary effort by automakers will support mandatory fuel-efficiency regulations that will come into force for the 2011 model year.

ecoENERGY Retrofit – provides financial support to homeowners, small and medium-sized businesses, public institutions and industrial facilities to help them implement energy saving projects that reduce energy-related GHGs and air pollution, thereby contributing to a cleaner environment for all Canadians.

ecoENERGY for Buildings and Houses – is designed to encourage the construction and operation of more energy-efficient buildings and houses using complementary activities such as rating, labelling and training. Energy efficiency makes for healthy workplaces and living spaces, increases comfort and saves money.

ecoENERGY for Fleets – introduces fleets to energy-efficient practices that can reduce fuel consumption and emissions. This program offers free practical advice on how energy-efficient vehicles and business practices can reduce fleet operating costs, improve productivity and increase a fleet's competitiveness.

Along with the latest developments in fleet and fuel management, ecoENERGY for Fleets will also help ensure fleet vehicle owners and managers are aware of the fuel efficiency benefits of new and developing technologies. On the education side of the initiative, it is expected that more than 200 000 professional drivers — of heavy trucks, buses, construction and other vehicles — will receive training in energy-efficient vehicle-operating techniques over the next four years.

ecoENERGY for Renewable Heat – will invest $36 million over four years to increase the use of renewable thermal energy, help develop renewable thermal energy industry capacity and contribute to cleaner air by displacing fossil fuel-based energy use for space heating and cooling and for water heating in Canadian buildings.

Under the program, a solar deployment incentive of 25 percent of project cost targets the industrial, commercial and institutional sectors. Industry capacity development funding is available to support the solar and geoexchange industries in upgrading standards and training installers. And a large-scale residential sector deployment pilot initiative will work with utilities and developers to deploy thousands of solar domestic water-heating systems across Canada.

ecoENERGY for Renewable Power – will invest $1.48 billion to increase Canada's supply of clean electricity from renewable sources such as wind, biomass, low-impact hydro, geothermal, solar photovoltaic and ocean energy.

An incentive of one cent per kilowatt hour to eligible low-impact, renewable electricity projects will encourage the production of 14.3 terrawatt hours of new electricity from renewable energy sources. This represents about 4000 megawatts of new capacity, enough electricity to power approximately 1 million homes.

ecoENERGY Technology Initiative – will fund RD&D to support the development of the next-generation clean-energy technologies to increase the clean energy supply, reduce energy waste and reduce pollution from conventional energy sources. Examples are technologies for clean-coal, carbon sequestration and the reduction of the oil sands' environmental impact; and new end-use technologies, such as hydrogen and fuel cells and energy-efficient buildings and industry. The initiative will also develop technologies for producing and using renewable energy from clean sources such as wind, solar, tidal and biomass.

For more information: ecoaction.gc.ca

CHAPTER 1

Trends in Energy Use

INTRODUCTION

Canadians enjoy an abundance of energy from a variety of sources. This comparative advantage in the supply of energy helps Canadians deal with the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. It has also fostered the development of industries that have a particularly strong energy demand.

Canadians spent about $152 billion in 2005 on energy to heat and cool their homes and offices and to operate their appliances, vehicles and industrial processes. This amount represents 14.2 percent of the country's gross domestic product (GDP).

ENERGY USE AND GREENHOUSE GAS EMISSIONS

Energy use is categorized in two general types: primary and secondary. Primary energy use encompasses the total requirements for all users of energy, the energy required to transform one energy form to another (for example, coal to electricity) and the energy used to bring energy supplies to the consumer. Secondary energy use is energy used by final consumers for residential, commercial/institutional, industrial, transportation and agricultural purposes.

Primary energy use in Canada today reflects changes over several decades in energy-consuming equipment and buildings and in the behaviour of energy users. Primary energy use increased by 27.0 percent between 1990 and 2005, from 9740 petajoules (PJ) to 12 369 PJ.

Secondary energy use (8475 PJ) accounted for 68.5 percent of primary energy use in 2005. It was responsible for 66.2 percent (495 megatonnes [Mt]) of total greenhouse gas (GHG) emissions in Canada, if indirect emissions are included—namely, those produced by electric utilities to meet end-use electrical demand.

This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). CO_2 accounts for most of Canada's GHG emissions. All subsequent references in this report to CO_2 and GHGs include emissions that are attributable directly to secondary energy use and indirect emissions attributable to electricity generation, unless otherwise specified.

From 1990 to 2005, secondary energy use increased by 21.9 percent and related GHG emissions increased by 21.5 percent. The GHG intensity of energy changed during the period because fuel switching towards less GHG-intensive fuels offset an increasing energy demand. The industrial sector is the largest energy user, accounting for 37.9 percent of total secondary energy use in 2005. The transportation sector is the second largest energy user at 29.5 percent, followed by the residential sector at 16.5 percent, the commercial/institutional sector at 13.6 percent and the agriculture sector at 2.5 percent.

ENERGY INTENSITY AND ENERGY EFFICIENCY

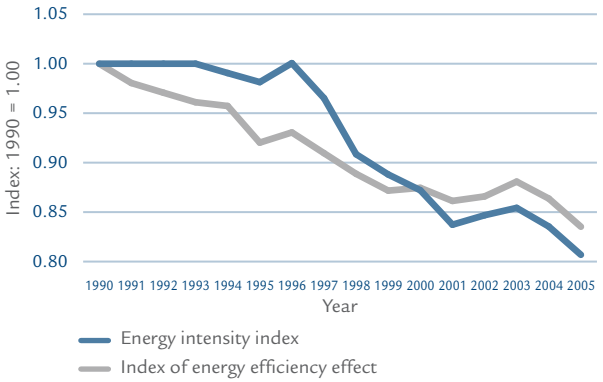
Aggregate energy intensity is the ratio of energy use per unit of GDP or, alternatively, energy use per capita. Aggregate energy intensity is sometimes used as a proxy for energy efficiency because it is simple and straightforward and the data for the calculation are readily available. However, this measure is misleading because, in addition to pure energy efficiency, intensity captures impacts such as weather variations and changes in the structure of the economy.

To properly gauge changes in energy efficiency over time, differences in economic structure and weather need to be normalized or factored out of the intensity calculation. Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) applies an internationally recognized factorization analysis technique to isolate the impact of energy efficiency on changes in Canadian energy use.

Figure 1-1 compares, for Canada, an index of annual variation in energy intensity with the OEE's index of changes in energy efficiency over the period 1990 to 2005. The indexes present improvements in energy intensity and efficiency as a downward trend.

FIGURE 1-1

Energy Intensity and the Energy Efficiency Effect, 1990 to 2005



TRENDS IN ENERGY EFFICIENCY

Every year, NRCan publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use (and GHG emissions) and the contribution of the following key factors to these changes:

- Increases in sector **activity** lead to increased energy use and emissions. In the residential sector, for example, an increase in the number of households results in increased energy use.
- Fluctuations in **weather** lead to changes in space-heating and space-cooling requirements. A colder winter or a warmer summer can lead to increased energy use.
- A shift in the **structure** of activity toward more energy-intensive components of activity leads to increased energy use and emissions. For example, if the distribution of activity in the industrial sector shifts from forestry to the iron and steel industry, industrial energy use will increase because the former sector is less energy intensive than the latter.
- A higher **service level** for auxiliary equipment (for example, computers, fax machines and photocopiers) increases energy use and emissions. During the 1990s, these types of equipment were widely adopted. However, improvements in functionality increased productivity and moderated increases in energy consumption caused by the use of more machines.
- **Energy efficiency** refers to how effectively energy is being used – for example, how long an appliance can be operated with a given amount of energy.

In this report, changes in energy efficiency are the net result after allowing for the changes in energy use due to changes in activity, weather, structure and service level. To the extent that other factors that affect energy use are not captured, this measure of energy efficiency improvement may overstate or understate the "actual" change. For example, in the industrial sector, in an industry such as other manufacturing, there may have been changes in energy use due to shifts in the mix of products, but this is not captured.

Secondary energy use increased between 1990 and 2005 (from 6952 to 8475 PJ). Without improvements in energy efficiency, increases attributable to activity, weather, structure and service level would have led to an increase in secondary energy use of 37.7 percent. However, as a result of a 15.8 percent (1096 PJ) improvement in energy efficiency,[1] actual secondary energy use increased by 21.9 percent to 8475 PJ.

[1] Based on the OEE Index.

TABLE 1-1

Explanation of Changes in Secondary Energy Use, 1990 to 2005

	Sectors					
	Residential	Commercial/ Institutional	Industrial	Transportation	Total**	Percentage change
1990 energy use (PJ)*	1286.2	867.0	2721.8	1877.9	6952.1	
2005 energy use (PJ)	1402.2	1153.0	3209.4	2501.8	8475.1	
Change in energy use (PJ)	115.9	286.0	487.6	624.0	1523.0	21.9
Explanatory factor (change due to)						
Activity	353.1	246.6	1166.0	750.4	2516.1	36.2
Weather	5.5	25.2	n/a	n/a	30.8	0.4
Structure	7.1	-1.2	-331.1	186.8	-138.4	-2.0
Service level	71.0	91.8	n/a	n/a	162.9	2.3
Energy efficiency	-320.9	-75.4	-347.3	-352.4	-1096.0	-15.8
Other factors		-1.0		39.2	47.7	0.7

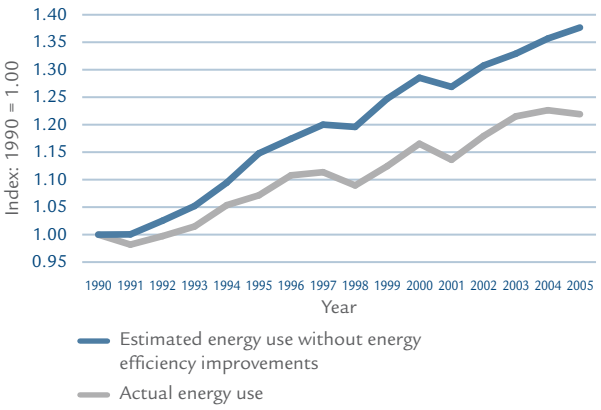
*Petajoules

**Total also includes energy use for agriculture (not shown in "Other factors" in table).

The change in energy use between 1990 and 2005, actual and without energy efficiency improvements, is shown in Figure 1-2. The difference in energy use due to energy efficiency—the estimated energy saving—represents a reduction in energy costs of $20.1 billion in 2005 and a reduction in GHG emissions of almost 64 Mt. Changes in energy efficiency are estimated for each of the four major end-use sectors and are presented in Chapters 3 to 6. The energy efficiency improvements were largest in the residential sector (24.9 percent), followed by the transportation sector (18.8 percent), industrial sector (12.8 percent), and commercial/institutional sector (8.7 percent).[2]

FIGURE 1-2

Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2005



[2] The aggregate energy-use data presented in this report are taken from Statistics Canada's *Report on Energy Supply-Demand in Canada* (RESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of RESD energy-use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix A of NRCan's *Energy Use Data Handbook, 1990 and 1997 to 2005*.

TRENDS IN RENEWABLE ENERGY

Canada is a leader in the production of renewable energy with almost 16 percent of its primary energy supply coming from renewable sources in 2005. Although renewable energy is often associated with electricity, renewable energy sources also produce thermal energy (steam or heat) or transportation fuels. Renewable energy sources in Canada include water, wind, solar, geothermal and biomass.

Canada has a significant renewable electricity supply due primarily to the widespread use of hydroelectricity. In 2005, 60 percent of Canada's electricity generation was provided by conventional and small hydroelectric plants, which generated more than 358 terawatt hours (TWh) of electricity, up from 337 TWh in 2004. Small hydro plants (less than 50 megawatts [MW]), with installed generating capacity of 3401 MW, provided about 2 percent of the total electricity generated in Canada.

Non-hydro renewable sources accounted for an estimated 2 percent of Canada's total electricity generation. Biomass (waste and virgin biomass and landfill gas) is the main non-hydro renewable energy source in Canada, but wind energy is growing rapidly with an increase in capacity from 139 MW in 2000 to 1459 MW in 2006. Solar photovoltaic has also experienced high rates of capacity growth of about 20 percent annually between 1993 and 2006, although starting from a very low baseline. In 2006, there was a total of 20.5 MW of solar photovoltaic systems installed in Canada, an increase of 3.7 MW over the previous year.

CHAPTER 2

Equipment, Standards and Labelling

INTRODUCTION

Natural Resources Canada's (NRCan's) wide range of energy efficiency initiatives includes standards, labelling programs and Canada's *Energy Efficiency Regulations* (the Regulations).

The *Energy Efficiency Act* (the Act) of 1992 gives the Government of Canada the authority to make and enforce regulations on performance and labelling requirements for energy-using products that are imported into Canada or shipped across provincial borders for the purpose of sale or lease.

The *Energy Efficiency Regulations* came into effect in February 1995, after extensive consultations with provincial governments, affected industries, utilities, environmental groups and others. The Regulations refer to national consensus performance standards developed by accredited standards writing organizations such as the Canadian Standards Association (CSA). Such standards include testing procedures that must be used to determine a product's energy performance. Regulated products that fail to meet the minimum performance levels identified in the Regulations cannot be imported into Canada or traded interprovincially.

NRCan works with stakeholders to improve standards development and approval processes and to accelerate the market penetration of high-efficiency residential, commercial and industrial equipment.

Regulations have now been established for more than 30 products that consume 71 percent of the energy used in the residential sector in Canada and 50 percent 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. The Regulations apply to these products even if they are incorporated into a larger unit or machine that is not regulated.

NRCan regularly amends the Regulations to strengthen the minimum energy performance requirements for prescribed products in situations where the market has been transformed to a higher level of efficiency. The Regulations are also amended to add new products, harmonize minimum energy performance requirements with those of other jurisdictions, and update testing methodologies or labelling requirements. Also, regulations can be established for gathering market data on the energy performance of certain types of equipment. For example, the data gathered for gas fireplaces is used to support programs developed by the industry and NRCan and its partners for gas fireplace performance.

Before amending the Regulations, NRCan conducts studies to analyse how the proposed change will affect the market. For example, NRCan checks if it will have a measurable impact on energy efficiency levels without imposing undue hardship on manufacturers. A key criterion for amending the Regulations is that the change must have a significant positive impact on consumers and the environment. Stakeholders are consulted on all proposed changes to the Act and Regulations, as well as on their practical application in the market.

The Act and the Regulations support labelling initiatives designed to help consumers and commercial/industrial procurement officials identify and purchase energy-efficient equipment that will save them money and reduce greenhouse gas (GHG) emissions over the life of the product.

For example, the Act and the Regulations require that an EnerGuide label be displayed on major electrical household appliances and room air conditioners. For appliances, the EnerGuide label shows the estimated annual energy consumption of the product in kilowatt hours and compares it with the most and least efficient models of the same class and size. The EnerGuide label for room air conditioners indicates the model's energy efficiency ratio and provides a comparative bar scale.

The EnerGuide label is also used voluntarily by manufacturers and suppliers of residential oil and gas furnaces, vented gas fireplaces, central air conditioners and air-to-air heat pumps. In this case, the EnerGuide rating for a specific product (annual fuel utilization efficiency rating for oil and gas furnaces, fireplace efficiency rating for gas fireplaces and seasonal energy efficiency ratio for central air conditioners) is published on the back page of the manufacturer's brochure. The rating information includes a bar scale that compares the model with others of the same size and capacity.

The EnerGuide for Industry Program used the EnerGuide name on labels to encourage the use of off-the-shelf industrial equipment that is more energy efficient, including equipment prescribed under the Regulations. This equipment includes electric motors; dry-type transformers; heating, cooling and ventilation equipment; and certain lighting products. EnerGuide for Industry offered up-to-date product databases, Web-based applications and energy-use information. Equipment buyers are able to use this information to compare the energy performance of products and select the most energy-efficient model that meets their needs.

As well, the Regulations are consistent with, and build on, the ENERGY STAR® Initiative in Canada. The internationally recognized ENERGY STAR symbol is a simple way for consumers to identify products that are among the most energy efficient on the market. Products that are prescribed in the Regulations and are also part of the initiative must meet levels of energy efficiency starting at 10 percent or more above the minimum performance levels set out in the Regulations to qualify for the ENERGY STAR symbol. As higher-performance products penetrate the market, their efficiencies become candidates for new standard levels.

STANDARDS

As a world leader in the use of energy efficiency standards, NRCan is committed to harmonizing federal standards and labelling requirements with those developed in other jurisdictions. Harmonization reduces barriers to trade and sustainable development by improving the flow of energy-efficient products within Canada and around the world. This practice minimizes the regulatory burden on manufacturers and avoids confusion for consumers.

For example, the performance requirements in the Regulations are similar to those in several Canadian provinces that regulate energy-using equipment that is manufactured and sold within their borders. Although NRCan works closely with provinces to harmonize standards, some provincial regulations can differ from the federal requirements or can apply to other types of energy-using equipment.

Due to the highly integrated North American market, Canada's energy performance requirements for many products are similar to those regulated in the United States (U.S.). As well, Canada's EnerGuide labelling requirements are coordinated with the EnergyGuide labelling program in the U.S.

Harmonization work is also undertaken through the North American Energy Working Group established by Canada, the U.S. and Mexico.

The Asia-Pacific Economic Cooperation (APEC) organization is another important forum for regional cooperation on harmonization issues. Trade and investment liberalization and facilitation are high on the agenda of the APEC Energy Working Group (EWG). One EWG initiative is to harmonize energy efficiency test methods and conformity assessment

regimes of Asia-Pacific economies that use energy efficiency standards and labels as part of their environmental or energy programs.

NRCan supports Canadian representation on committees of the International Organization for Standardization and the International Electrotechnical Commission as well as supporting the national and international policy work of the Standards Council of Canada.

COMPLIANCE AND ENFORCEMENT

The Regulations outline a number of responsibilities for dealers who import to Canada, or ship from one Canadian province to another, any prescribed energy-using product. NRCan is committed to securing voluntary compliance but can use enforcement measures when necessary.

NRCan emphasizes self-monitoring, reporting, voluntary compliance and collaboration. However, the Act prescribes specific enforcement measures when dealers violate the law. Enforcement activities include preventing the importation of non-compliant products to Canada; preventing the sale or lease of non-compliant products in Canada; and fines. Violators can also be fined under the Administrative Monetary Penalty System of the Canada Border Services Agency for not providing required information on the prescribed product at the time of import; serious violations can be prosecuted.

To monitor compliance with the Regulations, NRCan captures information from energy efficiency reports and import documents. Section 5 of the Act requires that dealers provide energy efficiency reports when they market a new product model. The required information includes the energy performance of each model, the name of the testing agency and the size category, as described in Schedule IV of the Regulations.

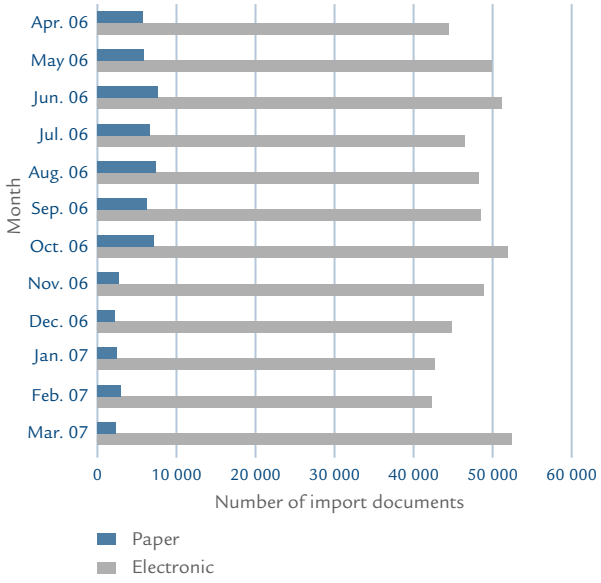
The Regulations require that, when importing a regulated product into Canada, dealers provide specific product information on customs documents for all shipments (type of product, brand name, model number, name and address of dealer and purpose of import). Customs documents contain much less information than an energy efficiency report, but there is enough to allow NRCan to verify that there is a matching energy efficiency report. NRCan can then verify that all products entering Canada meet the required energy performance levels and can take action when necessary.

Key 2006–2007 Achievements

- NRCan processed over 631 559 records relating to the importation of regulated energy-using products to Canada in 2006–2007. The records were from April 1, 2006, to March 31, 2007. Figure 2-1 illustrates the volume of import documents received in paper form and electronically each month.
- More than 773 621 new or revised model numbers were submitted to NRCan. The records were from April 1, 2006, to March 31, 2007, in energy efficiency reports received from dealers.

FIGURE 2-1

Volume of Monthly Import Documents



REGULATORY IMPACT TO DATE FROM THE REGULATORY IMPACT ANALYSIS STATEMENT

In preparing amendments to the Regulations, NRCan analyses the impact of the proposed amendment on society, the economy and the environment. This information is made available through the Regulatory Impact Analysis Statement, which is annexed to the Regulations and published in the *Canada Gazette, Part II*.

It is estimated that Canada's energy performance standards will cause a reduction of 25.6 megatonnes in aggregate annual emissions by 2010 (see Table 2-1). This reduction is equivalent to taking 4 million cars off the road.

TABLE 2-1

Estimated Impact of *Energy Efficiency Regulations*, 2010 and 2020 (aggregate annual savings)

Product (amendment number in brackets)	Energy savings (petajoules)		CO_2 reductions (megatonnes)	
	2010	2020	2010	2020
Residential appliances	117.20	133.84	13.26	15.60
Lamps – fluorescent/incandescent	11.60	13.40	7.55	9.80
Motors	16.30	17.70	2.03	2.14
Commercial HVAC	6.40	7.50	0.43	0.57
Refrigerators (5)	4.92	10.96	0.49*	1.10*
Ballast/room A/C, PAR lamps (6)	3.96	9.44	0.39*	0.94*
Clothes washers, domestic hot water, exit signs, chillers (8)	16.20	42.67	1.29	3.61
A/C, commercial refrigeration (9)	1.64	5.51	0.16	0.55
Total	**178.22**	**241.02**	**25.60**	**34.31**

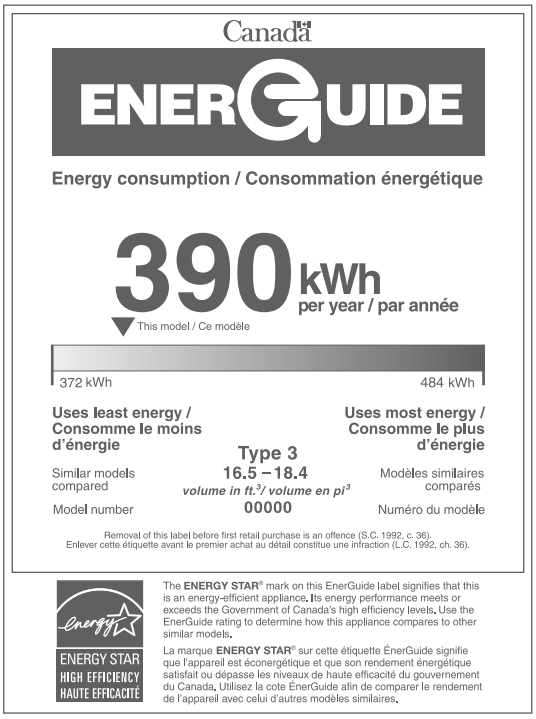
*Values are different from the Regulatory Impact Analysis Statement because of the change in the emission factor (using 99.3).

LABELLING AND PROMOTION

Since 1978, the EnerGuide label (see Figure 2-2) has given Canadians an opportunity to compare the energy consumption of appliances. In 1995, with the introduction of the Regulations, placing an EnerGuide label on major electrical household appliances and room air conditioners became mandatory. The label on a product shows how much energy a product uses, allowing the customer to consider the most energy-efficient choice.

FIGURE 2-2

EnerGuide Label



A voluntary EnerGuide rating program was established in 1997 and included gas furnaces, central air conditioners, heat pumps and oil furnaces. In the fall of 2003, gas fireplaces were added to the EnerGuide rating program. Manufacturers were asked to integrate EnerGuide ratings for fireplace efficiency in their brochures. These changes were coincident with the requirement in the Regulations to test, verify and report on fireplace efficiency.

Because these products are typically purchased from a product brochure or catalogue, prescribing a label on the product is not useful. Manufacturers are encouraged to include an EnerGuide rating in product brochures or catalogues, so consumers can compare the efficiency of the product when they are in the buying process. Major distributors of such products for sale in Canada report the verified energy performance rating of their products, as tested to the standards in the Regulations. The verified energy performance rating corresponds to the EnerGuide rating published in the brochures or catalogue. To date, manufacturers representing 85 percent of the products in the market participate in the EnerGuide rating program and publish the ratings in their brochures. In addition, participants in the EnerGuide rating program must provide shipment data and aggregate energy efficiency information to track the progress of the program and identify marketplace improvements that can result from labelling.

EnerGuide directories that list energy ratings for major appliances and room air conditioners are published annually. They are distributed to consumers, retailers and appliance salespeople. In fulfilling requests for information, electric utilities and provincial governments also distribute the directories. On-line directories for all appliances and heating and cooling equipment are published on the Web site of the Office of Energy Efficiency (OEE) and updated monthly.

Regularly conducted polls indicate that more than 50 percent of Canadians surveyed are aware of the EnerGuide label.

In 2001, responding to public interest in a labelling system that identifies the best performers, Canada officially introduced ENERGY STAR, the international symbol for energy efficiency (see Figure 2-3). Canada signed an agreement with the U.S. Environmental Protection Agency and the U.S. Department of Energy. The OEE is the custodian of the program for Canada. Canada was the fifth country to join the ENERGY STAR program, along with Australia, New Zealand, Japan and Taiwan. The European Union adopted ENERGY STAR for office equipment.

FIGURE 2-3

ENERGY STAR® Label

ENERGY STAR establishes high efficiency criteria and levels for selected products for the residential and commercial sectors. Product categories are selected for the technical potential for high efficiency. This is a voluntary program. However, organizations must demonstrate that products meet the admission criteria and performance levels. For appliances and heating and cooling products, the criteria are based on the same test standards as those applied under the Regulations. Canada promotes specific product categories for which levels and criteria can be harmonized with those of the U. S., including the following:

- major appliances
- heating, cooling and ventilation
- consumer electronics
- office equipment
- windows and doors (Canadian levels)
- selected lighting products (currently not fixtures)
- selected commercial equipment

Canada has also integrated ENERGY STAR with the EnerGuide label for major appliances and room air conditioners to help consumers identify the best-performing products. While the EnerGuide label shows how much energy a product uses under normal conditions in one year, the ENERGY STAR symbol on the label identifies the most energy-efficient product. Now that industry-accepted standards of high efficiency have been established, ENERGY STAR has become the criterion to meet for incentive and rebate programs.

Pilot projects were implemented in partnership with seven Canadian gas utilities and a non-government organization to address three major barriers to higher efficiency: awareness, accessibility to high-efficiency products and acceptance.

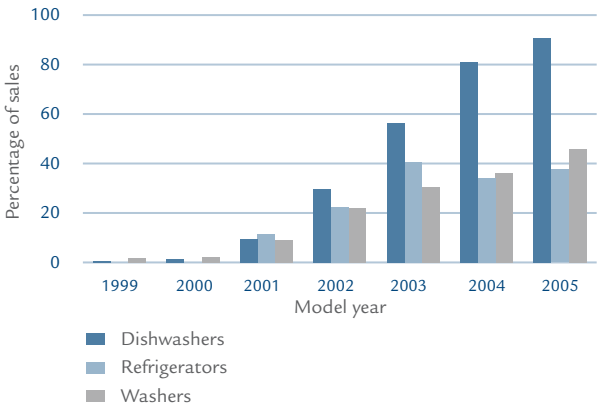
With NRCan's involvement, several utilities doubled the number of incentives and/or loans that they would have disbursed without government participation or under their previous programs. The organizations also coordinated the delivery of coupons from manufacturers to complement the incentives. Canada's participation in this initiative also helped to increase the market penetration of high efficiency gas-fired furnaces and boilers and to include higher efficiency products from markets that supported mid-standard-efficiency products in the past.

ENERGY STAR was also used as the basis for sales tax rebates in British Columbia for heating and cooling equipment, and in Saskatchewan for the purchase of furnaces, boilers and qualifying appliances (refrigerators, dishwashers, clothes washers and freezers). Organizations across Canada have used ENERGY STAR as a campaign driver to promote replacement with, or purchase of, higher-efficiency products.

Continuous promotion of ENERGY STAR qualified appliances has paid off. Industry statistics for 2005 show an increase in market penetration from almost nil in 2000 to 38 percent for refrigerators and 91 percent for dishwashers (see Figure 2-4). The increase in market penetration indicates growing acceptance of ENERGY STAR as the brand for high efficiency and the willingness of manufacturers to raise their products to qualifying levels. ENERGY STAR specifications and levels are periodically updated as product saturation is reached to encourage industry to strive for more efficient products and thus maintain the relevance and credibility of the brand.

FIGURE 2-4

ENERGY STAR Qualified Appliances as a Percentage of Total Category Sales in Canada, 1999 to 2005



ENERGY STAR is also well known in the commercial sector, with criteria for products ranging from office equipment to traffic signals. NRCan supports demonstration projects to validate the savings and other benefits of some of these products and to address barriers to their widespread acceptance.

One example is NRCan's support for the accelerated replacement and promotion of light-emitting diode (LED) exit signs for retrofit applications in Alberta. Exit signs operate around the clock; and for high-rise buildings, with a minimum of four signs per floor at approximately 25 watts (W) for each sign, these products represent a constant electrical draw and, therefore, an energy savings opportunity for building owners.

The project objectives were to

- target apartment building owners
- stimulate demand for LED exit signs
- increase awareness of the benefits of early replacement of standard incandescent exit signs with more efficient LED units that consume 5 W

The project also included recycling the replaced units. The program influenced the conversion of 7311 incandescent exit signs with LED exit signs. This change will save approximately 1.6 gigawatt hours of electricity and 570 tonnes of carbon dioxide annually. For all new installations, the Regulations require that exit signs meet the ENERGY STAR level of 5 W per face.

Canada continues to promote ENERGY STAR guidelines to procurement officials. It has updated an interactive cost calculator that compares energy cost savings and GHG emissions reductions that are associated with the purchase of ENERGY STAR qualified products. Workshops were held across Canada to make governments, institutions and municipal officials aware of the ENERGY STAR criteria and procurement tools. Canada is also working with housing agencies to help them identify energy savings in their properties and to specify ENERGY STAR qualified products for replacement equipment.

Canada continues to expand the types of products included in its ENERGY STAR agreement. For example, Canada recently included vending machines, commercial refrigeration, compact fluorescent lamps and commercial clothes washers in its correspondence with the U. S. government.

NRCan developed a rating and labelling system for efficient refrigeration applications in ice and curling rinks, under the name CoolSolution.* CoolSolution designates innovative technologies and practices and consists of three main elements:

- heat recovery from the refrigeration system to meet all the building heating requirements (e.g. hot air, hot water) or to export this energy for other purposes

* CoolSolution is an official mark of Her Majesty the Queen in the Right of Canada as represented by the Minister of Natural Resources.

- adaptation to the Canadian climate by taking benefit of the naturally occurring cold temperatures. This is done by varying the temperature of the heat that is released into the environment according to the outdoor temperature.
- reduction of the synthetic refrigerant charges of the refrigeration system, which have a serious adverse impact on climate change. This is done by confining the synthetic refrigerant to the mechanical room and using environmentally friendly fluids to remove and distribute heat.

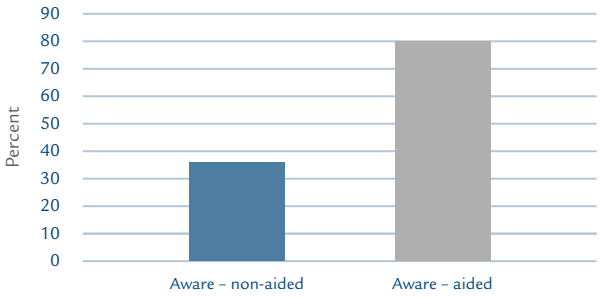
An ice rink application is qualified "CoolSolution" if it has a score higher than 50 percent. An incentive program to encourage the adoption of CoolSolution and reduce the initial payback of the first implementations started in November 2006. Partnerships to accelerate the program have been successful. (See Chapter 4: Buildings.)

Key 2006–2007 Achievements

- Held three workshops with public sector procurement officials.
- Participated in federal-level greening government committees and department-level sustainable development committees to include ENERGY STAR.
- Worked with the Ontario Power Authority and Social Housing Services Corporation on procurement of ENERGY STAR equipment and incentives.
- Provided cost-shared incentives for selected ENERGY STAR qualified heating equipment through various stakeholder organizations (gas utilities, the Ontario Power Authority).
- Established a framework for a strategic lighting initiative.
- Established high performance criteria for decorative lighting for ENERGY STAR in Canada (an international first).
- Maintained 28 CSA energy performance subcommittees, published four CSA standards and completed nine technology and market studies.

FIGURE 2-5

ENERGY STAR Awareness Levels in Canada, 2005



CHAPTER 3

Housing

ENERGY USE AND GREENHOUSE GAS EMISSIONS

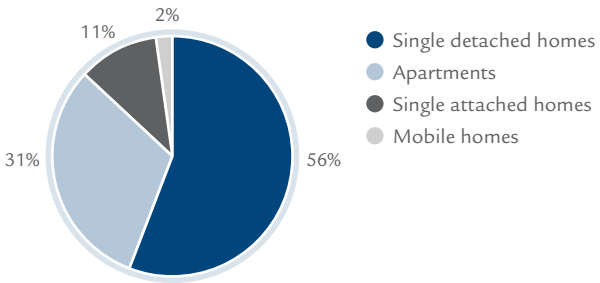
The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling, heating water, and for operating appliances, electronic equipment and lights. This sector accounts for 16.5 percent (1402 petajoules [PJ]) of secondary energy use and 14.9 percent (74 megatonnes [Mt]) of greenhouse gas (GHG) emissions.

Most dwellings in Canada are single detached houses. The next largest number of dwellings is apartments, followed by single attached dwellings and mobile homes (see Figure 3-1). Because single detached and attached houses predominate, most Natural Resources Canada (NRCan) residential building programs focus on these types of dwellings.

Space and water heating constitute 78.0 percent of residential energy use, followed by the shares devoted to operating appliances, lighting and space cooling (see Figure 3-2).

FIGURE 3-1

Canadian Households by Type of Dwelling, 2005



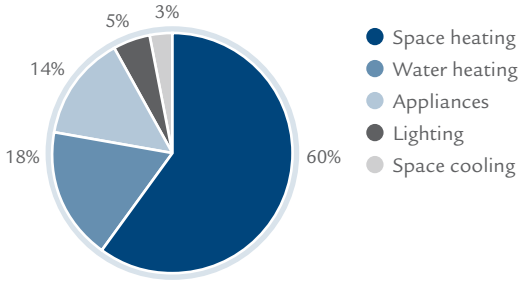
Between 1990 and 2005, residential energy use increased by 9.0 percent, or 116 PJ (from 1286 to 1402 PJ). For the same period, GHG emissions from the residential sector increased by 6.3 percent. GHG intensity changed little because fuel switching toward less GHG-intensive fuels offset an increase in the GHG intensity of electricity production over the period.

Five main factors influenced residential energy use—activity, weather, structure, service level and energy efficiency:

- activity – The increase in the number of households and the size of dwellings (the principal measures of residential activity) increased energy use by 27.5 percent (353 PJ).
- weather – The winter in 2005 was similar to the winter in 1990 but summer temperatures were much warmer and the result was a 0.4 percent (6 PJ) increase in energy use in 2005 compared with 1990.
- structure – The relative share of households by dwelling type (single detached, apartments, etc.) has changed over the period. This change contributed to an increase in energy use of 0.6 percent (7 PJ) in 2005 compared with 1990.
- service level – The increased penetration rate of appliances and increased floor space cooled by space cooling units increased energy use by 5.5 percent (71 PJ).
- energy efficiency – Improvements in energy efficiency decreased energy use by 24.9 percent (321 PJ).

FIGURE 3-2

Residential Energy Use by Purpose, 2005



The change in residential energy use between 1990 and 2005 and the estimated energy savings due to energy efficiency are shown in Figure 3-3. Figure 3-4 shows how energy consumption differs for houses built in different periods, which reflects improvements in building construction.

Growth in residential energy use was driven in large part by growth in activity. This growth in activity, which is, more specifically, growth in total floor space and number of households, was due to the increase in the average size of newly constructed houses, the rising population and the trend toward fewer individuals per household (see Figure 3-5). Such increases were partially offset by significant improvements in energy efficiency. Structural changes also contributed to growth in energy use as more individuals tended to live in single detached homes and the relative share of individuals living in apartments declined. Similarly, service level increased energy demand because in 2005 more Canadians cooled their homes during the summer months and operated more appliances than they did in 1990.

Figure 3-6 shows how average energy consumption of new appliances has improved by comparing 1990 and 2005 models.

NRCan delivers initiatives to increase energy efficiency in the following residential subsectors:

- new houses
- existing houses
- residential equipment (see Chapter 2)

FIGURE 3-3

Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2005

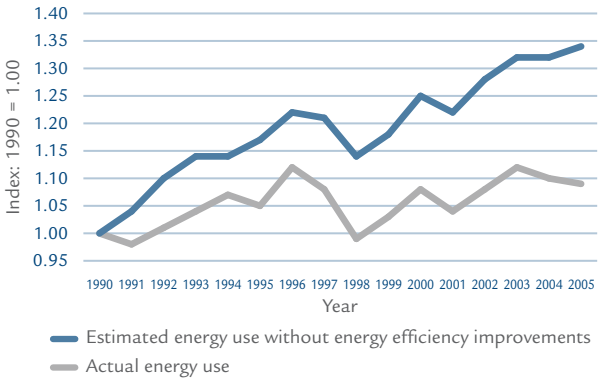
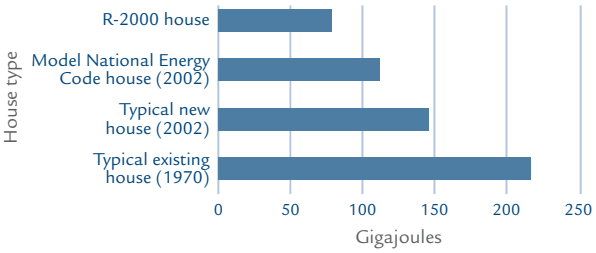


FIGURE 3-4

Annual Heating Consumption for Houses* Constructed to Different Standards



* 198-m² one-storey, single detached house heated with natural gas, Ottawa, Ontario

FIGURE 3-5

Number of Households, Average Floor Space of New Houses and Energy Intensity Indexes, 1990 to 2005

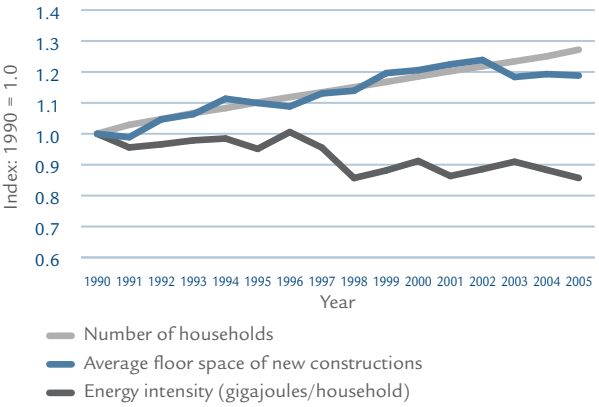
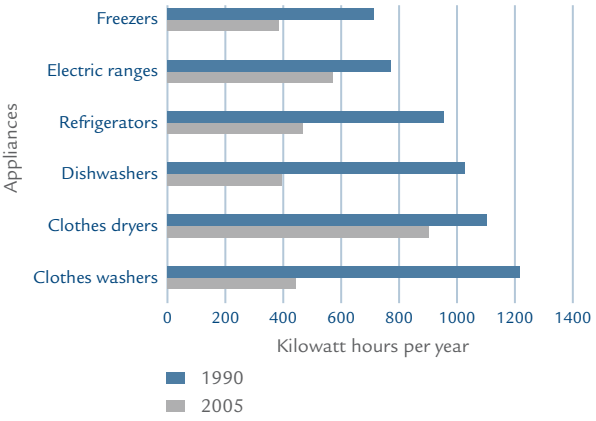


FIGURE 3-6

Average Energy Consumption of New Appliances, 1990 and 2005 Models



NEW HOUSES:
R-2000 Standard and EnerGuide for (New) Houses

Objective: To increase market adoption of energy-efficient new houses by promoting changes in construction practices and by labelling houses for energy performance.

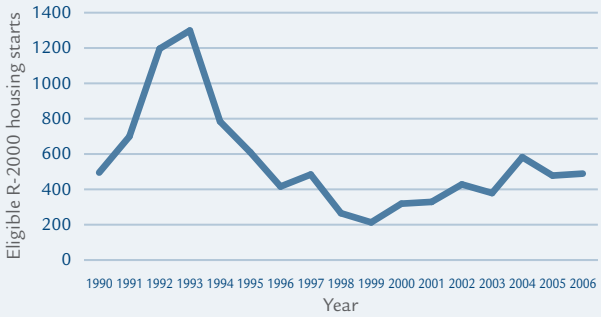
The R-2000 Standard is a voluntary technical performance standard. It encourages Canadian builders to build, and Canadian consumers to purchase, houses that are more energy efficient and environmentally responsible than is required by current Canadian building codes. NRCan trains and licenses R-2000 homebuilders and other professionals in R-2000 Standard construction techniques and practices, and provides third-party quality assurance by testing and certifying R-2000 homes.

EnerGuide for (New) Houses is an energy-performance rating and labelling scheme designed to encourage the industry to build, and consumers to purchase, houses that are more energy efficient. The EnerGuide for Houses scheme is based on the R-2000 Standard and training, and it targets large-volume, mass-market builders. GHG reductions for fiscal year 2006–2007 were 0.089 Mt.

For more information:
oee.nrcan.gc.ca/r-2000/english

FIGURE 3-7

Number of Eligible R-2000 Housing Starts, 1990 to 2006



Key 2006–2007 Achievements

- Supported 169 workshops nationally and trained 2433 people in energy-efficient construction systems for the new housing sector.
- Supported the Heating, Refrigeration and Air-Conditioning Institute and made available 38 courses about the design and installation of heating, ventilating and air-conditioning (HVAC) systems for 557 individuals.
- Achieved 10 percent penetration in the new housing market in Ontario (responsible for 45 percent of the new housing starts in Canada), largely as a result of efforts with tract builders.
- Collaborated with provinces to incorporate energy efficiency requirements within building codes. British Columbia, New Brunswick, Nova Scotia, Ontario and Quebec announced moves to achieve an energy rating level of 80 points by 2012. Eighty is the minimum rating for an R-2000 house.

EXISTING HOUSES:
EnerGuide for Houses and Retrofit Incentives

Objective: To encourage Canadians to improve the energy efficiency of their homes.

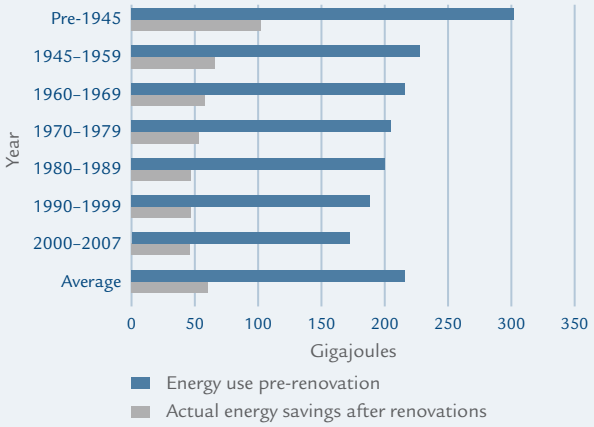
EnerGuide for Houses gave Canadian homeowners personalized advice about how to best improve the energy performance of their houses, especially for renovation and maintenance projects. Under EnerGuide for Houses, a retrofit incentive was officially launched in October 2003. Under this incentive, homeowners qualified for a non-taxable grant representing 10 to 20 percent of their retrofit expenditures. The grant was based on the differential improvement in the house's energy rating, as measured by a pre- and post-renovation EnerGuide for Houses energy evaluation. The program was terminated in 2006, but received $45 million in funding to be used for wind down activities.

Key 2006–2007 Achievements

- Processed more than 105 000 grants under the retrofit incentive.
- Achieved cumulative GHG reductions of 0.9 Mt as of March 31, 2006.
- Signed six Memorandums of Agreement with provinces and municipalities to ensure a smooth transition to provincial and municipal programs.

FIGURE 3-8

Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000–2007



NEW AND EXISTING HOUSES:
Energy Science and Technology in Housing

Objective: To accelerate the development and market adoption of energy-efficient housing technologies in domestic and foreign markets through improved design, performance and cost-effectiveness and to develop practical decision-making tools to help communities and developers choose efficient energy systems and low-polluting waste and water technologies.

Working in partnership with associations, government and industry, the CANMET Energy Technology Centre (CETC) develops and deploys highly specialized solutions to help achieve cost-effective reductions in the energy consumption and GHG emissions of residential housing. CETC experts in energy innovations for the built environment take a leadership role, nationally and internationally, in the research, development, and deployment of leading-edge energy-efficient and renewable energy technologies for new and retrofit housing.

Key focuses of CETC take into consideration the following:

- Design and analysis tools remain a key element for accelerating innovation in both the new housing and retrofit markets. The ability to model emerging technologies to ascertain potential impacts and identify other opportunities is essential. The advancement of the design tools must keep pace with evolving technologies.
- Guidelines for both new and retrofit housing projects remain a high priority to enable voluntary, incentive-driven and regulated improvement to the housing stock.
- Energy demand reduction continues to offer opportunities in housing for improved envelope technologies and more efficient HVAC technologies.
- Improved energy systems, including integrating cogeneration, fuel cell and renewable energy alternatives, are essential to meeting long-term energy use goals.

Key 2006–2007 Achievements

- The success of a zone heating and cooling product named Zone Comfort is a great example of how CETC supports technology innovation in the private sector. Zone Comfort addresses comfort, humidity, energy, and peak energy demand in the summer. Key technical aspects of this new product evolved from the participation of Ecologix Heating Technologies Inc. in the ēKOCOMFORT®* initiative. This product demonstrates how CETC supports technology innovation in the private sector and effectively guides innovative technologies from concept to commercialization and reduces the time to market. In this case, time to market was 18 months. CETC created a complete commercialization team that included market research, a development plan, a sales plan, funding and technology support.
- A research project used a hybrid hydrogen generator and natural gas furnace to evaluate if combustion appliances such as a furnace or hot water tank can burn more cleanly without requiring a retrofit. CETC evaluated the risks and performance characteristics of the combustion appliances. The test fuels were hydrogen and natural gas mixtures whose composition ranged up to 25 percent hydrogen. Results showed that a mixture of natural gas and 10 percent hydrogen is viable. Future integration with wind turbines and excess off-peak power is under consideration.

* ēKOCOMFORT is a registered trademark of Her Majesty the Queen in Right of Canada as represented by the Minister of Natural Resources.

- Super E™* housing is a technology transfer initiative that has increased market penetration of energy-efficient housing technologies and building practices from Canada into international markets. Through Super E, CETC has helped Canadian companies adapt their products and services to meet increasingly higher international demands for environmentally friendly and energy-efficient housing. The Super E consortium includes 39 Canadian housing exporters who partner with 48 overseas companies. As of March 2007, over 400 houses were completed or under construction in markets such as Japan, the United Kingdom, Ireland, China, Korea and Iceland. The benefits to Canada are estimated at more than $40 million since the beginning of the initiative. Super E has also influenced the energy efficiency standards of housing packages offered by Canadian Super E members to the Canadian marketplace. Super E is delivered by CETC in partnership with the Canadian Forestry Service and the Canada Mortgage and Housing Corporation.
- CETC develops and supports building simulation software for the Canadian housing industry. Using the HOT2000™** software created by CETC, 275 000 houses have been simulated for improved energy efficiency. CETC also develops and validates improved methods for modelling conventional energy systems while integrating more sophisticated technologies such as co-generation and renewable energy systems. Through the International Energy Agency – Energy Conservation in Buildings and Community Systems Annex 42, CETC developed simulation models for residential scale co-generation systems and tested natural gas technologies (e.g. fuel cells, Stirling engines, internal combustion engines) to validate these models.
- A project with CETC and the City of London, Ontario and seven of its local builders was undertaken to provide the builders with a method to systematically evaluate new energy-efficient products, systems and techniques. Some builders sent three or four staff to technology sessions as part of this project and are now starting to use the technologies. As a result of this project, the London Home Builders Association is now sponsoring its own project technology sessions. The City of London is very pleased with the results, and is creating an implementation plan for the subsequent field trial phase.

For more information:
sbc.nrcan.gc.ca

* Super E is a registered trademark of Her Majesty the Queen in Right of Canada as represented by the Minister of Natural Resources.

** HOT2000 is an official mark of Natural Resources Canada.

CHAPTER 4

Buildings

ENERGY USE AND GREENHOUSE GAS EMISSIONS

The commercial/institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services, including tourism. This sector uses energy mainly for space and water heating, space cooling, lighting, motive power for services such as pumping and ventilation in buildings, and street lighting.

In 2005, the commercial/institutional sector accounted for 13.6 percent (1153 petajoules [PJ]) of secondary energy use and 13.2 percent (65.3 megatonnes [Mt]) of greenhouse gas (GHG) emissions.

To highlight energy use in commercial/institutional activities, the following analysis excludes energy use for street lighting. The commercial/institutional sector comprises many activity types (see Figure 4-1). Offices account for 35 percent of the sector's energy demand. Retail trade, educational services, health care and social assistance, and accommodation and food services account for another 47 percent of that demand. Natural Resources Canada's (NRCan's) initiatives address all these major energy-using activity types.

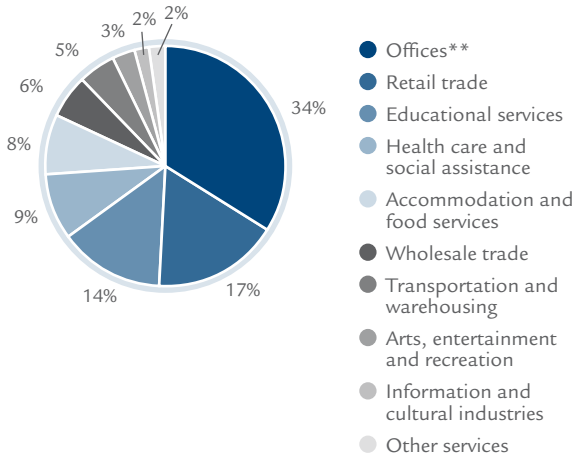
Energy is used for six purposes in commercial/institutional activities. The largest of these is space heating, which accounts for more than half of energy use in this sector (see Figure 4-2). Each of the remaining five uses of energy accounts for between 8 and 14 percent of energy demand in this sector.

Between 1990 and 2005, the commercial/institutional energy use increased by 33 percent, or 286 PJ (from 867 to 1153 PJ).

However, GHG emissions from the sector rose by 36.7 percent in the same period. Emissions increased more quickly than energy use because of the increased use of energy sources with a higher GHG content.

FIGURE 4-1

Commercial/Institutional Energy Use by Activity Type*, 2005

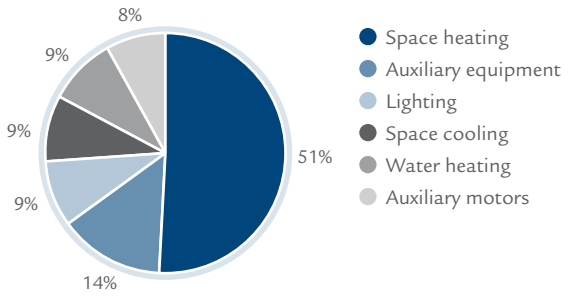


* Excludes street lighting

** "Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

FIGURE 4-2

Commercial/Institutional Energy Use by Purpose*, 2005



*Excludes street lighting

During 1990–2005, a steady increase in activity largely contributed to increased energy use. To a lesser degree, the service level, which refers to the increase of auxiliary equipment and the space cooling penetration rate, and the weather affected energy use. The impact of structural changes (the mix of building types) was marginal. However, energy efficiency slowed this rate of increase. Specifically, the energy use changes attributed to each of these factors are:

- activity – A 28.1 percent increase in floor space caused a 247-PJ increase in energy use. This year, the Office of Energy Efficiency (OEE) reviewed the historical floor space database.
- weather – The winter in 2005 was colder than in 1990, but the summer was warmer than in 1990. The net result was a 2.9 percent increase in energy use (25 PJ).
- structure – A shift in activity caused a 0.1 percent decrease in energy use (1 PJ).
- service level – An increase in the service level for end-users caused a 10.6 percent increase in energy use (92 PJ).
- energy efficiency – An 8.7 percent improvement in energy efficiency caused a decrease in energy use of 75 PJ.

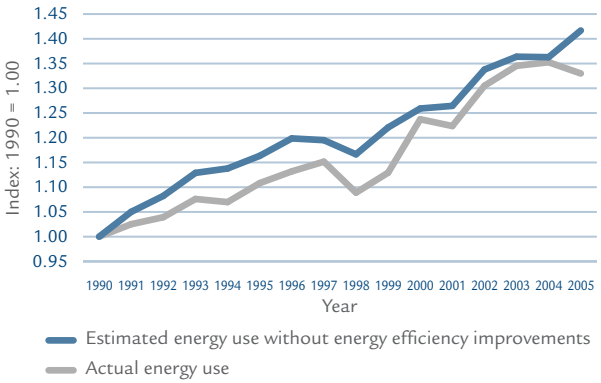
The change in energy use between 1990 and 2005, as well as the estimated energy savings due to energy efficiency, are shown in Figure 4-3.

NRCan delivers initiatives to increase energy efficiency in the following subsectors of the commercial/institutional sector:

- new buildings
- existing buildings
- equipment (See also Chapter 2.)
- communities

FIGURE 4-3

Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2005



NEW BUILDINGS:
Commercial Building Incentive Program

Objective: To improve the energy efficiency of new commercial, institutional and multiunit residential buildings.

The Commercial Building Incentive Program (CBIP) provided financial incentives to builders and developers who incorporated energy-efficient features into the design and construction of new commercial, institutional and multiunit residential buildings.

To qualify for the incentive, buildings had to be at least 25 percent more energy efficient than similar buildings constructed to the *Model National Energy Code of Canada for Buildings* (MNECB). However, results indicate that CBIP buildings are on average 36 percent more energy efficient than similar buildings constructed to the MNECB.

The program was delivered by the Government of Canada and co-marketed by provincial/territorial utilities, provincial/territorial energy efficiency and climate change agencies, and building professional organizations. CBIP achieved 0.07 Mt of GHG reductions in fiscal year 2006–2007.

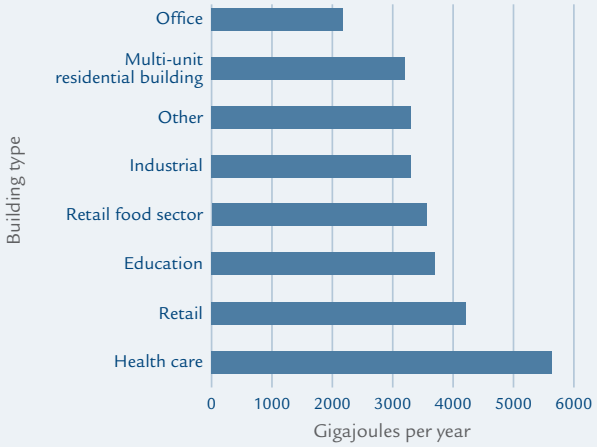
Key 2006–2007 Achievements

- The program validated that more than 250 projects met the CBIP criteria and gave incentives to 229 projects, which represent 5 percent of building starts and 17 percent of construction floor space.
- The registered users of NRCan's building design energy simulation/compliance software increased by more than 1000 to 6500.
- The Canadian Commission on Building and Fire Codes approved a business plan submitted by the NRCan-supported Buildings Energy Codes Collaborative to update the MNECB.

For more information:
oee.nrcan.gc.ca/newbuildings

FIGURE 4-4

Estimated Average Energy Savings by Type of Building Under the Commercial Building Incentive Program, 2006



NEW BUILDINGS:
Industrial Building Incentive Program

Objective: To improve the energy efficiency of new industrial buildings.

The Industrial Building Incentive Program (IBIP), a demonstration program, extended the precepts of CBIP to the industrial sector. IBIP offered an incentive to companies that built new energy-efficient industrial facilities. The incentive offset the additional costs involved in initial attempts to produce energy-efficient designs and achieve building and process integration. The design was assessed against a reference generated from the MNECB. The program resulted in GHG reductions of 0.001 Mt in fiscal year 2006–2007.

Key 2006–2007 Achievements

- Supported two IBIP projects that showed building and process integration. The program supported 28 projects (including these two) since the launch of the program in 2002.
- Produced a case study on refrigerated warehouses.
- Completed five recipient audits of the demonstration projects.

For more information:
oee.nrcan.gc.ca/newbuildings

EXISTING BUILDINGS:
EnerGuide for Existing Buildings or the Existing Buildings Initiative

Objective: To encourage commercial businesses and public institutions to become more energy efficient and reduce GHG emissions.

The EnerGuide for Existing Buildings (EEB) program helps commercial organizations and public institutions explore energy efficiency options and strategies. The program provides access to tools and financial assistance to help reduce energy costs and improve competitiveness.

Members join EEB by sending a letter to the Minister of Natural Resources from senior management that states their commitment to energy efficiency. The program has more than 2800 commercial, institutional and multiunit residential organizations as members. GHG reductions in the 2006–2007 fiscal year under EEB were 0.1 Mt.

Key 2006–2007 Achievements

- The EEB program signed 143 contribution agreements for retrofit projects (see Table 4-1) and 61 contribution agreements for planning activities.
- Projects that received financial incentives under EEB are expected to result in averaged energy savings of approximately 20 percent.
- Over 250 organizations registered with the program.

For more information:
oee.nrcan.gc.ca/existingbuildings

TABLE 4-1

EnerGuide for Existing Buildings – Incentive Retrofit Projects, 1998 to 2006

Fiscal year	Retrofit projects signed	Estimated annual energy cost savings (millions of dollars)	Eligible client investment (millions of dollars)	Federal incentive (millions of dollars)
1998	12	5.67	57.29	2.56
1999	35	16.78	143.17	5.38
2000	4	5.44	9.29	0.62
2001	30	10.57	58.03	3.66
2002	58	19.06	147.53	7.89
2003	66	16.09	140.88	8.37
2004	168	34.88	237.93	16.52
2005	129	23.36	133.62	11.29
2006	143	21.71	156.80	10.40
Total	**645**	**153.56**	**1084.54**	**66.69**

NEW AND EXISTING BUILDINGS:
Refrigeration Action Program for Buildings

Objective: To reduce GHG emissions by reducing energy consumption and synthetic refrigerant use in Canadian supermarkets and ice and curling rinks.

The program activities include information, capacity building, demonstrations, partnerships, and incentives. NRCan delivers the program in partnerships with provincial governments and utilities, associations, manufacturers, and consulting firms.

(See Chapter 2: Equipment, Standards and Labelling.)

Supermarkets provide a window of opportunity for innovative refrigeration systems because new construction and major renovation projects are expected in the coming years. Every three years, approximately 10 percent of the supermarkets undergo major renovation work. Also, approximately 100 large supermarkets are built every year.

There are 2501 ice rinks and 1037 curling rinks in Canada that are used by local communities and contribute to the social well being of many Canadians. Most of these buildings are 25 years old and an estimated 30 to 40 percent of the rinks are operating beyond their projected lifespan.

During the next decade, major renovations of ice rinks will exceed 2000 units, with an additional 1000 units for curling rinks. The potential impacts for these applications have been evaluated at 4.0 Mt carbon dioxide equivalent per year. The energy use savings are in the range of 25 to 50 percent.

Key 2006–2007 Achievements

- RETScreen® Refrigeration software for ice and curling rinks was launched.
- CoolSolution*, an efficient refrigeration application to reduce energy use and contribute to reducing GHG emissions, was implemented to qualify ice and curling rink installations.
- An incentive program was put in place for Canadian ice and curling rinks. Incentives were given for 21 feasibility studies and 25 installations.
- NRCan participated in a Canadian Standards Association committee to update the code for commercial refrigeration, in particular considering the use of carbon dioxide (CO_2).
- NRCan signed an agreement with Loblaw Properties Limited to demonstrate, for the first time in Canada, the use of CO_2 for commercial refrigeration.

For more information:
cetc-varennes.nrcan.gc.ca/en/b_b/parb_rapb.html

* CoolSolution is an official mark of Her Majesty the Queen in Right of Canada as represented by the Minister of Natural Resources.

NEW AND EXISTING BUILDINGS:
Intelligent Buildings

Objective: To develop and promote the adoption of intelligent building technologies and innovative building operation practices that reduce energy consumption and GHG emissions.

The program focuses on intelligent building technologies and practices, such as recommissioning, that reduce a building's energy consumption while ensuring the occupants' comfort and preserving indoor air quality. To meet its objectives, the program develops, demonstrates and deploys, in partnership with key stakeholders, intelligent buildings technologies in Canadian commercial/institutional buildings.

Key 2006–2007 Achievements

- Continued demonstration projects across Canada aimed at evaluating and improving the Continuous Building Optimization approach and the Diagnostic Agent for Building Operators (DABO) software.
- Delivered advanced retrocommissioning training at CETC-Varennes, in collaboration with Portland Energy Conservation Inc., to enhance the practical knowledge of its demonstration projects partners.
- Improved the DABO software by incorporating performance indices. DABO is the software tool developed at CETC-Varennes to support the process of optimizing building operation and ensure persistence of the energy efficiency measures implemented.

For more information:
cetc-varennes.nrcan.gc.ca/en/b_b/bi_ib.html

BUILDINGS AND COMMUNITIES:
Energy Science and Technology in Buildings and Communities

Objectives: To reduce energy use, resource consumption and emissions from commercial buildings through design, construction and retrofitting while increasing cost-effectiveness. To optimize the interactions between buildings, the energy systems involved within them, and their communities. To develop and demonstrate practical decision-making tools and best practices that allow communities to undertake effective energy planning initiatives.

The CANMET Energy Technology Centre (CETC) works in partnership with associations, government and industry. They develop and deploy specialized solutions to achieve cost-effective reductions in the energy consumption and GHG emissions of buildings and communities.

CETC experts in energy innovations for the built environment take a leadership role, nationally and internationally, in the research, development, and deployment of energy-efficient and renewable energy technologies for new and retrofit buildings and communities.

Design and analysis tools remain key elements for accelerating innovation in new construction, retrofit and major renovation projects in large buildings. These tools are essential components of integrated design approaches that allow the implementation of energy efficiency at minimal incremental costs. There is still a lack of uptake for these tools, leading to capacity shortages in the marketplace.

Tools also enable advancement of technologies by allowing a project to simulate ideas rather than run expensive trials at the early high-risk stages and help the integration of emerging technologies

by using advanced design and modelling. Building envelope work in hybrid systems (e.g. building integrated photovoltaics) continues to offer almost untapped (at least by market penetration numbers) opportunities for advancement.

Services such as lighting, daylighting and intelligent building control are key innovation areas, and system recommissioning in existing buildings offers opportunities for energy savings with little physical change. Finally, integration of a diversified energy supply, from fuel cells to renewable energy technologies, represents a significant gap between the current status and the desired status to meet long-term energy goals.

A key barrier that prevents change in standard development practices is the lack of tools and information that relate development style to energy and environmental impact.

Innovation in the following areas can create change:

- tools (computational or others) that consider energy consumption and emissions from the community from a systems perspective
- processes that guide the creation of community strategies for energy efficiency and the reduction of GHGs
- methods that help decision-makers differentiate between urban development alternatives based on their environmental impact on the community
- community energy standards that support policies, codes and technical standards for energy-efficient development practices

Key 2006–2007 Achievements

- The Code Commission agreed to update the MNECB for 2012. CETC founded the Building Energy Code Collaborative with provincial, territorial and NRCan representation. The Collaborative submitted a business plan to the Code Commission for the update.
- A combined heat and emergency power system was installed at Villa Colombo, a long-term care facility in Vaughn, Ontario, to replace the oil-fired emergency power plant. This 335-kilowatt natural gas unit provides both heat and emergency power. A critical component of this project was a revision to the CSA 282 code that previously did not allow the use of natural gas in emergency power systems. This change removes a large barrier to adoption of combined heat and power (CHP) systems and reduces the cost of a CHP system by 20 percent because a separate emergency system is not needed.
- CETC developed a *Community Energy Planning Guide*. The guide helps communities understand and evaluate land use, infrastructure, energy systems, building and site design and waste management decisions in the context of a sustainable energy future. To date, communities have requested 700 guides.
- CETC assessed the feasibility and monitored the progress of the Iqaluit District Energy System project on behalf of the Opportunities Envelope Secretariat. The Iqaluit District Energy System collects waste heat from the diesel-electric power plant in Iqaluit and provides it to a new hospital built adjacent. The system was commissioned in January 2007.
- Construction began for the installation of a 1-megawatt expansion turbine at the letdown station of a gas utility in Toronto, Ontario. This concept replaces the conventional pressure-reducing valve with an expansion turbine, which reduces pressure and, at the same time, uses this pressure reduction to produce electricity by turning a turbine wheel at very high speeds.

For more information:
sbc.nrcan.gc.ca

CHAPTER 5

Industry

ENERGY USE AND GREENHOUSE GAS EMISSIONS

The industrial sector includes all manufacturing industries, all mining activities, forestry and construction. However, it excludes electricity generation. This sector uses energy in industrial processes as a source of motive power and to produce heat or to generate steam. Overall, industrial energy demand accounts for 37.9 percent (3209 petajoules [PJ]) of secondary energy use and 33.1 percent (164 megatonnes [Mt]) of greenhouse gas (GHG) emissions (including electricity-related emissions).

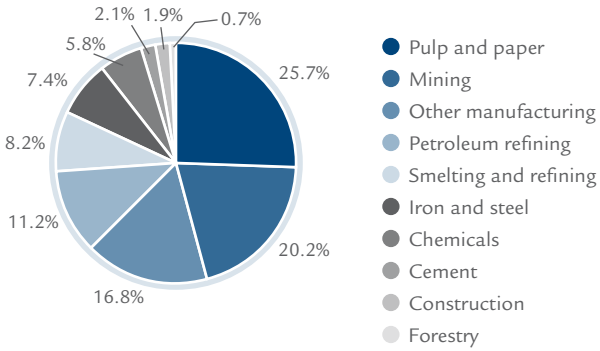
In the industrial sector, energy is consumed primarily in pulp and paper production, mining, petroleum refining, and in the smelting and refining industries. Pulp and paper production alone accounted for approximately 25.7 percent of total industrial energy demand in 2005 (see Figure 5-1).

In most industries, energy purchases account for only a small portion of total expenditures. However, for some relatively energy-intensive industries—cement, aluminum, pulp and paper, iron and steel, and chemicals—this share is higher than 12 percent (see Figure 5-2). For cement, in particular, the share is as high as 37.1 percent.

Actual industrial energy use increased by 17.9 percent (488 PJ) between 1990 and 2005. This increase was caused by a 43.9 percent increase in industrial activity, measured as a combination of physical units of production, gross output and gross domestic product (GDP). However, some of the increase in energy use that would have resulted from the increase in activity was offset by improvements in energy efficiency and structural change (the shift to less energy-intensive industries such as electrical and electronics).

FIGURE 5-1

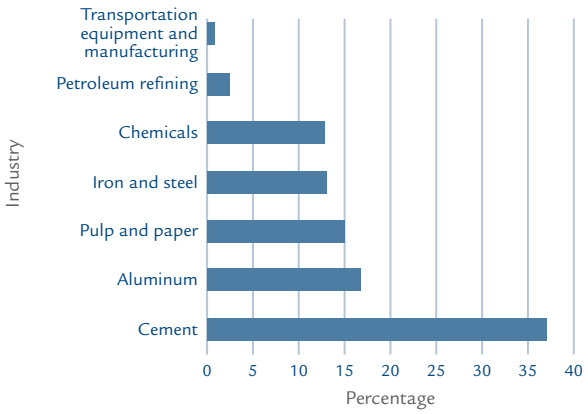
Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2005



*Note: The above subsectors reflect the current definitions in the *Report on Energy Supply-Demand in Canada*. "Other manufacturing" comprises more than 20 manufacturing industries.

FIGURE 5-2

Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2005



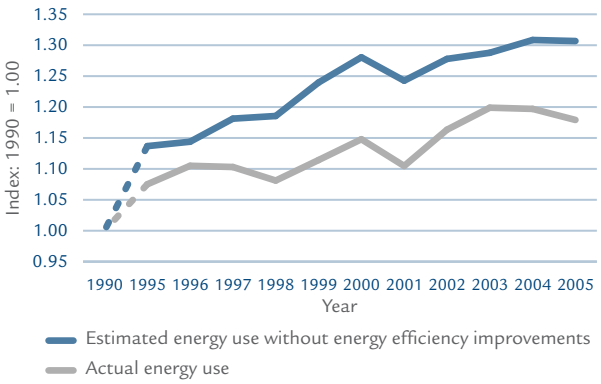
Three main factors influenced energy use:

- activity – Increases in the physical units of production, gross output and GDP contributed to a 43.9 percent increase in industrial activity resulting in a 1166-PJ increase in energy use.
- structure – The change in the mix of activity toward less energy-intensive industries caused a 331-PJ decrease in energy use.
- energy efficiency – Due to a 12.8 percent improvement in energy efficiency, the industrial sector avoided 347 PJ of energy use between 1990 and 2005.

The change in energy use between 1990 and 2005 and the estimated energy savings due to energy efficiency are shown in Figure 5-3.

FIGURE 5-3

Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2005



Between 1990 and 2005, industrial GHG emissions, including electricity-related emissions, increased by 15.5 percent. Excluding electricity-related emissions, industrial GHG emissions increased by 8.0 percent. Most of this increase in direct GHG emissions occurred in the upstream oil and gas industry, because the mining (excluding upstream), manufacturing and construction industries realized an 8.7 percent decrease in GHG emissions.

Natural Resources Canada (NRCan) delivers initiatives to increase energy efficiency in the following components of the industrial sector:

- industrial processes and technologies
- equipment (see Chapter 2)
- buildings (see Chapter 4)

INDUSTRIAL PROCESSES AND TECHNOLOGIES:
Industrial Energy Efficiency (Canadian Industry Program for Energy Conservation)

Objective: To help Canadian industry use energy efficiency investments to improve productivity and competitiveness and to contribute to Canada's clean air and climate change goals.

The Canadian Industry Program for Energy Conservation (CIPEC) is a unique industry-government partnership committed to promoting and encouraging energy efficiency improvements and reductions in GHG emissions through voluntary action across Canada's industrial sectors, including the mining, manufacturing, forestry, construction, upstream oil and gas, and electricity generation sectors.

CIPEC's network comprises 28 sector leadership networks (including four regional) that share information and best practices; more than 1000 industrial companies that have made a written voluntary commitment to become more energy efficient and support Canada's climate change initiatives; and partnerships with 52 industry associations that disseminate information and advice on energy efficiency to their members.

CIPEC's multifaceted approach focuses on introducing technological innovations, bringing about behavioural change, and shifting organizational culture to generate a sustainable market transformation. Tools and services offered through CIPEC included energy fora and conferences; communications products including Web sites and newsletters, technical guidebooks, energy benchmarking and best practices studies; Dollars to $ense energy management workshops; cost-shared energy audits and Process Integration (PI) studies; and provision of technical information relating to the eligibility of renewable energy and/or energy efficiency systems for accelerated capital cost allowances under Class 43.1 and Class 43.2 of the *Income Tax Act*. CIPEC achieved GHG reductions of 0.36 Mt in fiscal year 2006–2007.

Key 2006–2007 Achievements

- Conducted energy audits at 137 industrial facilities.
- Trained 1303 industrial energy managers in Dollars to $ense workshops.
- Sent the *Heads Up CIPEC* newsletter to 1500 new industrial clients.

FIGURE 5-4

CIPEC Energy Intensity Index, 1990 to 2005

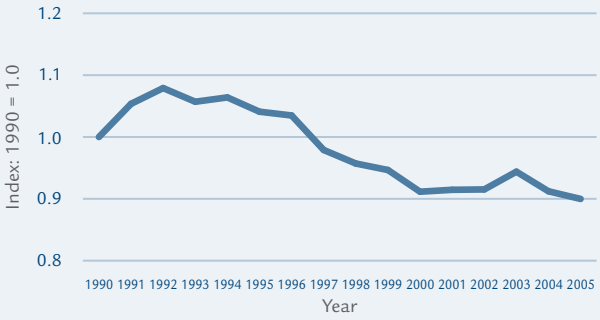


FIGURE 5-5

Estimated CIPEC Energy Savings, 2001 to 2006

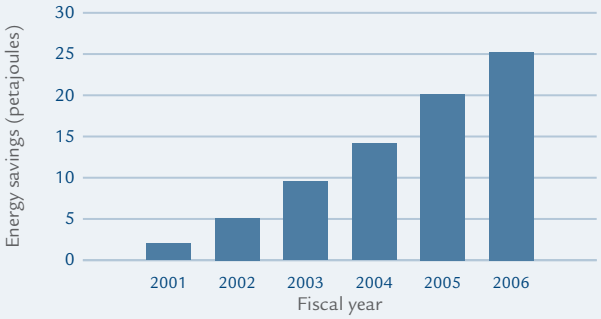
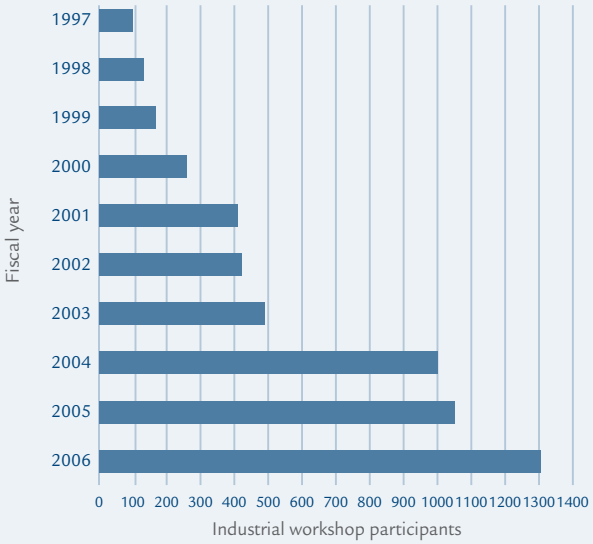


FIGURE 5-6

Industrial Dollars to $ense Participants, 1997 to 2006



INDUSTRIAL PROCESSES AND TECHNOLOGIES: Industrial System Optimization Program

Objective: To support the development and adoption of innovative energy-efficient design practices in Canadian industry to improve energy efficiency and productivity while reducing GHG emissions and other environmental impacts.

The Industrial System Optimization Program focuses on techniques to analyse plant-wide industrial processes, such as PI and advanced process control systems. The Program analyses these processes to identify and correct inefficiencies in plant operation and design, while also considering energy, economy and environmental factors.

The Program tries to meet its objective by conducting leveraged research and development (R&D) through national and international cooperation. Furthermore, the Program disseminates technical information to encourage adoption of these techniques and practices in targeted energy-intensive sectors of Canadian industry. Those sectors include pulp and paper, oil upgrading and refining, petrochemicals, steel, chemicals, food and drink, and solid wood.

Key 2006–2007 Achievements

- Successfully completed a pilot PI program to promote and implement sound PI practices in 31 plants in both regulated and non-regulated sectors. NRCan offers support to help industrial companies conduct PI studies to identify opportunities for increasing energy efficiency and improving production processes. By using energy more efficiently, industry can become more competitive and help reduce GHGs and air pollution. It is estimated that annual energy-cost savings of approximately $1 billion and economic spin-offs of approximately $6 billion are achievable over a 5-year period. The PI program also represents a major opportunity to change the way energy analysis is conducted in the industry, thereby improving productivity and competitiveness of this sector.

- Developed a systematic approach to assess potential upgrading of distillation systems in the chemical industry. A clear methodology was developed, Thermodynamically Guided Modelling, for top-level analysis of the energy, purity and productivity tradeoffs in separation processes and for structural optimization of retrofit separation installations. For example, the conceptual retrofit design of a C_2 splitter of the NOVA Chemical ethylene site was completed. The potential energy savings in the heat supply can reach up to 47 percent. The savings in the heat supply correspond to electrical power savings of 5.6 megawatts in the refrigeration system that serves the C_2 splitter. These results will be key assets for future studies on petrochemicals.
- Developed a multi-objective optimization methodology for industrial production systems. This methodology simultaneously integrates the adaptability of an algorithm, advanced constraint handling, system decomposition, a combined local optimality search and global optimality determination. The algorithm gives a choice of solutions that represents the best trade between the targeted objective functions.

For more information:
cetc-varennes.nrcan.gc.ca/en/indus.html

INDUSTRIAL PROCESSES AND TECHNOLOGIES: Industry Energy Research and Development Program

Objective: To encourage and support the development and application of leading-edge, energy-efficient and environmentally responsible processes, products, systems and equipment in industry.

The Industry Energy Research and Development (IERD) program gives financial support for commercially confidential applied R&D activities. If the project is a commercial success, the clients must repay the funds. Program clients from all industrial sectors range from small and medium-sized companies to multinational corporations.

Key 2006–2007 Achievements

- DDI-Heat Exchangers Inc. of Dollard-des-Ormeaux, Quebec successfully demonstrated that its Cube™ heat exchanger technology can recover heat from liquids (sludge) containing a high percentage (65 percent) of suspended solids in an application where conventional heat exchanger designs have failed. This demonstration helped DDI sell its heat exchanger technology to a bio-solids processing plant in the United States (U.S.). Considering the untapped market for heat recovery from sewage sludge and other high viscosity liquids in industry, it is projected energy savings will be 11 PJ and projected carbon dioxide (CO_2) reduction from the heat exchanger technology in Canada will be 0.545 Mt over the next 10 years.
- The Puratone Corporation of Niverville, Manitoba, developed an energy management system for hog producers. This award-winning system is called "BarnMax." The technology is expected to help hog producers reduce energy consumption by an average of 86 megajoules for each pig produced. Energy savings from BarnMax technology in Canada over the next 10 years is projected to be 15 PJ. Over the same period, the technology is expected to reduce CO_2 emissions by 0.726 Mt.

- The IERD program supported General Comminution Inc. (GCI) of Toronto, Ontario in a full-scale field trial. The trial proved the technical feasibility of the GCI Szego mill to reactivate spent sorbent for a fluidized bed combustion boiler. Using reactivated limestone will reduce CO_2 emissions from limestone calcination and will also reduce the landfill requirements for solid wastes. Successful implementation will result in reduced landfill requirements for spent sorbent and a reduction in GHG emissions by 14 850 t annually initially in Canada, growing to 162 000 t in North America with the potential to reach 1 305 000 t globally by 2011. Total energy savings in Canada from implementation of the development is 222 750 gigajoules (GJ) annually.
- Financial support was provided in conjunction with the BC Hydro Power Smart Progam for a field trial of a newly developed pulp screen rotor by the University of British Columbia. Other supporters of the project were Canadian Forest Products and Advanced Fiber Technologies. The new rotor used 52 percent less electrical energy than the conventional equipment it replaced. The potential energy savings if all 300 pulp mills in British Columbia were converted are 153 200 megawatt hours of electricity annually.
- A project with Hamilton Steel G.P. Inc. was completed with results of a reduction of 104 500 t of CO_2 annually and an annual energy reduction of 260 000 GJ for their No. 5 Blast Furnace project in Hamilton, Ontario. The project was one of several initiated almost eight years ago by Union Gas Limited of Chatham, Ontario with IERD and Technology Early Action Measures. The objective was to convert key heavy industry production processes from high-carbon fuel (oil or coal) to lower-carbon natural gas using advanced, innovative technologies. The funding partners were Hamilton Steel, NRCan, Union Gas Limited and Air Liquide Canada Inc. Based on an advanced computational fluid dynamic modelling by the CANMET Energy Technology Centre in Ottawa, Ontario, the approach taken was to optimize the co-injection of pulverized coal and natural gas in the blast furnace. This process enabled the displacement of a greater percentage of the coke requirement and resulted in reductions in overall CO_2 emissions from the site as well as other benefits such as cost reduction and productivity improvement.
- With IERD support, Agile Systems Inc. successfully completed an R&D program for integrated electronic motor controls. The potential energy savings by 2012 are 2013 terajoules and GHG emission reductions of 109 105 t.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/Publications/ierdpublications/factsheet_industry_energy_r&d_e.htm

INDUSTRIAL PROCESSES AND TECHNOLOGIES: Clean Electric Power Generation

Objective: To design, develop and deploy technologies for power generation from fossil fuels with increased efficiency and the reduction, and ultimately elimination, of emissions of acid rain precursors, GHGs, particulates and identified priority substances – mercury, trace elements and organic compounds.

Research focuses on improving the performance of and reducing emissions from existing fossil fuel power plants and on developing new advanced cycles for conversion of fossil fuels to electricity with complete or nearly complete capture and elimination of CO_2 and other emissions. Issues covered by other research projects include the transport and storage of CO_2.

NRCan's work also includes changing the interaction of the combustion system within the process through advanced tools and technologies to assist major industrial energy consumers to reduce the energy intensity of their operations and to reduce GHG emissions and emissions of other air pollutants, while enhancing competitiveness and profitability.

Key 2006–2007 Achievements

- Completed a technology feasibility study that identifies the ThermoEnergy Integrated Power System Process, a new generation power cycle, as having technical and economic advantages over existing clean coal technologies currently identified in both Canada and the U.S.
- Developed a combustion methodology to burn emulsified bitumen and water mixtures cleanly in conventional boilers in place of more expensive fuels. This technology will be used to support the economic viability of Canadian industries in the resource recovery sectors and to ensure a reliable and inexpensive supply of electricity from Canadian utilities.
- Assembled an International Flaring Consortium comprised of seven private sector and special interest organization members to establish best practices for industrial flares to minimize climate change effects and the health impacts of all industrial flares and to improve air quality.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/Groups/clean_electric_power_generation_e.htm

INDUSTRIAL PROCESSES AND TECHNOLOGIES: Processing and Environmental Catalysis Program

Objective: To solve industrial process problems and undertake research in areas with high potential for significant environmental and economic benefits.

The program's facilities, including semi-pilot-scale plants, are used for process testing and the evaluation of novel concepts in chemical and energy conversion, including hydrogen production from hydrocarbon and renewable sources. Clients include oil and gas companies, petrochemical companies, engine manufacturers, waste oil recyclers and renderers, and specialty ceramic manufacturers.

Key 2006–2007 Achievements

- Developed technology for desulphurizing diesel fuel that is produced by thermally cracking waste lubricating oil. A bench-scale continuous processing unit was commissioned for testing the CANDES process. The project has support from the waste oil recycling industry.
- Determined the preferred operating conditions to transform bitumen residue from oil sands upgrading to an additive suitable for making high quality concrete.
- Developed a direct ammonia fuel cell with unique catalytic surfaces for efficient combined heat and power applications. Bench-scale fuel cell development is being undertaken by three federal laboratories. A field trial using ammonia and the catalytic fuel cell surface in a conventional 5-kilowatt fuel cell control system is being arranged in partnership with a fuel cell and ammonia company.

INDUSTRIAL PROCESSES AND TECHNOLOGIES: Mine Ventilation

Objective: To reduce energy consumption and GHG emissions associated with mine ventilation through infrastructure automation (to support demand-based delivery systems), ventilation network optimization and management and less air-volume-demanding technology.

Ventilation is required in underground mines to maintain a safe working environment. It is used to dilute and remove harmful pollutants (dusts and gases) and to provide suitable working climates. However, providing adequate ventilation can account for 40 percent of the energy consumed during mineral extraction in underground mines. Ventilation systems naturally include some over-supply capacities in order to accommodate all potentially available production locations. This over-supply is highly dependent on the individual mine, the mineral deposit and the mining method employed.

Metal mines that were traditionally designed to operate at maximum delivery – i.e. peak demand across all potential production locations 24 hours a day, 7 days a week – are now starting to adjust ventilation systems to match actual production needs. Energy savings can be significant and include potential reductions in the use of the auxiliary and main ventilation infrastructure, as well as savings in the energy used in air cooling or heating processes.

Optimizing energy use and reducing GHG emissions and costs is not a straightforward proposition because it depends on the specific consumption profile (i.e. electricity versus heating fuels and primary versus secondary delivery systems), design criteria and geographic location of each mine and therefore requires evaluation on a case-by-case basis.

Key 2006–2007 Achievements

- To assess potential cost savings, energy requirements and GHG reduction strategies, CANMET Mining and Mineral Sciences Laboratories worked on a process-based modelling approach for determining ventilation needs. Historical production data from a large northern Ontario mine was used to analyze diesel equipment deployment to estimate the energy savings that could have resulted from adjustments in the ventilation regimes, based on activity. Results show that depending on the level of automated control, energy cost savings of the order of 50 percent or higher could have been realized at that mine.
- The concept of ventilation on demand continues to be investigated through collaborative work with Hydro-Québec and the Quebec mining industry. The impact of automation of ventilation systems will be investigated in representative mine operations and will be extrapolated to all Quebec mines.

For more information:
nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mines/air/air-e.htm

INDUSTRIAL PROCESSES AND TECHNOLOGIES: Enhanced Recycling for Minerals and Metals

Objective: To reduce GHG emissions from Canada's minerals and metals sector by enhancing mineral and metal recycling processes and practices.

The Enhanced Recycling Program for Minerals and Metals aims to increase Canada's potential to recycle mineral and metal materials by developing new approaches and improving on existing recycling infrastructure, practices and policies. In August 2006, the Program received $505,000 for the implementation of selected projects that held high potential for GHG emission reductions.

The Enhanced Recycling Advisory Committee expanded to include a broader range of experts. The 2006–2007 implementation plan identified three main initiatives: scrap metal from municipal sources; end-of-life roofing materials; and federal government waste electronic and electrical equipment.

Key 2006–2007 Achievements

- An estimated 40 000 t (52 000 t of CO_2 equivalent [CO_2e]) of municipal stockpiled scrap metal was identified for recycling in northern communities of British Columbia, Alberta, Saskatchewan, Manitoba and the territories. The Ottawa Valley Waste Recovery Centre in the Township of Laurentian Valley, Ontario, expanded its residential curbside collection of metal recyclables, resulting in a tripling of revenues from $50/t to $195/t. A Nova Scotia pilot project proposed to add empty paint and aerosol cans to municipal curbside collection programs, resulting in savings of 5460 t of CO_2e annually.
- A workshop with experts from across Canada and the U.S. took place in Toronto, in February 2007, to evaluate options for environmentally sound recycling of roofing materials. It was estimated that 1.25 million t of asphalt-based roofing materials are discarded annually in Canada. If 5 percent of this discarded material is substituted for virgin asphalt, this would produce an annual savings of 90 000 t of CO_2e. Two key applications for recycled asphalt are for road surfaces and energy recovery.
- NRCan, in consultation with key stakeholders, is developing a Federal Government Waste Electronic and Electrical Equipment Strategy that will ensure environmentally sound recovery and recycling of end-of-life information technology equipment arising from government use (65 000 computers per year, or 1000 t of CO_2e).

For more information:
recycle.nrcan.gc.ca

INDUSTRIAL PROCESSES AND TECHNOLOGIES: Supplementary Cementing Materials Program

Objective: To reduce annual GHG emissions by promoting increased use of supplementary cementing materials (SCMs) in concrete as partial replacement of cement.

The Supplementary Cementing Materials (SCM) Program has the objective of increasing awareness of the benefits of SCMs, both in terms of GHG reduction potential and the performance of concrete. In August 2006, the Program received $235,000 specifically to conduct the following two activities:

- disseminating of information dealing with the use of SCMs in concrete and holding consultative meetings, in order to increase acceptance from stakeholders and to better understand stakeholders' positions and concerns
- assessing improvement in SCM use by conducting a qualitative assessment survey and evaluating the change in SCM use during the last three to five years

Key 2006–2007 Achievements

- Disseminated SCM information through the development and distribution of a brief, yet informative, *SCM Basics* document and a series of consultative meetings with key industry and government stakeholders. Feedback was obtained at 18 consultative meetings, held in 9 cities, with approximately 80 people in attendance.
- Conducted an online survey for a qualitative assessment. The survey response (173 completed) was statistically significant and satisfactory, considering the small number of people who could respond to the specialized topic.
- Interviewed stakeholders across Canada. The information collected confirmed the increased use of SCMs during the last three to five years:
  - Manitoba Infrastructure and Transportation is increasing the amount of fly ash in its specification from 0 percent to 15 percent.
  - The City of Winnipeg, Manitoba, is experimenting with a change to 25 percent fly ash in city roads and sidewalks.
  - Inland Cement is introducing a sulphate-resistant blended cement incorporating approximately 30 percent fly ash.
  - The average content of fly ash in concrete in Nova Scotia in 2002 was from 17 percent to 19 percent, as opposed to 6 percent in the rest of Atlantic Canada.

For more information:
scm.gc.ca

CHAPTER 6

Transportation

ENERGY USE AND GREENHOUSE GAS EMISSIONS

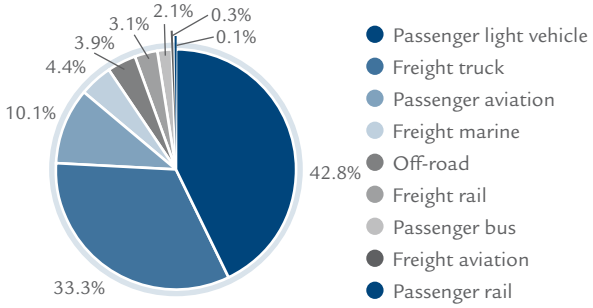
The transportation sector consists of three subsectors: passenger, freight and off-road. Passenger and freight transportation accounted for 55.0 percent and 41.1 percent, respectively, of transportation energy use, and off-road represented only 3.9 percent in 2005 (see Figure 6-1). Due to limitations in the available data and the small percentage it accounts for, the off-road subsector is not analysed in further detail.

The passenger subsector has three modes: road, rail and air. The freight subsector, as defined by Natural Resources Canada (NRCan), is composed of road, rail, air and marine modes. In these two subsectors, road transport uses the most energy, accounting for 78.1 percent of total transportation energy use in 2005. Of this amount, 57.4 percent was passenger energy use and 42.6 percent was freight energy use.

All transportation energy-use programs in NRCan focus on the energy used in road transportation. Total transportation energy use increased by 33.2 percent (624 petajoules [PJ]) between 1990 and 2005 (see Figure 6-2). Passenger transportation energy use increased by 15.9 percent (189 PJ), while freight transportation energy use increased by 61.5 percent (391 PJ).

FIGURE 6-1

Transportation Energy Use by Mode, 2005



Three main factors influenced energy use:

- activity – Increases in population and economic activity caused increased transportation activity (measured as passenger-kilometres for passenger transportation and tonne-kilometres for freight transportation). The change in activity increased transportation energy use by 40.0 percent (750 PJ). The freight and passenger segments contributed to this increase by 52.4 percent and 47.6 percent, respectively.
- structure – Shifts between modes of transport within both the freight and passenger segments caused an increase of 9.9 percent in transportation energy use (187 PJ). The effects of mode shifting were more pronounced in the freight segment because freight truck activity is growing faster than rail and marine activity.
- energy efficiency – Improvements in energy efficiency decreased energy use by 18.8 percent (352PJ).

Without improvements in energy efficiency, increases attributable to activity and structure would have led to an increase in transportation energy use of 49.9 percent (937 PJ). However, actual energy use increased by only 33.2 percent. This change in energy use between 1990 and 2005, as well as the estimated energy savings due to energy efficiency, are shown in Figure 6-2.

The transportation sector accounts for 29.5 percent (2502 PJ) of secondary energy use and 35.9 percent (178 megatonnes [Mt]) of greenhouse gas (GHG) emissions. From 1990 to 2005, transportation energy use increased by 33.2 percent, and GHG emissions increased by 31.8 percent. The change in GHG intensity of transportation energy use was negligible.

Figure 6-3 shows how the market share of new light trucks increased in the 1990s, reflecting the increase in popularity of minivans and sport-utility vehicles. Recently however, this trend seems to have stabilized with the share of light trucks remaining steady over the past few years. This higher share of heavier and more powerful passenger vehicles has had a significant effect on the increase in passenger energy use.

FIGURE 6-2

Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2005

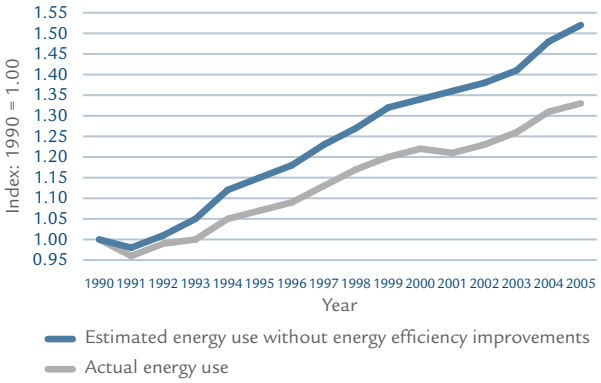


FIGURE 6-3

Market Shares of New Passenger Car and Light Truck Sales, 1990 to 2005

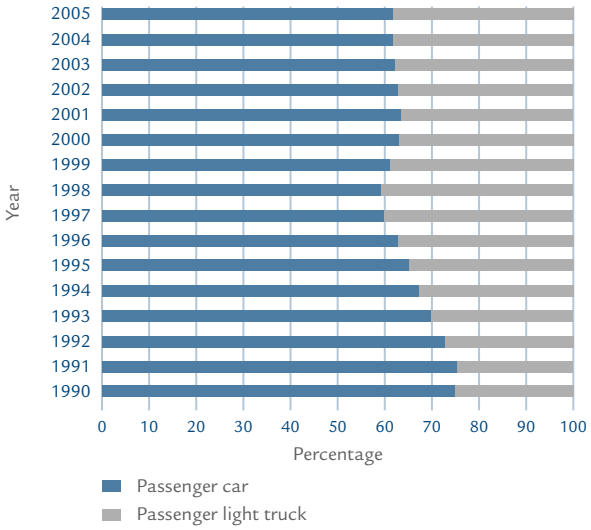


FIGURE 6-4

Average Activity per Truck, 1990 to 2005

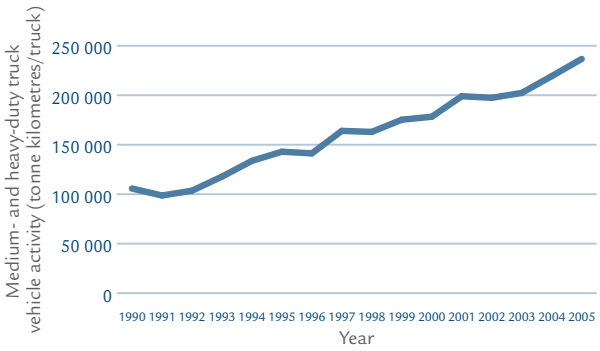
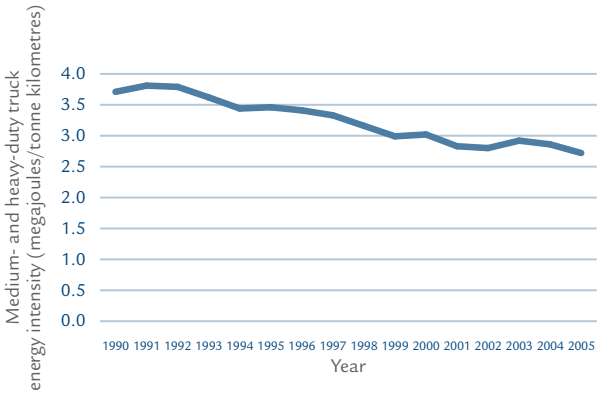


FIGURE 6-5

Trucking Energy Intensity, 1990 to 2005



Figures 6-4 and 6-5 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2005. Improved fleet practices, caused by an increase in the competitiveness of the transportation sector and by the introduction of electronic engines, have improved fuel efficiency in medium- and heavy-duty trucks.

NRCan delivers initiatives in the following areas to increase the efficiency of motor vehicles and encourage the use of alternative fuels:

- vehicles
- transportation research and development
- alternative transportation fuels
- transportation technologies

VEHICLES:
Marketing of Efficient Vehicles

Objective: To improve motor vehicle fuel efficiency by encouraging private motorists to purchase energy-efficient vehicles and develop energy-efficient vehicle use and maintenance practices.

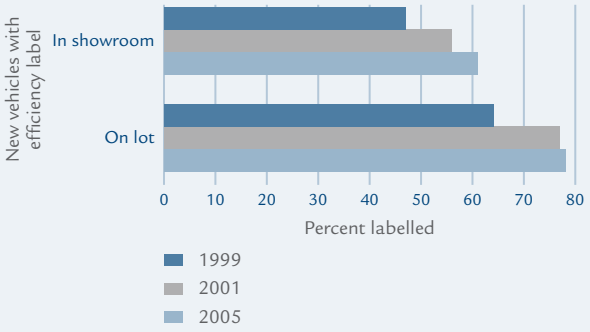
The Marketing of Efficient Vehicles program focuses on education and awareness campaigns that aim to improve fuel conservation behaviour with relation to vehicle selection, maintenance and use. Other objectives are to provide a coordinated approach to vehicle selection and use issues through the provision of information, tools and services to provinces, municipalities and community-level organizations. The program achieved GHG reductions of 0.01 Mt in fiscal year 2006–2007.

Key 2006–2007 Achievements

- Continued a carbon dioxide (CO_2) rating system introduced in 2004. Since its inception, CO_2 information has been distributed to over 1 million Canadians through on-line Web tools and the distribution of the annual fuel consumption guide. A vehicle ranking system is currently under development and in discussion with the vehicle manufacturers.
- Surveys confirmed that
  - 60 percent of drivers believe that changing their driving habits and improving vehicle maintenance will result in reduced fuel costs
  - 71 percent of Canadians considered fuel economy to be an important consideration in their next vehicle purchase
  - 50 percent of Canadians would consider the vehicle's impact on the environment in their next vehicle purchase decision
- One hundred and thirty thousand of the four hundred thousand new drivers taking driver education annually receive the Auto$mart Driver Education program.
- Thirty-three percent of driver instructors in Canada received driver training kits and/or training (the target is to ensure 50 percent of driver instructors are so educated).

FIGURE 6-6

Vehicle Fuel Efficiency Labelling



VEHICLES:
Motor Vehicle Fuel Efficiency Initiative

Objective: To improve the fuel efficiency and reduce the GHG emissions of new light-duty vehicles sold in Canada.

The goal of the Motor Vehicle Fuel Efficiency Initiative is to bring about a 25 percent improvement in the fuel efficiency of new light-duty vehicles sold in Canada by 2010. NRCan led negotiations with the automotive industry to a successful conclusion, reaching an agreement to reduce GHG emissions from this sector. The auto industry committed to a voluntary reduction in GHG emissions of 5.3 Mt annually from light-duty vehicle use by 2010. This 5.3-Mt target goes beyond fuel consumption reductions by incorporating reductions in all GHG emissions associated with vehicle use.

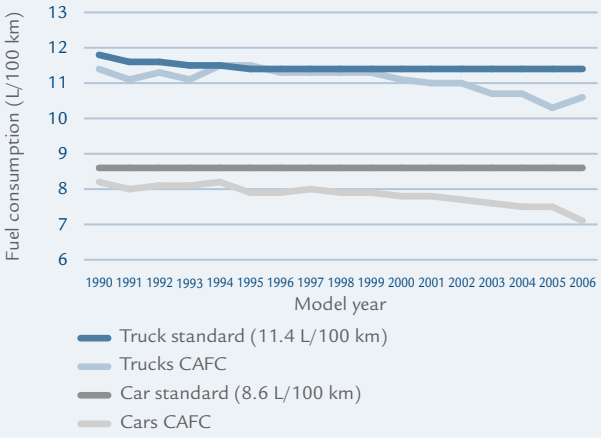
Key 2006–2007 Achievements

- The first progress report for the Motor Vehicle Fuel Efficiency Initiative was released in June 2006. It includes details about the Memorandum of Understanding (MOU), its approach and benefits, as well as the 5.3-Mt reduction goals. The report also outlined the mandate and terms of reference for the joint government-industry committee, which serves as the accountability mechanism to track progress and report on the MOU.
- Idle-free campaigns were conducted in communities that represent 32 percent of the Canadian population. Approximately 100 communities launched a campaign, and 90 percent will continue with their campaign in the 2007–2008 fiscal year. Several communities are implementing idling by-laws; 25 communities have already done so and 25 more are in the planning stages.
- Be Tire Smart campaigns were conducted with approximately 6 million Canadians. Surveys show that the number of people who properly inflate their tires by measuring the tire pressure at least once a month increased by 9 percent between 2003 and 2005. It is estimated that 50 percent of these people improved their tire inflation; this rate of change is expected to stay constant.
- While there was a modest increase of 2 percent in new light-duty vehicle sales in Canada in 2006, the sale of fuel-efficient subcompact vehicles increased by 19.8 percent.

For more information:
oee.nrcan.gc.ca/transportation/fuels/motorvehicles.cfm

FIGURE 6-7

Company Average Fuel Consumption (CAFC) versus Canadian Voluntary Standards, 1990 to 2006*



*2002–2006 data are estimates.

VEHICLES:
Commercial Transportation Energy Efficiency and Fuels Initiative

Objective: To reduce the growth of GHGs from Canada's on-road commercial transportation fleets (passenger and commercial) through increased awareness and uptake of new technologies in energy efficiency, low GHG emissions technologies and alternative fuels.

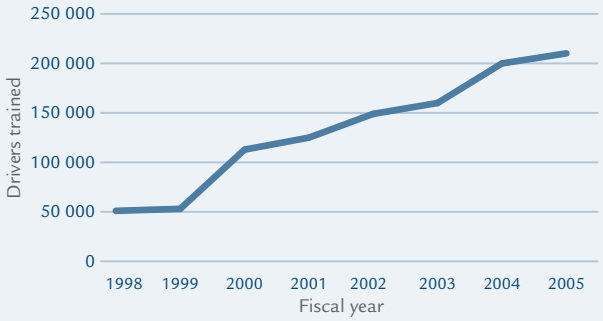
Program delivery focuses on training initiatives such as SmartDriver and education activities to improve fuel conservation and increase awareness about the benefits of efficiency technologies. The Commercial Transportation Energy Efficiency and Fuels Initiative conducts studies and reports, and develops demonstration and technology transfer projects. GHG reductions for fiscal year 2006–2007 were 0.045 Mt.

Key 2006–2007 Achievements

- The demonstration of 3 "Star Trucks" affected the specification improvements of 66 trucks. The improvements are equal to removing 2000 t of GHG emissions from each truck annually.
- Long vehicle configuration was demonstrated along the Québec City–Windsor corridor.
- A Liquefied Natural Gas/Heavy-duty Pilot Ignition demonstration was completed.

FIGURE 6-8

Drivers Trained, 1998 to 2005*



* Estimates are based on NRCan internal data.

VEHICLES:
Freight Efficiency and Technology Initiative

Objective: To reduce the growth of GHG emissions in the on-road freight transportation sector.

The Freight Efficiency and Technology Initiative aims to reduce the growth of GHGs through

- increased participation of the commercial transportation industry in voluntary climate change initiatives
- increased operating efficiency and environmental awareness among commercial transportation carriers and shippers
- increased adoption of existing and innovative environmental technologies and efficient best practices within the freight transportation sector

GHG emissions reductions for fiscal year 2006–2007 were 0.101 Mt.

Key 2006–2007 Achievements

- Conducted four Fuel Management 101 workshops with 55 participants. Thirty percent of participants implemented action plans that led to GHG reductions.
- Initiated an E-learning strategy to facilitate shippers' requirement for environmental carriers.
- Conducted the fifth annual Truck Stop Quiet Zone campaign. Seventy truck stops participated.

TRANSPORTATION RESEARCH AND DEVELOPMENT: Canadian Lightweight Materials Research Initiative

Objective: To develop low-density, high-strength, lightweight materials to achieve weight reductions in ground transportation vehicles.

The Canadian Lightweight Materials Research Initiative (CLiMRI) is a research network comprising 29 companies, 8 universities and 7 government departments and funding agencies. CLiMRI's goal is to develop and implement lightweight, high-strength materials with transportation applications for the purpose of reducing GHG emissions where vehicle weight reduction results in improving vehicle efficiency and enhancing the competitiveness of Canadian primary metals producers, automotive part manufacturers and suppliers.

Key 2006–2007 Achievements

- Magnesium alloys are increasingly considered for automotive applications due to the potential for weight reduction, resultant fuel economy improvement and emissions reduction. Magnesium trials were completed to identify the effect of alloying additions, coatings, and sand systems on the fluidity of magnesium. The results indicated that it is possible to cast thin-walled sections for use in future automotive applications. Additionally, coatings were developed for sand casting processes to reduce cover gases used in this process and resulted in high-integrity castings. These achievements show significant potential for increasing the use of magnesium in the automotive industry.
- The demand for lightweight vehicles requires new advanced, high strength steel. The challenge for the steel industry is to develop ultra-high strength steels that have better ductility, to allow the formation of complex shapes. The properties of TRIP and DP steels, in particular, were developed incrementally. New ultra-high strength steels with ductility improvement through the Twinning Induced Plasticity effect show weight reduction and impact resistance. This is a major focus of the CANMET Materials Technology Laboratory (CANMET-MTL) research.
- Titanium components for automotive applications offer high strength, low density and resistance to corrosion. Conventional processing of titanium is expensive, whereas powder injection moulding (PIM) development at CANMET-MTL eliminates most secondary machining processes, is adaptable to high production rates and could reduce production costs by up to 50 percent. CANMET-MTL is evaluating the use of titanium powder in the PIM process.

For more information:
climri.nrcan.gc.ca/default_e.htm

TRANSPORTATION RESEARCH AND DEVELOPMENT: Fuel Cell-Powered Mining Vehicles

Objective: To develop the technology to replace diesel power with hydrogen fuel cell power in underground mining vehicles.

NRCan has a coleadership role in the North American Consortium for Fuel Cell-Powered Mining Vehicles. Hydrogen fuel-cell power systems are more efficient in delivering power than conventional diesel equipment.

Retrofitting diesel-powered vehicles with hydrogen fuel cells should improve vehicle productivity, operating costs and the work environment for underground miners. Using fuel cells will eliminate toxic underground diesel emissions and reduce heat and noise. Fuel cells have the potential to reduce CO_2 or GHG emissions by up to 1 Mt annually (26 percent of the total CO_2 equivalent emitted by mining extraction) and decrease operating costs by lowering mine ventilation needs.

Key 2006–2007 Achievements

- The first International Symposium on Fuel Cells Applied to Mining was held in Montréal, Quebec. Bringing together mining companies, mining equipment manufacturers, hydrogen and technology suppliers as well as regulatory agencies, the symposium fostered the transfer of technology, highlighting Canada's lead in introducing fuel cells into the mining industry. The European Commission's Chairman for fuel-cell introduction in mining requested cooperative meetings to share information and harmonize the introduction of fuel cells in mining between North America and Europe. The symposium also fostered continued industry interest for funding new hydrogen use projects.
- The development project for an underground mine loader that uses fuel cells is at the vehicle testing stage, at the Caterpillar proving grounds in Tucson, Arizona. Mining application tests will follow at NRCan's Experimental Mine in Val-d'Or, Quebec.

For more information:
nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mines/mines-e.htm

TRANSPORTATION RESEARCH AND DEVELOPMENT: Hybridization of a Load-Haul-and-Dump Mining Vehicle

Objective: To build and test a prototype diesel/electric hybrid Scooptram®, also known as a Hybrid-Load-Haul-and-Dump (H-LHD) Mining Vehicle.

The Hybridization of a Load-Haul-and-Dump Mining Vehicle project consists of establishing and verifying the potential to use diesel/electric hybrid technology in the mining industry. It will involve the development of a reliable and efficient hybrid power plant for underground applications that will be subsequently adapted to a full line of mining equipment.

The first step of the project is to select the configuration and components for the hybrid power plant and then work out engineering details that will enable component integration into the H-LHD. The next step following fabrication is optimization of vehicle design, which will make the Scooptram effective and reliable while keeping gas emissions such as diesel particulate to a minimum.

Comparison of the emission levels (respirable combustible dust, elementary/organic carbon, CO, NO, NO_2, SO_2 and O_2; size, distribution and characterization of diesel particles) of the hybrid LHD and a conventional LHD will follow. GHG emissions from the hybrid system are expected to decrease by at least 35 percent. The CANMET Mining and Mineral Sciences Laboratories will advise on the proper size of the exhaust purifier to optimize results. The H-LHD prototype vehicle will then be transferred to participating mines to determine if performance is adequate.

Key 2006–2007 Achievements

- The final choice of the configuration and the components was made.
- The engineering details of the integration of all the components were done.
- The H-LHD was manufactured and is ready to be tested.

For more information:
nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mines/mines-e.htm

ALTERNATIVE TRANSPORTATION FUELS: Ethanol Expansion Program

Objective: To expand fuel ethanol production and use in Canada.

The Ethanol Expansion Program (EEP), co-managed by NRCan with Agriculture and Agri-Food Canada (AAFC), is contributing to the expansion of ethanol production and use in Canada, and the reduction of transportation GHG emissions. The program provides contributions, with repayment terms, towards the construction costs of new ethanol production facilities or the expansion of existing ones.

The intermediate outcomes of the EEP are expanded ethanol production, increased consumer adoption of ethanol and more markets for ethanol fuels in Canada. The longer-term outcome is a reduction of GHG emissions from the transportation sector (as ethanol replaces conventional fuels). EEP achieved 0.3 Mt of GHG reductions in fiscal year 2006–2007.

Key 2006–2007 Achievements

- In 2006–2007, four new ethanol plants that were allocated $51 million under the EEP were completed and started producing fuel ethanol. These four plants added 480 million litres (L) to the ethanol production capacity in Canada. The annual capacity had been 200 million L.
- Four more ethanol plants started construction under the EEP in 2006–2007. These plants have a combined production capacity of 390 million L annually.
- NRCan represented and coordinated the federal government presence at two ethanol plant openings.

For more information:
vehiclefuels.gc.ca

ALTERNATIVE TRANSPORTATION FUELS: Future Fuels Initiative

Objective: To increase Canada's fuel ethanol production and use in the transportation sector.

The Future Fuels Initiative, co-managed by NRCan with AAFC, targets motorists, provinces and territories, and industry stakeholders. The main activities are federal-provincial policy coordination, industry consultation, public awareness campaigns and analytical work on feed stocks, production costs, emissions and socio-economic impacts.

Key 2006–2007 Achievements

- Completed 5 bio-diesel workshops for fleet managers and mechanics with over 120 participants.
- Co-lead in the development of the Government of Canada's Renewable Fuels Strategy in coordination with Environment Canada and AAFC. The result was regulation of renewable fuels, a $200-million AAFC capital program for farmer participation in renewable fuels production and a 2007 Budget announcement for $2 billion for renewable fuels.
- Conducted five life-cycle emission studies on renewable fuels pathways using GHGenius.

For more information:
vehiclefuels.gc.ca

ALTERNATIVE TRANSPORTATION FUELS: Biodiesel Initiative

Objective: To support increased biodiesel production and use in Canada's transportation sector.

The Biodiesel Initiative was initially designed to support the Government of Canada's proposed target of 500 million L of biodiesel production annually by 2010. The work done under this initiative also supports the Government of Canada's implementation of a Renewable Fuel Standard that requires 2 percent renewable content in diesel fuel by 2010 at the earliest and 2012 at the latest.

The main components of this initiative are research and development, technical and socio-economic studies, end-use demonstrations and testing, stakeholder education and standards development.

Key 2006–2007 Achievements

- The *Assessment of Canadian Biodiesel Distribution Infrastructure* study was completed. This study was designed to address potential distribution infrastructure roadblocks and proposed solutions and options to ensure sustainable growth of the Canadian biodiesel industry.
- A demonstration project that evaluated biodiesel use in agricultural equipment was conducted. This demonstration studied the use of biodiesel in six Ontario farms. Blends of 5 percent and 20 percent biodiesel were used, and data on fuel efficiency, emissions and maintenance/operational issues were collected.
- Five workshops for fleet managers and engine mechanics provided information about the purchase, handling, storage and use of biodiesel.
- A fuel testing study was conducted. It provided data on the suitability of biodiesel and renewable diesel for use in Canadian climate conditions, particularly cold weather applications. The results will be used to inform the biodiesel fuel selection process for the Alberta Biodiesel Demonstration Pilot.

For more information:
vehiclefuels.gc.ca

TRANSPORTATION TECHNOLOGIES: Canadian Transportation Fuel Cell Alliance

Objective: To demonstrate and evaluate processes for producing and delivering hydrogen to fuel-cell vehicles at fuelling stations, to develop and demonstrate hydrogen-fuelled vehicles, and to participate in the development of codes and standards.

NRCan's Canadian Transportation Fuel Cell Alliance (CTFCA) is a private-public sector initiative that includes technology developers, fuel providers, auto manufacturers, federal and provincial/territorial governments, academia and non-governmental organizations. The CTFCA contributes to a reduction in GHG emissions by encouraging advances in hydrogen and fuel-cell technologies through demonstration projects. They evaluate the technical, economic and environmental feasibility of hydrogen fuelling options for fuel-cell vehicles. The initiative also establishes a supporting framework for hydrogen fuelling by assisting in the development of codes and standards and certification and training programs.

Key 2006–2007 Achievements

- Four of the seven "Hydrogen Highway" fuelling stations in British Columbia are operational. The five Ford Focus fuel-cell cars completed the second of three years of on-road testing and evaluation in the Vancouver and Victoria areas.

- Initiated the development of "hydrogen highways" in Saskatchewan and Prince Edward Island. Each of these will include two or more hydrogen fuelling stations and several hydrogen-fuelled vehicles.
- Installed a hydrogen fuelling station at NRCan's Booth Street complex in Ottawa, Ontario to provide fuel for the three Ford internal combustion engine shuttle buses that are operated on Parliament Hill by the Senate.
- Published the new Canadian Hydrogen Installation Code as a National Standard of Canada. The Code will govern the installation of hydrogen-generating equipment, hydrogen-using equipment such as fuel cells, hydrogen-dispensing equipment, hydrogen storage containers, hydrogen-piping systems and related accessories.

For more information:
nrcan.gc.ca/es/etb/ctfca/ index_e.html

TRANSPORTATION TECHNOLOGIES: Hydrogen, Fuel Cells and Transportation Energy Program

Objective: To develop and deploy hydrogen, fuel cell and transportation technologies that reduce GHG emissions, minimize other environmental impacts, increase the potential for job and economic growth, and extend the life span of Canada's energy resource base.

The Hydrogen, Fuel Cells and Transportation Energy Program, in partnership with industry, works with stakeholders in the domestic and international hydrogen and transportation industries. These include original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial and territorial governments, research organizations, universities, other federal departments, the United States Department of Energy and the International Energy Agency.

Highlights of the program's work include the following:

- supporting Canadian industry in developing a water electrolysis technology for the production of hydrogen from clean renewable energy sources
- working with Canada's fuel cell industry over the last 20 years and establishing Canada as a world leader in fuel cell and refuelling technologies. For example, the world's first hydrogen fuel cell bus was demonstrated in Canada.
- supporting student vehicle challenges since the 1980s and bringing university and college students from across North America together with automotive manufacturers to modify existing vehicles to run on a variety of alternative fuels
- supporting the development of fuel technologies for alternative transportation

Key 2006–2007 Achievements

- Developed a regenerative braking system that is coupled to a lithium-ion battery.
- Demonstrated a 100-kilowatt flywheel energy storage system.
- Improved cell efficiency and lowered costs of water electrolysis.
- Reduced the weight and increased the laminate strength of pressure cylinders for hydrogen storage.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/Groups/hyfate_e.htm

CHAPTER 7

Renewable Energy

RENEWABLE ENERGY USE

In 2005, renewable sources accounted for approximately 61 percent of the Canadian installed electricity capacity (see Table 7-1). Most of the renewable energy used in Canada comes from either hydro-electricity or thermal energy from biomass such as wood-waste sources.

Hydro-Electricity

Hydro-electricity is a renewable form of electricity that is generated from a system or technology that uses a mechanical method to capture and convert the potential energy of water.

Hydro is the main source of electricity in Canada, accounting for approximately 60 percent of the electricity generated in 2005. Canada's hydro supply is dominated by large-scale projects that were developed by electric utilities. Of the 72 000 megawatts (MW) of installed hydro capacity, approximately 3200 MW comes from small hydro sites (less than 50 MW), about 2.7 percent of Canada's total installed electricity capacity. Significant potential remains for additional hydro-electric development in Canada, in most provinces and territories.

Biomass

Bioenergy is a renewable source of energy derived from the conversion of materials of either living organisms or metabolic by-products. Canada has an abundant supply of many types of biomass, which is important in the production of energy, biofuels, materials and chemicals. The two largest sources of biomass supply in Canada come from forestry and agricultural operations.

The typical biomass supply is derived from

- forestry – mill or pulp and paper residues, black liquor from the pulping process, forest residue, forest management thinnings and short rotation crops
- agriculture – agricultural crops, crop residue, processing residues, algae and aquatic biomass
- other organic waste – animal waste such as manure from feed lots, municipal solid waste and industrial wastes

Canada is using approximately 6 percent of its energy demand from bioenergy. This amount of renewable bioenergy ranks second to hydro power (which generates 11 percent of Canada's energy). Most of the bioenergy being produced is in the form of industrial process heat, electricity, steam and residential space heating.

TABLE 7-1

Electricity Generation Capacity From Renewable Sources (Includes Hydro-Electricity)

Year	Renewable electricity generation capacity (megawatts)	Percent of total capacity
1990	59 557	58
1991	61 116	58
1992	62 895	58
1993	63 114	56
1994	63 175	56
1995	66 542	57
1996	67 101	59
1997	68 202	61
1998	68 340	62
1999	68 686	62
2000	69 005	62
2001	68 734	61
2002	70 895	62
2003	72 160	62
2004	72 783	62
2005	74 373	61

Source: Statistics Canada catalogue 57-206-XIB

TABLE 7-2

Renewable Energy Markets and Technologies Used in Canada

Electricity	*Thermal Energy*
Hydro-electricity	Biomass (e.g. roundwood, pellets, wood chips)
Tidal power	Ground-source heat pumps (e.g. earth energy)
Biomass (e.g. wood waste)	Solar air-heating systems
Biogas (e.g. methane from landfill sites)	Solar hot water systems
Wind turbines	
Photovoltaic systems	
Mechanical Power	*Transportation*
Wind water pumps	Biodiesel
	Ethanol from biomass

The pulp and paper industry is Canada's major producer and user of bioenergy. Heat and electricity produced by industry, electricity generated by independent power producers, and residential wood heat are all considered commonplace in Canada's energy mix. As an example, approximately 3 million Canadian households use wood for home heating. Roundwood is typically used but alternatives include wood chips and pellets. Home eating with wood usually takes the form of stand-alone wood stoves, wood furnaces with hot-water or forced-air systems, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters.

Biogas and landfill gas (methane rich gases that are derived from manure, animal processing wastes, other agricultural residues and municipal waste) for energy production is just emerging and contributed just over 100 MW of power in 2006.

Biomass also shows potential as a feedstock for liquid fuels. Approximately 200 million litres of fuel ethanol are produced annually in Canada from cereal grain and corn. Biodiesel is also produced in small quantities but production is increasing. It is accepted that Canada has potential to increase its bioenergy production in a sustainable manner.

Earth Energy

As a result of the sun heating the surface of the planet, the temperature of the earth that is 1 or 2 metres (m) below the surface remains fairly constant—between 5°C and 10°C. This temperature is warmer than the air during the winter and cooler than the air in the summer. A ground-source heat pump takes advantage of this temperature difference by using the earth or the ground water as a source of heat in the winter and as a "sink" for heat removed from indoor air in the summer. For this reason, a ground-source heat pump is known as an earth energy system (EES).

During winter, EES installations remove heat from the earth using a liquid, typically an antifreeze solution or water, that circulates within an underground loop. The EES then upgrades the heat with a conventional heat pump and transfers it to indoor space or the water-heating system. During summer, the system reverses this process to operate as an air conditioner. EES installations supply less than 1 percent of the market for space and water heating and cooling in Canada.

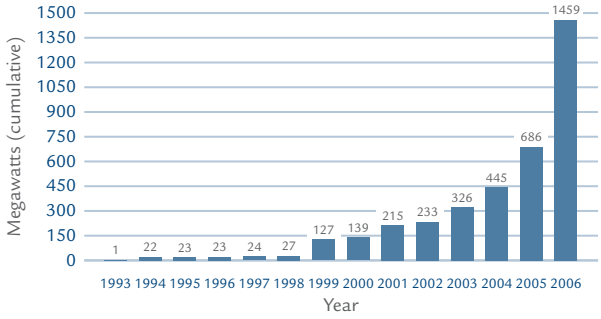
Wind Energy

Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada's land mass and coastal waters combine to provide a wind resource with potential estimated at more than 100 000 MW. As of December 2006, a total of 1460 MW of wind power were installed in Canada, making it the thirteenth country that has reached the 1000 MW milestone and the twelfth largest nation in terms of installed wind energy capacity. 2006 was a record year for Canadian wind power with an increase of 776 MW from last year's level of 683 MW, which is a 113 percent increase. Recent policy developments have spurred record growth in the Canadian wind generation industry (see Figure 7-1). Wind energy currently accounts for approximately 0.7 percent of Canada's total electricity generation, up from 0.4 percent in 2005.

Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairie provinces. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses.

FIGURE 7-1

Canadian Wind Power Capacity, 1993 to 2006



Source: Canadian Wind Energy Association

Solar Energy

Three main technologies use energy from the sun:

- passive solar technologies – Buildings are designed and located to maximize their reception of solar energy.
- active solar thermal systems – Solar radiation is converted into thermal energy for heating air or water in residential, commercial and industrial applications.
- solar electric (photovoltaic) systems – Solar radiation is used to produce electricity.

The Canadian solar thermal installed capacity in 2005 was 419 000 m^2 or 290 $MW_{thermal}$. The domestic market increase has averaged 17 percent annually since 1998. In 2005, the solar thermal collector market in Canada was 61 500 m^2 compared with 53 600 m^2 in 2004.

The Canadian total photovoltaic (PV) installed capacity in 2006 was 20.5 MW with a sustained domestic market growth that has averaged 22 percent annually since 1992. In 2006, the PV module market in Canada was 3.75 MW compared with 3.68 MW in 2005.

Module prices declined from $11.09/W in 1999 to $5.36/W in 2006. This is an average annual price reduction of 9 percent. Twelve manufacturers in Canada reported revenues from manufacturing operations related to system sales of $137 million and the addition of 55 jobs in 2006. The PV business in Canada is valued at $205 million and employs 1030 people.

Natural Resources Canada (NRCan) delivers several initiatives to increase the use of small-scale renewable energy in Canada. The following is the array of NRCan renewable energy programs.

RENEWABLE ENERGY PROGRAMS:
Wind Power Production Incentive

Objective: To support the installation of 1000 MW of wind energy capacity or the production of 2.6 terawatt hours by March 31, 2007.

Under the Wind Power Production Incentive (WPPI), electric utilities, independent power producers and other stakeholders could qualify for an incentive averaging $0.01/kilowatt hour (kWh) on electricity produced from wind over a 10-year period. The commitment period for new wind energy projects under the program came to an end on March 31, 2007.

Key 2006–2007 Achievements

- Three wind energy projects were commissioned in fiscal year 2006–2007: two are in Ontario and one is in Alberta. These projects represent approximately 173 MW of wind energy capacity and a financial contribution of more than $51 million over 10 years.
- Since WPPI's introduction in 2002, the program has supported 924 MW of new capacity, which included 22 projects and a financial commitment of approximately $314 million.

For more information:
canren.gc.ca/wppi

RENEWABLE ENERGY PROGRAMS:
Initiative to Purchase Electricity From Emerging Renewable Energy Sources

Objective: To purchase electricity from emerging renewable energy sources (ERES) certified by a third party as having low environmental impact, with the objective of reducing GHGs and other air pollution emissions associated with federal electricity consumption.

Between 1998 and 2001, NRCan entered into three pilot projects to purchase electricity from ERES for federal facilities in Alberta, Saskatchewan and Prince Edward Island. The Government of Canada pledged to purchase 20 percent of its electricity from ERES by 2010.

Key 2006–2007 Achievements

- Approximately 90 gigawatt hours (GWh) of electricity were generated from ERES in Ontario through an agreement with Energy Ottawa.
- Approximately 57.4 GWh of electricity are generated annually from ERES for federal facilities in Alberta, Saskatchewan and Prince Edward Island. As a result, GHG emissions were reduced by approximately 50 000 tonnes.

For more information:
reed.nrcan.gc.ca

RENEWABLE ENERGY PROGRAMS:
Renewable Energy Deployment Initiative

Objective: To stimulate the demand for renewable energy systems by helping the supply industry with its marketing and infrastructure development, including the provision of financial incentives.

The Renewable Energy Deployment Initiative (REDI) targets four systems: solar water heating, solar air heating and cooling, earth energy, and high-efficiency, low-emission biomass combustion. REDI promotes these systems in the business, federal and industrial markets through various means: a financial incentive, industry infrastructure development, a partnership with a utility coalition, market assessment, and information provision and awareness-raising activities.

Key 2006–2007 Achievements

- The program experienced a record level of interest, completing 298 projects at the end of fiscal year 2005–2006 and receiving over 1000 applications (see Table 7-3). Two market documents were published: *The REDI Strategic Business Plan to March 2007* and *A Survey of Active-Solar Thermal Collectors, Industry and Markets in Canada*.
- REDI supported a solar domestic hot water system. It was the first packaged system of its type to receive Canadian Standards Association certification in Canada.

For more information:
nrcan.gc.ca/redi

TABLE 7-3

REDI for Business Projects Completed, 1998 to 2005

Fiscal year	Number of projects completed	Estimated GHG reduction (tonnes CO_2/yr)	Client investment ($)	Federal incentive ($)
1998	10	2 909	1,428,063	176,392
1999	70	329	689,633	189,910
2000	131	6 370	2,170,918	327,078
2001	51	23 465	6,708,120	1,362,399
2002	50	7 643	5,048,607	956,600
2003	119	33 975	25,060,504	3,226,694
2004	65	47 446	11,200,943	2,250,421
2005	298	18 987	21,494,497	2,920,750
Total	**794**	**141 124**	**73,801,285**	**11,410,244**

RENEWABLE ENERGY PROGRAMS:
Photovoltaic and Hybrid Systems Program

Objective: To support the development and application of solar photovoltaic technologies in Canada.

The Photovoltaic and Hybrid Systems program contributes to increasing the use of photovoltaic (PV) energy technologies in Canada by developing technologies and by facilitating the development of a Canadian-based globally competitive solar industry. It also contributes to the development of policies and programs. In collaboration with Canadian industry and universities as well as international energy research organizations, the program undertakes research and development (R&D) activities and fosters information exchanges. This leads to the adoption of PV-hybrid systems that produce electricity from solar energy and another energy source; validates the performance and safety of utility-interactive inverter products; supports the development of building-integrated PV technologies and systems; and facilitates the development and adoption of harmonized standards and codes for micropower systems in Canada.

Key 2006–2007 Achievements

- Published the PV and solar resource maps for Canada. These "on-line" Web maps were unveiled on November 3, 2006, at the Canadian Solar Industries Association annual conference in Ottawa. The maps give estimates of the electricity that can be generated by PV arrays and of the mean daily global insolation for any location in Canada. The maps are complemented by a municipality database that gives PV potential data for more than 3500 municipalities. The maps and database are important new tools that allow users to rapidly assess the potential of PVs throughout Canada and to examine how this potential varies with location, time of year and PV panel orientation.
- A research partnership with universities and industry has been established to optimize the use of renewable energy in buildings in Canada. This Solar Buildings Research Network is headquartered at Concordia University and brings together top Canadian researchers in solar energy and buildings to develop the solar-optimized homes and commercial buildings of the future. The network will also develop and implement a strategy to effectively transfer this knowledge to architects, manufacturers and home builders and utilities. See www.solarbuildings.ca.
- The first Canadian interconnection standard was adopted in 2006. This new national standard of Canada (CAN/CSA-C22.2 No. 257-06) was issued by the Canadian Standards Association under Part II of the *Canadian Electrical Code* and specifies the electrical requirements for safe interconnection of inverter-based micro-distributed resource (micro-DR) systems connected to 600 volt (nominal) or less distribution systems (single or three phase). Program support and expertise in the area of PV inverter-based interconnection established the technical foundation for the national standard.

For more information:
cetc-varennes.nrcan.gc.ca/en/er_re.html

RENEWABLE ENERGY PROGRAMS:
Bioenergy Technology Program

Objective: To support efforts by Canadian industry to develop bioenergy technologies.

Technologies supported by the Bioenergy Technology program include combustion, biochemical conversion of biomass to ethanol, thermochemical conversion of biomass to bio-oil and biogas, and biomass preparation and handling. Activities are directed toward improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics to potential users, and helping industry commercialize its products in domestic and foreign markets.

Key 2006–2007 Achievements

- BIOX Corporation of Oakville, Ontario, completed the construction and commissioning of a biodiesel production facility in Hamilton, Ontario, that will produce 60 megalitres (ML) annually. The facility is now in continuous full commercial production. This innovative technology was developed at the University of Toronto and licensed to BIOX with technical and funding support from NRCan, including the demonstration of a 1-ML per year pilot plant. The technology is unique in that it can convert low quality oils and greases into a high quality biodiesel fuel with lower capital and operating costs than competing technologies. Sustainable Development Technology Canada provided funding support to this facility, which is the largest biodiesel production facility in Canada, and one of the few in the world capable of running on multiple triglyceride feedstocks.
- In February 2007, the United States Department of Energy announced that it would be investing US$385 million in six biorefineries over the next four years. The six successful consortiums were selected after rigorous technical and economic reviews. Iogen Corporation of Ottawa, Ontario, was one of the six companies chosen. Iogen technology makes it economically feasible to convert biomass into cellulose ethanol by using a combination of thermal, chemical and biochemical techniques.
- NRCan has played a key role in a gasification project in Kamloops, British Columbia. A gasification technology developed by Nexterra Energy was installed at a plywood mill in Heffley Creek, British Columbia, that is owned by Tolko Industries. This energy plant is the first application of its type in the North American forest industry to make use of green technologies that can convert hog fuel waste produced at mills to a renewable energy source that can replace natural gas in lumber kiln drying applications. As a result of this successful commercial demonstration, Nexterra has announced that other projects such as Dockside Green in Victoria, British Columbia, will be utilizing its technology.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/Groups/Research%20Programs/program_bioenergy_e.htm

RENEWABLE ENERGY PROGRAMS:
Science and Technology in Renewable Energy

Objective: To promote energy diversity and support efforts by Canadian industry to develop renewable energy technologies.

Working in partnership with associations, government and industry, the CANMET Energy Technology Centre (CETC) aims to improve the economics and efficiency of renewable energy technologies, including wind energy, small and low-head hydro, ocean energy, solar thermal and energy storage. It is actively involved in R&D to support the growth of the renewable energy industry in Canada. Growth will be achieved by

- identifying and accelerating strategic R&D
- fostering the commercialization of new technologies
- identifying and developing opportunities for renewables integration
- developing infrastructure to support innovation, such as codes, policies and standards
- developing links between utilities, industry and academia
- conducting resource assessments
- supporting training and education
- disseminating results and findings
- supporting policy and programs
- engaging in international cooperation through the International Energy Agency

Key 2006–2007 Achievements

- Construction began in 2005 on the Drake Landing Solar Community, a 52-home subdivision in Okotoks, Alberta, south of Calgary. This seasonal project stores solar thermal energy. It was designed and led by CETC to capture solar energy in the summer and store it for use in the winter. The solar district heating system will meet 90 percent of the community's needs for residential space heating. This result is unprecedented anywhere in the world. In 2006–2007, all homes were sold and 40 homes were occupied, with 25 percent of solar collectors online and the remainder installed. The final commissioning is scheduled for September 2007.
- CETC works to improve Canadian standards for renewable energy technologies. In 2006–2007, CETC helped form the Canadian National Technical Committee for Wind Turbine Standards. The committee worked on adopting and adapting a set of International Electrotechnical Commission (IEC) standards for Canadian use. The existence of these standards will significantly improve the Canadian wind regulatory framework and facilitate the commercial transactions between Canada and other countries. In addition, CETC represents Canadian interests (such as cold climate requirements) internationally in the development of future IEC standards for wind energy. CETC also led the development of Canada's first certification program for solar domestic hot water systems (SDHW), which will allow these systems to be installed anywhere in Canada. The first SDHW system has been certified.
- CETC was the Canadian Executing Agency for the Canadian International Development Agency's Canada Climate Change Development Fund ($2 million) contribution to a small hydro project that was completed in China. The project used automation equipment to improve the operational efficiency of small hydro plants. The project maximized river basin power production by using optimized equipment and hydrological modeling. It also increased energy efficiency and power production by using a new and enhanced turbine design. On average, a 10 to 12 percent increase in energy production from the small hydro generating plants was achieved. That increase now serves approximately 18 000 additional households.

- A Vanadium-Based Redox Battery System with a 3.3-kW, 3-hour storage capacity was purchased by the National Research Council and installed at CETC. CETC has been operating the battery and developing testing programs with partners to assess the performance of the system. Work is progressing towards application-specific testing (e.g. wind/storage simulations).
- Canada's ocean energy resources are among the largest in the world. A new feasibility study was started to assess the viability of a tidal power plant demonstration, located on the northeast coast of the Queen Charlotte Islands in British Columbia.

For more information:
sbc.nrcan.gc.ca

RENEWABLE ENERGY PROGRAMS: Canadian Biomass Innovation Network

Objective: To develop sustainable and cost-effective technologies in bioenergy, biofuels, bioproducts and industrial bioprocesses for market acceptance, utilizing biomass resources in a sustainable and responsible way.

The Canadian Biomass Innovation Network (CBIN) supports strategic R&D in the areas of bioenergy, biofuels, bioproducts and industrial bioprocesses to displace Canada's fossil fuel energy consumption; directly or indirectly reduce GHG emissions; and seed the sustainable development of Canada's bio-based economy.

CBIN is a horizontal program developed and managed by five federal departments: Agriculture and Agri-Food Canada, Environment Canada, Industry Canada, National Research Council and NRCan.

Key 2006–2007 Achievements

- Polylactide, a rigid and transparent polymer made from lactic acid, is presently not cost-competitive with petroleum-based polymers and is too brittle for many packaging applications. During the year, the network demonstrated that the addition of starch in a blend leads to a much more homogeneous product, with highly improved ductility, leading to potential new applications.
- A single window, interactive, Web-based biomass information portal is being completed. It will provide resources and tools that can be used by investors, policy makers and the research community to learn more about the industrial uses of herbaceous and woody biomass.
- In February 2007, Tembec announced that the Anaerobic Digester they installed on their mill effluent with assistance from NRCan and Technology Early Action Measures is now operating at full design capacity. They emphasized that the system has three benefits. The system provides methane gas that displaces 90 percent of the natural gas in the mill's pulp driers, the quality of the mill effluent is drastically improved, and the amount of sludge that goes to landfill is significantly reduced.
- The life cycle and impact assessment methodology
  was adapted to the Canadian pulp and paper industry for continuous environmental improvement, strategic planning and forest biorefinery assessment.

For more information:
cbin.gc.ca

CHAPTER 8

Federal House in Order

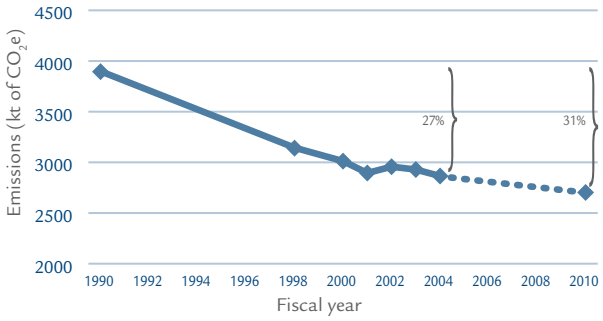
INTRODUCTION

The Government of Canada is the country's largest single enterprise. It is working to get its house in order by setting a target of a 31 percent reduction in greenhouse gas (GHG) emissions from its own operations by 2010.

Since 1990, through building retrofits, better fleet management, strategic "green power" purchases and the downsizing of operations, the Government of Canada has already achieved an emissions reduction of 27 percent. The Government of Canada plans to reduce its net emissions by an additional 6 percent by 2010 (see Figure 8-1).

FIGURE 8-1

GHG Emissions Reductions From Federal Operations, 1990 to 2010



The Government of Canada will achieve its goal through additional building retrofits, fuel switching, improved fleet management, energy-efficient procurement and increased use of renewable energy within government operations. Also, the Government of Canada can help "create the market" for certain new technologies that are on the verge of becoming viable. The departments that create 95 percent of government GHG emissions were assigned target shares for emission reduction. The level of progress of each department against their target shares is combined into one figure for the Government of Canada.

The task of target sharing entails assigning targets to the 11 organizations that produce the most emissions. The targets are based on the emission-reduction opportunities identified within each organization. Between 2001 and 2006, Natural Resources Canada (NRCan) had the lead role in managing this task and provided programs and support to departments and agencies to help them achieve their targets. In 2006, the responsibility was transferred to the Office of Greening Government Operations in Public Works and Government Services Canada. The leadership component of the Federal House in Order initiative encourages the reduction of all federal emissions by encouraging the participation of the departments, agencies and Crown corporations that were not designated with a target.

FEDERAL HOUSE IN ORDER LEADERSHIP MEASURES – BUILT ENVIRONMENT

Objective: To help Government of Canada organizations implement energy efficiency improvements that lead to reduced energy use, GHG emissions and operating costs.

The Federal House in Order Leadership Measures program develops and delivers products and services to federal organizations that demonstrate an interest in improving the efficiency of their building energy use. Products may include case studies, workshops, technical information, model procurement documents and a list of qualified private-sector energy management firms that can provide energy performance contracting services. Services may include facilitation such as energy management technical advice, program policy advice and procurement services to assist organizations at implementing energy efficiency improvements.

Key 2006–2007 Achievements

- Canadian Forces Base Kingston in Kingston, Ontario, is proceeding with an energy efficiency retrofit project. The project is expected to save $2.4 million in energy costs annually. The private sector is investing $21 million.
- The private sector made new and incremental investments of $30 million in Federal Building Initiative (FBI) projects.
- The FBI awarded energy efficiency projects that will reduce the federal government's annual utility bills by $3.7 million.

For more information:
oee.nrcan.gc.ca/fbi/home_page.cfm

FEDERAL FLEET INITIATIVE

Objective: To help federal government organizations increase the energy efficiency of their fleets and reduce the environmental impact of federal vehicle operations and to promote the *Alternative Fuels Act* within the federal fleet.

The Federal Fleet Initiative provided tools and information to federal fleet managers and drivers to help them respond to climate change and to improve the overall efficiency of their fleets. NRCan administered this initiative through an interdepartmental committee that includes the 11 largest emitting federal organizations. This committee discusses fleet management and operational issues and activities.

Key 2006–2007 Achievements

- Increased the penetration of ethanol-85 (E85) fuel across the federal fleet by subsidizing 471 599 litres (L) of E85 fuel to federal fleets (as of April 2007).
- Trained 1208 federal vehicle operators in fuel efficient driving techniques at workshops and on-line.
- Assisted in purchasing 51 Leadership Vehicles (E85 and hybrid vehicles).
- Increased the penetration of biodiesel fuel across the federal fleet by subsidizing 5100 L of B-100 fuel to federal fleets (as of April 2007).

For more information:
oee.nrcan.gc.ca/communities-government/transportation/federal/mandate.cfm

FIGURE 8-2

Federal Fleet Size and Fuel Consumption, 1997 to 2005

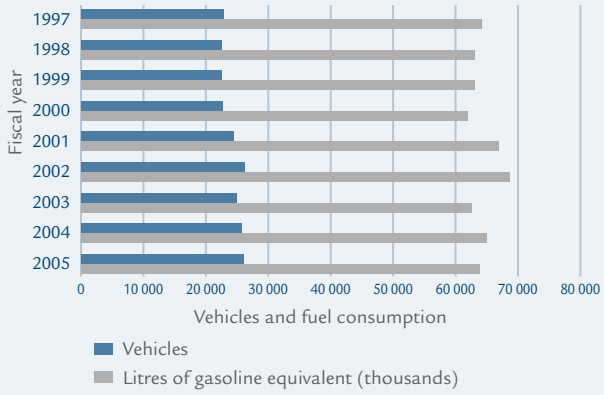
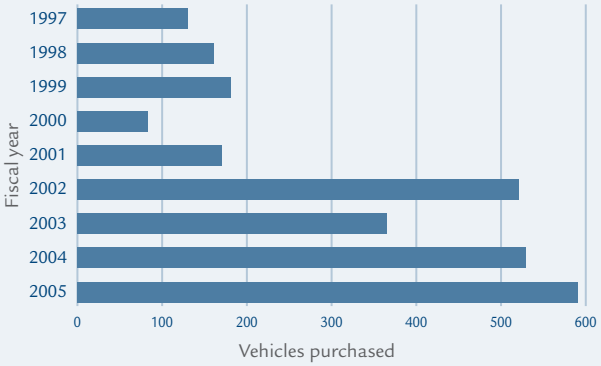


FIGURE 8-3

Purchases of Alternative Fuel Vehicles (Including Hybrids) for the Federal Fleet, 1997 to 2005



CHAPTER 9

General Programs

OUTREACH

Objective: To increase Canadians' awareness and understanding of energy efficiency information and supporting services and to encourage Canadians to take action.

The Outreach program provides information and activities to encourage Canadians to integrate energy efficiency into their energy-use decisions. Outreach supplements program communications activities with publications, contests, recognition awards and the Office of Energy Efficiency (OEE) Web site.

The Outreach program targets youth as future energy consumers by investing in joint initiatives in the education sector and through promotional projects. Public information activities increase awareness of the environmental impact of energy use. The activities also encourage consumers to adopt energy-efficient practices and to switch to alternative forms of energy.

Key 2006–2007 Achievements

- In 2006–2007, over 1 million OEE publications and information tools were distributed. This number is significant but is a decrease from the previous year.
- Efforts in 2006–2007 focussed on the launch of the new ecoENERGY suite of programs to promote smarter energy use.

For more information:
oee.nrcan.gc.ca/corporate/programs.cfm#Outreach

RETSCREEN® INTERNATIONAL CLEAN ENERGY DECISION SUPPORT CENTRE

Objective: To build the capacity of planners, decision-makers and industry to implement renewable energy and energy efficiency projects.

This objective is achieved by developing decision-making tools that reduce the cost of pre-feasibility studies, by disseminating knowledge to help people make better decisions, and by training people to better analyse the technical and financial viability of potential projects.

Key 2006–2007 Achievements

- Increased the number of users of the RETScreen International Clean Energy Project Analysis Software to more than 107 000 people in 217 countries. This number is growing at a rate of 500 new users every week. More than 131 colleges and universities worldwide are now using RETScreen for education.
- Released the beta version of a new software tool to evaluate energy efficiency measures in skating and curling rinks.
- Initiated beta testing of RETScreen Version 4. In version 4, the software includes an array of financially viable clean power, heating and cooling technologies and energy efficiency measures. Collaborated with NASA to increase the amount of climate data required by RETScreen to cover the entire surface of the planet. Coordinated with the Renewable Energy & Energy Efficiency Partnership to translate RETScreen into 25 languages that are used by two-thirds of the world's population.

For more information:
www.retscreen.net

PROGRAM OF ENERGY RESEARCH AND DEVELOPMENT

Objective: To fund research and development (R&D) designed to ensure a sustainable energy future for Canada in the best interests of our economy and our environment.

The Program of Energy Research and Development (PERD) budget for 2006–2007 was approximately $56.6 million. Natural Resources Canada (NRCan) allocated $40.7 million to energy R&D programs managed and performed in the department, approximately 50 percent of which contributed to improved energy efficiency and the integration of renewable energy sources in Canada. The remaining $16 million has been allocated to 12 federal departments and agencies that are PERD partners.

Efficiencies are sought in energy production, distribution and end-use. Production encompasses both fossil fuels and alternative sources, including biomass. Examples of funded projects are included in the performance reporting in Chapters 3 to 7 of this report.

During 2006–2007, based on recommendations of an advisory panel and as mandated in Budget 2005, the management of energy science and technology was reviewed, streamlining the delivery along the innovation chain from basic research and applied research to pilot plants and demonstrations, ensuring faster market access to technologies developed with federal funds.

For more information:
www2.nrcan.gc.ca/ES/OERD/english/

CLIMATE CHANGE TECHNOLOGY AND INNOVATION
Research and Development

Objective: To advance promising greenhouse gas (GHG) technologies through R&D, promote demonstration and early adoption initiatives to achieve long-term GHG reductions, and strengthen Canada's technology capacity.

Implemented in 2003 with $115 million in federal funding over five years, technology innovation research and development (T&I R&D) is based on long-term strategic planning that takes into account expected energy futures and visions to the year 2025. R&D is conducted in the five strategic areas of advanced end-use efficiency technologies in buildings, transportation and industry, decentralized energy production (including renewables), biotechnology, the hydrogen economy and cleaner fossil fuels—looking for efficiencies in bitumen and heavy oil, unconventional gas supply and clean coal and carbon capture. Expenditure Review reduced funding to $109 million.

The T&I R&D budget for 2006–2007 was $31.5 million. NRCan allocated $24.1 million to energy R&D programs managed and performed in the department. Key NRCan R&D achievements contributing to improved energy efficiency in Canada are included in the performance reporting in Chapters 3 to 7. The remaining $7.4 million was allocated to seven federal departments that are T&I R&D partners.

A result achieved through investment in energy efficiencies over many years (both PERD and T&I R&D funding) is the conversion to commercial operation of an experimental biomass to energy plant (methane recovery) in the pulp and paper industry, based on black liquor, a difficult to handle residue. The plant supplies up to 90 percent of the mill's heating requirements, displacing 6 million cubic metres of natural gas per year, saving 11 000 tonnes of CO_2 emissions.

CHAPTER 10

Cooperation

INTRODUCTION

This chapter describes Natural Resources Canada's (NRCan's) cooperation with provincial and territorial governments and internationally on energy efficiency and alternative energy (EAE) during the reporting period. Examples of program cooperation on specific EAE initiatives are in the "Key Achievements" sections in earlier chapters.

Note that municipal governments and agencies participate in NRCan's EAE measures as clients (for training workshops, as recipients of financial incentives, etc.) and as partners (for example, in anti-idling projects), and that NRCan also participates in ventures led by municipal organizations (for example, Green Municipal Fund, as explained in the accompanying textbox) and by provincially/territorially regulated electricity utilities and provincially regulated natural gas utilities.

Green Municipal Fund

- The Green Municipal Fund was created in 2000. The Government of Canada signed an agreement with the Federation of Canadian Municipalities (FCM), a non-profit organization, to deliver the Green Municipal Fund. The federal endowment to the fund at present totals $550 million. The fund supports municipal government action to reduce greenhouse gases, cut pollution and improve the quality of life.
- Under the agreement, the Government of Canada (represented by NRCan and Environment Canada) participates in governance of the fund, along with representatives from the public and private sectors, including municipal officials and technical experts, through a peer review committee and an advisory council. The FCM Board of Directors approves projects based on the council's recommendations.

Several institutions in Canada address energy efficiency issues in broad terms, including the three data and analysis centres established by NRCan, the host universities and other partners. These centres are also sponsored by other federal departments, provincial government agencies and various associations and energy supply utilities. The centres facilitate access to data on energy use in the industry, transportation and building sectors, monitor the quality of data, and investigate methods to improve data collection and analysis. The goal of another institution, the Canadian Centre for Energy Information, is to engage North Americans in critical inquiry and discussion on energy and energy-related issues affecting their quality of life.

A third institution, the Canadian Energy Efficiency Alliance, is a non-profit organization established to promote the efficient use of energy in Canada.

There are two national consultative bodies in the area of energy efficiency:

- Assistant Deputy Minister Steering Committee on Energy Efficiency (ASCEE), established under the Council of Energy Ministers
- Office of Energy Efficiency (OEE) National Advisory Council on Energy Efficiency (NACEE)

In 2004, federal, provincial and territorial energy ministers decided that the ASCEE should be formed and tasked with establishing a coordinated and complementary agenda for energy efficiency in the built environment, industry and transportation sectors. The ASCEE held seven meetings in 2006–2007, with members representing the federal, provincial and territorial governments.

There are three working groups under the auspices of the ASCEE:

- Originally formed in 2003, the Demand Side Management Working Group (DSM WG), now reports to the ASCEE and has members representing NRCan, industry, and seven provinces and territories. The DSM WG has initiated studies, for example, related to DSM potential in Canada, best practices in performance measurement and reporting and regulatory frameworks.
- The ASCEE sponsored the formation the Transportation Working Group on Energy Efficiency (TWGEE) in 2005. Its mandate is to seek opportunities for stronger cooperation among governments in harmonizing policies and programs that can affect energy efficiency and to make recommendations to ministers on the need for government action. The TWGEE comprises senior federal and provincial government officials.
- A third working group, the Industry Working Group on Energy Efficiency, was formed in 2006 to promote information exchange among industrial energy end-users and authorities, agencies, utilities and jurisdictions involved in the design, development and delivery of industrial energy efficiency programming in Canada.

NRCan created NACEE in April 1998 to advise the OEE on the most effective way to achieve its mission. The membership of NACEE is drawn from across Canada and all economic sectors and includes provincial/territorial officials and representatives of electricity and natural gas utilities. The members can comment on the OEE's business plan and programs. NACEE met three times during 2006–2007.

FEDERAL-PROVINCIAL AND FEDERAL-TERRITORIAL COOPERATION

Interest continues to grow in energy efficiency as a means of maximizing service from the existing energy supply capacity in the country. Provincial and territorial governments helped to deliver EAE programs to reduce energy costs, address climate change, increase competitiveness, improve air quality and generate economic opportunities. Coordination between the federal and provincial/territorial levels is essential to avoid duplication and ensure efficient program delivery. During the reporting period, governments cooperated on energy efficiency in general and on specific program initiatives.

All provinces and territories engage in energy efficiency activities and/or deliver programs in their jurisdictions. In some provinces and territories, specific organizations are mandated to promote energy efficiency. For example, Energy Solutions Alberta, under Climate Change Central, is a focus for information and action on energy efficiency and conservation in Alberta. In Saskatchewan, the mandate of the Office of Energy Conservation is to encourage and support voluntary action by the public and by industry through public information, energy efficiency demonstrations, and the development of pilot projects. The Ontario Power Authority's Conservation Bureau provides leadership in planning and coordinating measures for

electricity conservation and load management. The Energy Efficiency and Conservation Agency of New Brunswick seeks to influence efficient energy use, help control energy expenses and lessen the impact of energy use on the environment. The Canada-Yukon Energy Solutions Centre is a service and program delivery agency for federal and Yukon government programs on energy efficiency and green power. The Arctic Energy Alliance promotes energy efficiency and renewable energy in the Northwest Territories. The Nunavut Energy Centre promotes energy efficiency and renewable energy in Nunavut.

The Building Energy Codes Collaborative

The Building Energy Codes Collaborative (BECC) is a provincial-territorial-federal committee supported by the Council of Energy Ministers, ASCEE and NRCan. BECC consists of representatives from provincial/territorial code and energy ministries, departments and agencies; NRCan; and the Canadian Codes Centre.

The objectives of the BECC are to:

- provide a forum for provinces, territories and the federal government to support the update, regulatory adoption and implementation of the *Model National Energy Code for Buildings* (MNECB) as a document by authorities that have the jurisdiction
- work in cooperation with the provinces and territories and the Canadian Commission on Building and Fire Codes towards a national consensus on establishing energy efficiency in the code process
- explore other regulatory and/or programmatic instruments for increasing energy efficiency in new housing, including updating the Model National Energy Code for Houses
- seek political and financial support from the federal government, and both the energy and building code ministries in the provinces and territories, and engage their representatives in the process

The groundwork already laid by provinces and territories in the area of energy efficiency is a strong foundation to choose making a collaborative effort for the MNECB rather than pursuing individual regulatory paths.

NRCan and the BECC recognize that effective and influential partnerships are critical to the success of an updated MNECB that is adopted and implemented by provinces and territories. The membership and focused activity of the BECC itself is a signal of a high level of federal, provincial, and territorial collaboration on this initiative.

Cooperation Agreements

NRCan's Letter of Cooperation (LOC) on EAE with the Agence de l'efficacité énergétique du Québec provides for consultation and exchange of information between the two governments, coordination of EAE activities in Quebec, and the creation of opportunities for joint projects. The management committee established under the LOC reviewed policy and program developments, progress on joint program initiatives, and areas for further cooperation.

The LOC played a role in facilitating three activities in particular:

- management of the licensing agreement for local delivery of EnerGuide for Houses
- processing projects submitted to the EnerGuide for Existing Buildings and the Commercial Building Incentive Program by public organizations in Quebec. This cooperation framework is also being applied to other NRCan programs that target the Quebec public sector.
- management of an agreement that relates to the Programme d'intervention en réfrigération dans les arénas du Québec, under which NRCan has provided technical support for the implementation of innovative refrigeration systems in Quebec's ice rinks

NRCan's LOC on energy efficiency and renewable energy with the Government of Yukon facilitates information exchange and the creation of opportunities for joint projects in the Yukon, including

the establishment of the Canada-Yukon Energy Solutions Centre in Whitehorse, Yukon. The centre provides access to technical services and programs for the Yukon population and undertakes outreach and public education activities.

The Government of Canada contributes to the Arctic Energy Alliance to promote energy efficiency and renewable energy in the Northwest Territories and provide opportunities for EAE projects. The Alliance is also the delivery agent in the Northwest Territories for R-2000. Through the contribution agreement with the Qulliq Energy Corporation, the Government of Canada contributes to the Nunavut Energy Centre, which promotes energy efficiency and renewable energy in Nunavut.

NRCan works cooperatively with Ontario's Ministry of Small Business and Entrepreneurship, the Independent Electricity System Operator and local distribution companies to provide energy management training to individual companies across the province through Dollars to $ense workshops.

The Government of Canada promotes energy efficiency and renewable energy in Alberta by working with Climate Change Central, a non-profit corporation funded by a multistakeholder base, including the Government of Alberta.

INTERNATIONAL COOPERATION

NRCan cooperates with several international organizations and foreign governments in EAE program areas. Canada benefits from this cooperation:

- by learning about improved ways of designing and delivering EAE programs to meet policy objectives
- through working with others on the harmonization of energy efficiency tests and performance standards to reduce barriers to trade in energy-using products

International Energy Agency

The International Energy Agency (IEA), based in Paris, France, is an autonomous agency of the Organisation for Economic Co-operation and Development. The IEA conducts a comprehensive program of energy cooperation among its 26 member countries, including Canada. IEA member governments have committed to sharing energy information, coordinating energy policies and cooperating in the development of rational energy programs. The IEA and its Governing Board are assisted in their work by several standing groups and special committees, which bring together energy specialists from member countries.

The Standing Group on Long-Term Co-operation (SLT) is the key committee on the policy side. The group analyses policies to promote conservation and the efficient use of energy, the increased use of alternatives to oil, and other measures to increase long-term energy security while protecting the environment. The SLT monitors energy developments in member countries and makes recommendations on energy policy through a regular series of individual country reviews. The Energy Efficiency Working Party (EEWP) of the SLT undertakes IEA work on specific issues related to energy efficiency. The OEE represents Canada on the EEWP.

Canada's international energy research and development (R&D) objectives are mainly advanced through the IEA's Working Parties, implementing agreements and the Committee for Energy Research and Technology, chaired by NRCan. Canada participates in 32 of the IEA's 40 implementing agreements, that is, R&D collaboration programs. NRCan spent $605,000 on IEA Implementing Agreements in 2006–2007, plus personnel expenses and travel. In many programs, this work has permitted acceleration of technology development in Canada that far exceeds the direct costs of collaboration.

Canada also cooperates with research centres in member countries on several agreements and programs on R&D and technology. NRCan facilitates R&D and commercial business ventures abroad by Canadian firms by undertaking a wide variety of activities, including participating in various IEA tasks and supporting technical and trade-oriented workshops and conferences.

Group of Eight

The Group of Eight (G8) Summit in 2005 established the Gleneagles Plan of Action that includes a number of actions in the area of EAE. While NRCan's participation in IEA and international mechanisms for standards harmonization responds to many of the listed activities, others are implemented through NRCan's EAE programs.

United Nations

RETScreen® International is managed under the leadership of NRCan's CANMET Energy Technology Centre–Varennes (CETC–Varennes) through cost- and task-shared collaborative ventures with other governments and multilateral organizations, and with technical support from more than 250 experts representing industry, government and academia. Key partners are the NASA's Langley Research Center and the Renewable Energy & Energy Efficiency Partnership. Other international partners include the Energy Unit of the United Nations Environment Program (UNEP) and the Solar and Wind Energy Resource Assessment project sponsored by the UNEP-Global Environment Facility.

China

In February 2001, Canada and China signed a Memorandum of Understanding (MOU) on Energy Cooperation. In January 2003, they signed an MOU on Climate Change and the Clean Development Mechanism. Energy efficiency is one area of cooperation identified in both MOUs.

Mexico

NRCan signed an MOU on EAE cooperation with the Mexican Energy Secretariat in June 1996. Its objective is to contribute to the EAE objectives of Canada and Mexico by improving the design and delivery of EAE programs and by enhancing trade and investment as well as technical and other exchanges related to energy-efficient products, energy management services and alternative energy goods and services.

Under the MOU on EAE, officials of Mexico's National Commission for Energy Savings (CONAE) participated in an industrial energy efficiency conference held in May 2005 in Ottawa. Also under the MOU, NRCan organized an energy efficiency workshop in cooperation with CONAE. The workshop was held in Puebla, Mexico in March 2006.

United States

NRCan and the United States (U.S.) Department of Energy (DOE) have an MOU on road transportation, energy efficiency and alternative fuels. It provides a formal mechanism to advance harmonization of North American policy on fuel efficiency, fuel quality and alternative transportation fuels. The MOU provides a framework for joint projects and studies in areas of mutual interest, such as the costs and market potential of hybrid electric-powered and diesel-powered vehicles. The MOU facilitates bilateral discussion of a broad range of issues in the motor vehicle and fuels policy area and affords access to technology assessments and policy-related studies conducted for the DOE by its national laboratories.

Canada has been cooperating with the U.S. DOE under an MOU on energy R&D in the areas of fuel cells, fossil fuels, bioenergy, community systems and microgeneration, nuclear fission, and carbon sequestration.

North America

NRCan continues to participate with the U.S. and Mexico in the Energy Efficiency Experts Group of the North American Energy Working Group (NAEWG) to promote the harmonization of energy efficiency test methods, mutual recognition of conformity assessment systems for energy efficiency standards, and cooperation on trilateral energy efficiency labelling programs. In 2006–2007, work under NAEWG involved primarily coordinating the energy sector commitment to the Security and Prosperity Initiative. In addition to ongoing standards and program collaboration, a project was implemented to develop a North American approach to standby loss by electricity-using products.

The Canada-Mexico Partnership (CMP), established in 2004, serves as a mechanism for identifying policies for facilitating cooperation, enhancing investment and creating opportunities for Canadian entrepreneurs to take part in projects that contribute to the socio-economic development of Mexican society. Sustainable housing is a priority theme under the CMP. Canada Mortgage and Housing Corporation (CMHC) chairs a working group on sustainable housing technologies under the CMP within the framework of a Letter of Intent (LOI) with CONAVI, the Mexico national housing agency. The LOI provides the scope of the working group activities. NRCan participates as a member of this working group through CETC's Sustainable Buildings and Communities Group.

In 2006, under the CMP, NRCan and CMHC facilitated meetings between Mexican builders and developers and Canadian photovoltaic (PV) and solar domestic hot water companies. A PV grid-connect project was an area of common interest and a pilot project was carried out in 2007. Mexican stakeholders were interested in Canadian approaches to sustainable projects for entire neighbourhoods including standards for sustainable projects, decision-making tools and access to Canadian case studies. A workshop to facilitate this information exchange also took place in 2007.

Innovative financing for renewable energy and energy-efficient projects is an on-going theme under the CMP working group. Mexico is launching a "green mortgage" instrument and government and industry stakeholders want to learn more about financing instruments for renewable energy and energy efficiency features in housing. An element of this includes possible Clean Development Mechanism credits.

APPENDIX 1

NRCan's Efficiency and Alternative Energy Initiatives and Expenditures, 2006–2007

(millions of dollars)

Energy Efficiency – Equipment **$19.2**
Energy Efficiency Standards and Regulations
Equipment Labelling and Promotion
EnerGuide for Industry

Energy Efficiency – Housing and Buildings **$128.8**
R-2000 Standard and EnerGuide for (New) Houses
EnerGuide for Houses and Retrofit Incentives
Energy Science and Technology in Housing
Commercial Building Incentive Program
Industrial Building Incentive Program
EnerGuide for Existing Buildings or the Existing Buildings Initiative
Refrigeration Action Program for Buildings
Intelligent Buildings
Energy Science and Technology in Buildings and Communities
Federal House in Order Leadership Measures – Built Environment

Energy Efficiency – Industry **$32.4**
Industrial Energy Efficiency (Canadian Industry Program for Energy Conservation)
Industrial System Optimization Program
Industry Energy Research and Development Program
Clean Electric Power Generation
Processing and Environmental Catalysis Program
Enhanced Recycling for Minerals and Metals
Supplementary Cementing Materials Program
Mine Ventilation

(millions of dollars)

Energy Efficiency – Transportation **$10.5**
Marketing of Efficient Vehicles
Motor Vehicle Fuel Efficiency Initiative
Commercial Transportation and Energy Efficiency Fuel Initiative
Freight Efficiency and Technology Initiative
Canadian Lightweight Materials Research Initiative
Federal Fleet Initiative

Alternative Energy – Transportation **$49.5**
Fuel Cell-Powered Mining Vehicles
Hybridization of a Load-Haul-and-Dump Mining Vehicle
Ethanol Expansion Program
Future Fuels Initiative
Biodiesel Initiative
Canadian Transportation Fuel Cell Alliance
Hydrogen, Fuel Cells and Transportation Energy Program

Alternative Energy – Renewable Energy Sources **$54.0**
Wind Power Production Incentive
Initiative to Purchase Electricity From Emerging Renewable Energy Sources
Renewable Energy Deployment Initiative
Photovoltaic and Hybrid Systems Program
Bioenergy Technology Program
Science and Technology in Renewable Energy
Canadian Biomass Innovation Network

General Programs[1] **$5.8**
Outreach
RETScreen® International Clean Energy Decision Support Centre
National Energy Use Database

Total **$300.2**

[1] Totals allocated for funding programs in Chapter 9 are reflected in the relevant program entries.

APPENDIX 2

Data Presented in Report

The aggregate energy-use data presented in this report are taken from Statistics Canada's *Report on Energy Supply-Demand in Canada* (RESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of RESD energy-use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for the purpose of energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix A of Natural Resources Canada's *Energy Use Data Handbook, 1990 and 1997 to 2005*.

FIGURE 1-1: Energy Intensity and the Energy Efficiency Effect,* 1990 to 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Energy intensity index	1.00	1.00	1.00	1.00	0.99	0.98	1.00	0.97	0.91	0.89	0.87	0.84	0.85	0.85	0.84	0.81
Index of energy efficiency effect	1.00	0.98	0.97	0.96	0.96	0.92	0.93	0.91	0.89	0.87	0.87	0.86	0.87	0.88	0.86	0.84

* Index: 1990=1.00

FIGURE 1-2: Secondary Energy Use, Actual and Without Energy Efficiency Improvements,* 1990 to 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Estimated energy use without energy efficiency improvements	1.00	1.00	1.03	1.05	1.09	1.15	1.17	1.20	1.20	1.25	1.29	1.27	1.31	1.33	1.36	1.38
Actual energy use	1.00	0.98	1.00	1.01	1.05	1.07	1.11	1.11	1.09	1.12	1.17	1.14	1.18	1.22	1.23	1.22

* Index: 1990=1.00

FIGURE 2-1: Volume of Monthly Import Documents

Month and year	Paper	Electronic
Apr. 06	5 696	44,497
May 06	5 837	49 937
Jun. 06	7 660	51 181
Jul. 06	6 681	46 486
Aug. 06	7 407	48 317
Sep. 06	6 240	48 572
Oct. 06	7 188	51 983
Nov. 06	2 712	48 904
Dec. 06	2 254	44 867
Jan. 07	2 424	42 660
Feb. 07	2 912	42 363
Mar. 07	2 372	52 409
Total	**59 383**	**572 176**

FIGURE 2-4: ENERGY STAR Qualified Appliances as a Percentage of Total Category Sales in Canada, 1999 to 2005

Appliance	1999	2000	2001	2002	2003	2004	2005
Dishwashers	0.56	1.57	9.66	29.77	56.50	80.95	90.80
Refrigerators	—	—	11.40	22.26	40.68	34.16	37.60
Washers	1.93	2.24	9.24	22.07	30.55	36.16	45.90

FIGURE 2-5: ENERGY STAR Awareness Levels in Canada, 2005

	Percent
Aware – non-aided	36
Aware – aided	80

FIGURE 3-1: Canadian Households by Type of Dwelling, 2005

Dwelling type	Number of households	Percentage
Single detached homes	7 083 709	56
Apartments	3 936 757	31
Single attached homes	1 320 470	11
Mobile homes	245 834	2
Total	**12 586 770**	**100**

FIGURE 3-2: Residential Energy Use by Purpose, 2005

Activity	Energy use (petajoules)	Percentage
Space heating	846.1	60
Water heating	248.2	18
Appliances	203.0	14
Lighting	68.4	5
Space cooling	36.5	3
Total	**1402.2**	**100**

FIGURE 3-3: Residential Energy Use, Actual and Without Energy Efficiency Improvements,* 1990 to 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Estimated energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.22	1.21	1.14	1.18	1.25	1.22	1.28	1.32	1.32	1.34
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.05	1.12	1.08	0.99	1.03	1.08	1.04	1.08	1.12	1.10	1.09

* Index: 1990=1.00

FIGURE 3-4: Annual Heating Consumption for Houses* Constructed to Different Standards

Description	EnerGuide for Houses Annual Heating Consumption (GJ)
Typical existing house (1970)	216.81
Typical new house (2002)	146.27
Model National Energy Code house (2002)	112.10
R-2000 house	78.74

* 198-m^2 one-storey, single detached house heated with natural gas, Ottawa, Ontario

FIGURE 3-5: Number of Households, Average Floor Space of New Houses and Energy Intensity Indexes,* 1990 to 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of households	1.00	1.03	1.05	1.07	1.08	1.10	1.12	1.13	1.15	1.17	1.19	1.20	1.22	1.23	1.25	1.27
Average floor space of new constructions	1.00	0.99	1.05	1.06	1.11	1.10	1.09	1.13	1.14	1.20	1.21	1.22	1.24	1.18	1.19	1.19
Energy intensity (GJ/household)	1.00	0.96	0.97	0.98	0.98	0.95	1.01	0.96	0.86	0.88	0.91	0.86	0.89	0.91	0.88	0.86

* Index: 1990=1.00

FIGURE 3-6: Average Energy Consumption* of New Appliances, 1990 and 2005 Models

Appliance	1990	2005
Clothes washers	1218	444
Clothes dryers	1103	904
Dishwashers	1026	396
Refrigerators	956	469
Electric ranges	772	573
Freezers	714	386

* kWh/yr

FIGURE 3-7: Number of Eligible R-2000 Housing Starts, 1990 to 2006

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Number of R-2000 houses	495	699	1196	1299	784	610	416	484	265	213	319	329	428	379	582	478	489

FIGURE 3-8: Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000-2007

	Pre-1945	1945–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2007	Average
Energy use pre-renovation (GJ)	302	228	216	205	200	188	172	216
Actual energy savings after renovations (GJ)	102	66	58	53	47	47	46	60

FIGURE 4.1: Commercial/Institutional Energy Use by Activity Type,* 2005

Activity type	Energy use (petajoules)	Percentage
Offices**	399.5	35
Retail trade	192.1	17
Educational services	158.9	14
Health care and social assistance	105.3	9
Accommodation and food services	86.3	8
Wholesale trade	64.1	6
Transportation and warehousing	54.0	5
Arts, entertainment and recreation	36.3	3
Information and cultural industries	27.6	2
Other services	21.1	2
Total	**1145.2**	**100**

* Excludes street lighting

** "Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

FIGURE 4-2: Commercial/Institutional Energy Use by Purpose,* 2005

End use	Energy use (petajoules)	Percent
Space heating	585.34	51
Auxiliary equipment	165.60	14
Lighting	107.96	9
Space cooling	99.61	9
Water heating	98.58	9
Auxiliary motors	88.06	8
Total	**1145.15**	**1.00**

* Excludes street lighting

FIGURE 4-3: Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements,* 1990 to 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Estimated energy use without energy efficiency improvements	1.00	1.05	1.08	1.13	1.14	1.16	1.20	1.20	1.17	1.22	1.26	1.26	1.34	1.36	1.36	1.42
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.13	1.15	1.09	1.13	1.24	1.22	1.31	1.35	1.35	1.33

* Index: 1990=1.00

FIGURE 4-4: Estimated Average Energy Savings by Type of Building Under the Commercial Building Incentive Program, 2006

Building type	Average energy savings (GJ/year)
Health care	5640
Retail	4215
Education	3700
Retail food sector	3559
Industrial	3302
Other	3301
Multi-unit residential building	3199
Office	2175

FIGURE 5-1: Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2005

Subsector	Percent of industrial energy use
Pulp and paper	25.7
Mining	20.2
Other manufacturing	16.8
Petroleum refining	11.2
Smelting and refining	8.2
Iron and steel	7.4
Chemicals	5.8
Cement	2.1
Construction	1.9
Forestry	0.7
Total	**100.0**

* Note: The above subsectors reflect the current definitions in the *Report on Energy Supply-Demand in Canada*. "Other manufacturing" comprises more than 20 manufacturing industries.

FIGURE 5-2: Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2005

Industry	Energy cost/ total production cost (%)
Cement	37.07
Aluminum	16.78
Pulp and paper	15.04
Iron and steel	12.99
Chemicals	12.79
Petroleum refining	2.47
Transportation equipment and manufacturing	0.86

FIGURE 5-3: Industrial Energy Use, Actual and Without Energy Efficiency Improvements,* 1990 to 2005

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Estimated energy use without energy efficiency improvements	1.00	1.14	1.14	1.18	1.19	1.24	1.28	1.24	1.28	1.29	1.31	1.31
Actual energy use	1.00	1.08	1.11	1.10	1.08	1.11	1.15	1.10	1.16	1.20	1.20	1.18

* Index: 1990=1.00

FIGURE 5-4: CIPEC Energy Intensity Index,* 1990 to 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Energy intensity index	1.00	1.05	1.08	1.06	1.06	1.04	1.03	0.98	0.96	0.95	0.91	0.91	0.92	0.94	0.91	0.90

* Index: 1990=1.00

FIGURE 5-5: Estimated CIPEC Energy Savings, 2001 to 2006

Energy savings	2001	2002	2003	2004	2005	2006
Program total (petajoules)	1.99	5.10	9.56	14.13	20.16	25.25

FIGURE 5-6: Industrial Dollars to $ense Participants, 1997 to 2006

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Number of industrial workshop participants	98	132	167	260	410	421	490	1001	1051	1303

FIGURE 6-1: Transportation Energy Use by Mode, 2005

Mode of transportation	Energy use (petajoules)	Percentage
Passenger light vehicle	1070.4	42.8
Freight truck	833.0	33.3
Passenger aviation	251.5	10.1
Freight marine	111.2	4.4
Off-road	97.4	3.9
Freight rail	76.4	3.1
Passenger bus	51.8	2.1
Freight aviation	7.9	0.3
Passenger rail	2.5	0.1
Total	**2501.8**	**100.0**

FIGURE 6-2: Transportation Energy Use, Actual and Without Energy Efficiency Improvements,* 1990 to 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Estimated energy use without energy efficiency improvements	1.00	0.98	1.01	1.05	1.12	1.15	1.18	1.23	1.27	1.32	1.34	1.36	1.38	1.41	1.48	1.52
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.17	1.20	1.22	1.21	1.23	1.26	1.31	1.33

* Index: 1990=1.00

FIGURE 6-3: Market Shares of New Passenger Car and Light Truck Sales, 1990 to 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Passenger car (%)	74.7	75.2	72.7	69.7	67.2	65.1	62.8	59.7	59.1	60.9	63.0	63.4	62.7	62.1	61.58	61.59
Passenger light truck (%)	25.3	24.8	27.3	30.3	32.8	34.9	37.2	40.3	40.9	39.1	37.0	36.6	37.3	37.9	38.42	38.41

FIGURE 6-4: Average Activity per Truck, 1990 to 2005 (tonne kilometres/truck)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Medium- and heavy-duty truck vehicle activity	105 742	98 658	103 459	117 687	133 653	142 910	141 219	163 975	162 926	175 266	178 269	198 998	197 396	202 326	219 262	236 677

FIGURE 6-5: Trucking Energy Intensity, 1990 to 2005 (megajoules/tonne kilometre)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Medium- and heavy-duty truck energy intensity	3.71	3.81	3.79	3.62	3.44	3.46	3.41	3.33	3.16	2.99	3.02	2.83	2.80	2.92	2.86	2.72

FIGURE 6-6: Vehicle Fuel Efficiency Labelling

	Percentage of new vehicles with fuel efficiency label affixed	
	On lot	In showroom
1999	64	47
2001	77	56
2005	78	61

FIGURE 6-7: Company Average Fuel Consumption (CAFC) versus Canadian Voluntary Standards, 1990 to 2006*

Truck model year	Truck standard (11.4 L/100 km)	Trucks CAFC (L/100 km)	Car standard (8.6 L/100 km)	Cars CAFC (L/100 km)
1990	11.8	11.4	8.6	8.2
1991	11.6	11.1	8.6	8.0
1992	11.6	11.3	8.6	8.1
1993	11.5	11.1	8.6	8.1
1994	11.5	11.5	8.6	8.2
1995	11.4	11.5	8.6	7.9
1996	11.4	11.3	8.6	7.9
1997	11.4	11.3	8.6	8.0
1998	11.4	11.3	8.6	7.9
1999	11.4	11.3	8.6	7.9
2000	11.4	11.1	8.6	7.8
2001	11.4	11.0	8.6	7.8
2002	11.4	11.0	8.6	7.7
2003	11.4	10.7	8.6	7.6
2004	11.4	10.7	8.6	7.5
2005	11.4	10.3	8.6	7.5
2006	11.4	10.6	8.6	7.1

* 2002–2006 data are estimates.

FIGURE 6-8: Drivers Trained, 1998 to 2005*

	Drivers trained
1998	51 000
1999	53 000
2000	112 846
2001	125 000
2002	149 000
2003	160 000
2004	200 000
2005	210 158

* Estimates are based on NRCan internal data.

FIGURE 7-1: Canadian Wind Power Capacity, 1993 to 2006

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Wind power capacity (MW)	1	22	23	23	24	27	127	139	215	233	326	445	686	1459

FIGURE 8-1: GHG Emissions Reductions From Federal Operations, 1990 to 2010

Fiscal year	GHG emissions (kt of CO_2e)
1990	3895
1998	3140
2000	3012
2001	2895
2002	2957
2003	2929
2004	2865
Target 2010	2703

FIGURE 8-2: Federal Fleet Size and Fuel Consumption, 1997 to 2005

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Vehicles	22 873	22 505	22 558	22 611	24 463	26 233	24 981	25 652	25 968
Litres of gasoline equivalent (thousands)	64 200	63 100	63 100	61 900	66 900	68 619	62 500	64 900	63 800

FIGURE 8-3: Purchases of Alternative Fuel Vehicles (Including Hybrids) for the Federal Fleet, 1997 to 2005

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Vehicles purchased	131	161	181	83	170	521	365	529	591

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