Natural Resources Canada | Ressources naturelles Canada

ecoENERGY
an ecoACTION initiative

Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act* For the Fiscal Year 2008–2009

Canada

The digital mosaic of Canada that appears on the cover of this publication is produced by Natural Resources Canada (Canada Centre for Remote Sensing) and is a composite of individual satellite images. The differences in the density of vegetation are illustrated through shading.

Publishing by the authority of the Minister of Natural Resources Canada
Government of Canada

Aussi disponible en français sous le titre :
Améliorer le rendement énergétique au Canada –
Rapport au Parlement en vertu de la *Loi sur l'efficacité énergétique*
pour l'année financière 2008–2009

Cat. No. M141-10/2009E (Print)
ISBN 978-1-100-14494-8

Cat. No. M141-10/2009E-PDF (Electronic)
ISBN 978-1-100-14495-5

To obtain additional copies of this or other free publications on energy efficiency, please contact:

Energy Publications
Office of Energy Efficiency
Natural Resources Canada
c/o St. Joseph Communications
Order Processing Unit
1165 Kenaston Street
PO Box 9809 Station T
Ottawa ON K1G 6S1
Tel.: 1-800-387-2000 (toll-free)
Fax: 613-740-3114
TTY: 613-996-4397 (teletype for the hearing-impaired)

You can also view or order most Office of Energy Efficiency publications on-line.
Visit our Virtual Library at oee.nrcan.gc.ca/publications.
The Office of Energy Efficiency's Web site is at oee.nrcan.gc.ca.

PRINTED IN CANADA / IMPRIMÉ AU CANADA

Recycled paper

Table of Contents

LIST OF FIGURES AND TABLES

Figures

Tables

Minister's Foreword

I am pleased to introduce the 2008/2009 Report to Parliament on Improving Energy Performance in Canada.

This government is committed to achieving environmental and economic benefits for all Canadians. That is why our government has invested $4.1 billion in our ecoENERGY initiatives to improve energy efficiency and enhance clean energy technologies in Canada.

Our government has taken strategic action to respond to the global economic recession through a suite of measures announced in Canada's Economic Action Plan. In the Speech from the Throne, the government committed to reviewing our energy-efficiency and emissions-reductions programs to ensure they continue to be an effective and efficient use of Canadian tax dollars.

Our government has also amended Canada's *Energy Efficiency Act* to make it more effective by broadening and clarifying its scope. Regulations made under the Act have been amended a number of times, most recently, in 2008 to expand the list of products covered by the Act and enhance standards for some products already in place. Amendments to the *Energy Efficiency Act* and the *Energy Efficiency Regulations* ensure that Canadians continue to enjoy the economic and environmental benefits of living in a country that is among the world leaders in energy efficiency.

In fall 2009, some of my officials met with key stakeholders to discuss strategies for building on our success. Our government is committed to collaborating with senior decision-makers from government, industry, non-government organizations and academia to advance our leadership in clean energy while continuing to promote energy efficiency.

Canada has made significant improvements in the efficiency of its energy use in all sectors of its economy and continues to make progress with support from Natural Resources Canada's energy efficiency programs. As we move forward, we will continue to pursue innovative technologies and program approaches for improving energy use.

The Honourable Christian Paradis, P.C., M.P.
(Mégantic - L'Érable)
Minister of Natural Resources

Executive Summary

Canadians spent approximately $155 billion in 2006 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 represents Canada's total consumption, including energy required to transform one energy form to another – such as coal to electricity – and energy required to deliver energy to consumers. Secondary use is energy consumed for residential, commercial/institutional, industrial, transportation and agricultural purposes.

Key highlights in energy use include the following:

- Between 1990 and 2006, the latest year for which figures are available, primary energy use increased by 26 percent.
- In 2006, secondary use accounted for 69 percent of primary energy use and produced 69 percent (478 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 the energy efficiency improvements 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 consumed the most energy, accounting for 39 percent of total secondary energy use in 2006. Transportation was second (30 percent), followed by residential (16 percent), commercial/institutional (13 percent) and agriculture (2.5 percent).

Promoting Energy Efficiency

Natural Resources Canada (NRCan) promotes 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 initiatives, 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, the labelling of energy-using products and the collection of data on energy use. The *Energy Efficiency Regulations* are described in Chapter 2.

Energy Intensity / Energy Efficiency

As explained in Chapter 1, although energy intensity is sometimes used as a proxy for energy efficiency, there is a difference between the terms. It is important to understand this difference when comparing Canada with other countries.

Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar (or better) level of service with less energy consumption on a per-unit basis is considered an improvement in energy efficiency.

Energy intensity is the amount of energy use per unit of activity. Examples of activity measures in this publication are households, floor space, passenger-kilometres, tonne-kilometres, physical units of production and constant dollar value of gross domestic product. Energy intensity is a broader measure, capturing not only energy efficiency but also other impacts on energy consumption, such as weather variations, market behaviour 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 2006 are estimated to have reduced GHG emissions by almost 59.6 Mt and decreased energy expenditures by $20.7 billion in 2006.

Between 1990 and 2006, the residential sector recorded a 26.1 percent improvement in energy efficiency. The figures for the transportation (18.2 percent), industrial (9 percent) and commercial/institutional (14 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 (e.g. 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 2007.

Engaging Canadians

To maximize the effectiveness of its initiatives, NRCan engages a growing number of partners from the private and public sectors. Dozens of co-operative 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 and highlights NRCan's efficiency and alternative energy (EAE) programs and lists their key achievements for the 2008–2009 fiscal year. Program entries for market transformation programs also include quantitative performance indicators in graph or table format. A list of NRCan's EAE initiatives and expenditures appears in Appendix 1.

Introduction

NATURAL RESOURCES CANADA'S EFFICIENCY AND ALTERNATIVE ENERGY PROGRAMS

According to the International Energy Agency, if energy efficiency policies had not been introduced 30 years ago, today's worldwide energy consumption would be 50 percent higher.[1]

Gains in energy efficiency have substantial benefits for society, the economy and the environment. Energy efficiency can add to the global security of energy supplies by reducing the need for energy. It saves consumers and businesses money by decreasing their energy bills without disruptions to their daily routine, and it can increase access to energy services by reducing their effective cost.

In particular, greater energy efficiency is used as a strategy to reduce carbon dioxide and other greenhouse gases (GHGs) and thereby help reduce the effects of climate change.

Natural Resources Canada (NRCan) emphasizes the promotion of energy efficiency and the use of alternative energy (i.e. alternative transportation fuels and renewable energy) as ways to reduce GHG emissions and improve the Canadian economy.

A complete list of NRCan's efficiency and alternative energy (EAE) initiatives in 2008–2009 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 – i.e. to the consumption of energy in the residential, commercial/institutional, industrial and transportation sectors.

NRCan's EAE initiatives are managed by the following:

- the Office of Energy Efficiency (OEE), which delivers market transformation initiatives to improve energy efficiency and the use of alternative transportation fuels
- CanmetENERGY and the CANMET Mineral Technology Branch, which deliver EAE research, development and demonstration (R,D&D) initiatives
- the Office of Energy Research and Development, which coordinates NRCan's energy research and development planning and fund allocations
- 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 co-operation with stakeholders, such as other levels of government, the private sector and nongovernmental organizations.

[1] International Energy Agency, *Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency*, 2007.

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 and in 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

Regulation

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

Financial Incentives

NRCan uses financial incentives to encourage end-users of energy to adopt 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 ranging from broad distribution to individual consultations with clients. This increases awareness of the environmental impact of energy use and encourages consumers to become more energy efficient and make greater use of alternative energy sources.

One particular outreach program targets youth as the energy consumers of the future and undertakes joint initiatives in the education sector. Other information 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 set 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 major factors in energy use. The initiatives involve industry-government agreements and, for groups of large industrial energy users, commitments to develop energy efficiency improvement targets and action plans. NRCan provides support to assist and stimulate action by companies and institutions on energy efficiency, including developing standards, educational material and training.

Research, Development and Demonstration

Ongoing improvement in energy efficiency is contingent on improvements and innovations in technology. 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 and contracting research activities to other organizations. These initiatives are the only federal interdepartmental S&T investment funds that focus on the energy sector and its economic and environmental effects.

FIGURE INT-1

Moving the Market

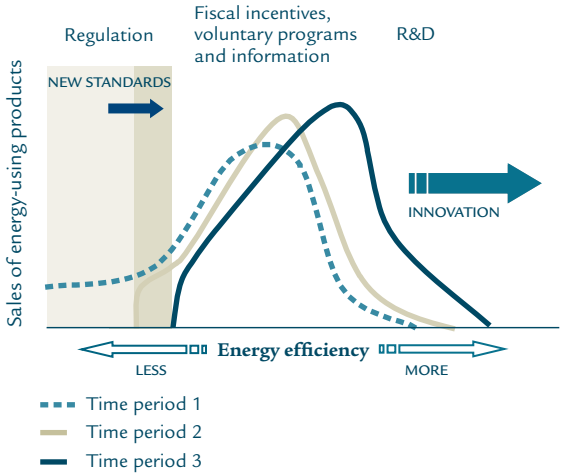


Figure INT-1 shows how these policy instruments work together to increase energy efficiency, that is, how they help to reduce the amount of energy required to complete a task or obtain a certain level of service. Energy performance regulations eliminate less efficient products from the market. Fiscal incentives, voluntary programs and information activities increase the number of people and organizations taking advantage 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.

MEASURING PROGRESS

The primary goal of NRCan's EAE initiatives is to change energy consumption patterns and thereby generate 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 government and non-government programs.

Because 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 toward 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 what source of electricity is involved 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 its 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 and monitoring the adoption of new technologies in the marketplace.

In 2008–2009, analysis of the commercial and residential sectors was undertaken for reference year 2007. These analyses form the basis of reports explaining how and where energy is used in each of these sectors (Commercial and Institutional Consumption of Energy Survey [CICES], Survey of Household Energy Use [SHEU]). Data on the transportation and industrial sectors continue to be collected on a quarterly and annual basis, respectively.

The NEUD initiative also produces 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 online at oee.nrcan.gc.ca/statistics.

The NEUD initiative also contributes to the development of energy end-use data and analysis centres (DACs) across Canada. Three DACs have been set up: the transportation centre at Université Laval in Québec, 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 trends in energy consumption and their 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 several 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 co-operation among all nations.

IN THIS REPORT

This sixteenth annual *Report to Parliament* focuses principally on EAE initiatives that address secondary energy use. Trends in energy use and GHG emissions in Canada for the residential, commercial, industrial, transportation and renewable energy sectors are discussed in Chapter 1.

Chapter 2 discusses equipment regulations under the *Energy Efficiency Act* and equipment-labelling activities. Chapter 3 describes the suite of ecoENERGY and related programs and lists key 2008–2009 achievements. Chapter 4 explains energy S&T programs and achievements related to energy efficiency and the continued integration of renewable sources. Chapter 5 outlines NRCan's involvement with renewable energy sources and use. The sixth and final chapter describes domestic and international co-operation in EAE.

Appendix 1 contains information about NRCan's EAE expenditures. Appendix 2 contains detailed information about the figure data presented in this report. Calculations of the estimated GHG savings in this report are based on Environment Canada's standardized emissions factors as described in its publication *Canada's Greenhouse Gas Inventory*. The emissions factor for electricity was based on the provincially weighted average of marginal fuel sources across the country.

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 also fosters the development of industries with a particularly strong energy demand.

Canadians spent about $155 billion in 2006 on energy to heat and cool their homes and offices and to operate their appliances, vehicles and industrial processes. This amount represented 14 percent of the country's gross domestic product (GDP).[2]

ENERGY USE AND GREENHOUSE GAS EMISSIONS

Energy use is of 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 (e.g. 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 represents the total requirements for all users of energy, including secondary energy use. In Canada, the increase in primary energy use reflects changes over several decades in energy-consuming equipment and buildings and in the behaviour of energy users. Primary energy use increased by 26 percent between 1990 and 2006, from 9740 petajoules[3] (PJ) to 12 257 PJ.

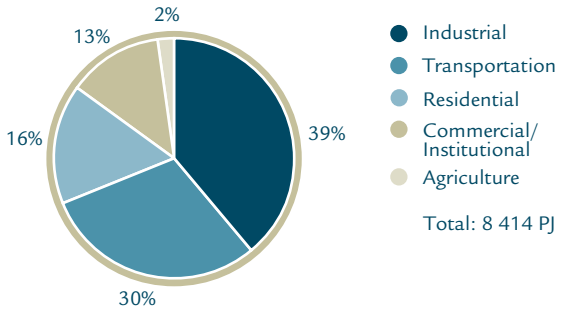
Secondary energy use accounted for 69 percent of primary energy use in 2006, or 8413 PJ. It was responsible for 69 percent (478 megatonnes [Mt]) of total greenhouse gas (GHG) emissions in Canada, including indirect emissions – those produced by electric utilities to meet end-use electrical demand.

From 1990 to 2006, secondary energy use increased by 21 percent. However, since 2005 there has been a slight downward trend. Also, from 1990 to 2006, the Canadian population grew 18 percent, and the GDP increased 55 percent. Thus energy use grew less rapidly than the economy but more rapidly than the population.

As demonstrated in Figure 1-1, the industrial sector was the largest energy user, accounting for 39 percent of total secondary energy use in 2006. The transportation sector was the second largest energy user at 30 percent, followed by the residential sector at 16 percent, the commercial/institutional sector at 13 percent and the agricultural sector at 2 percent.

FIGURE 1-1

Secondary Energy Use by Sector, 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

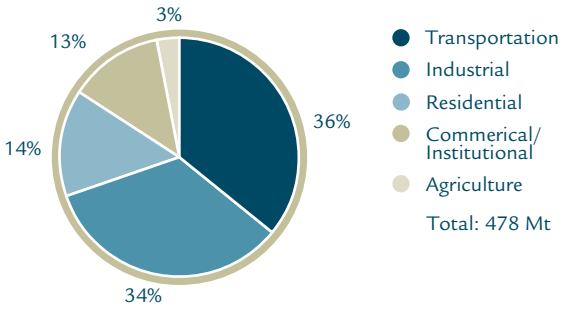
[2] Data in this chapter are presented for 1990–2006. Readers are encouraged to consult the Office of Energy Efficiency Web site to view data updates as they become available.

[3] One petajoule equals 1×10^{15} joules.

Figure 1-2 illustrates the distribution of GHG emissions by sector. This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane and nitrous oxide. 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 emissions that are attributable indirectly to electricity generation, unless otherwise specified.

FIGURE 1-2

GHG Emissions From Secondary Energy Use by Sector, 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

ENERGY INTENSITY AND ENERGY EFFICIENCY

The term "energy intensity" refers to the amount of energy use per unit of activity. Energy intensity is sometimes used as a proxy for energy efficiency because it is a simple calculation for which data are readily available. However, this measure can be misleading because, in addition to pure energy efficiency, intensity captures the impact of other factors that influence energy demand, such as weather variations and changes in the structure of the economy.

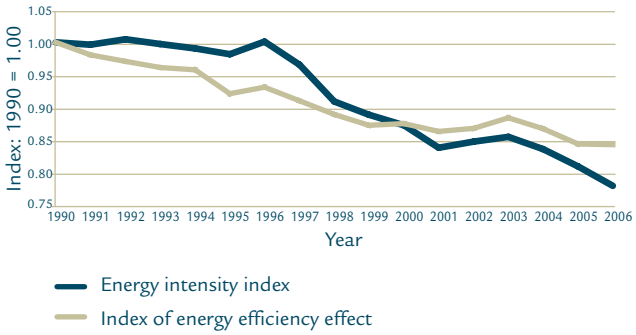
Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar (or better) level of service with less energy consumption on a per-unit basis is considered an improvement in energy efficiency.

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 – the Log-Mean Divisia Index I methodology – to isolate the impact of energy efficiency on changes in Canadian energy use.

Figure 1-3 compares, for Canada, an index of annual variation in energy intensity with the OEE's index of changes in energy efficiency from 1990 to 2006. As illustrated, Canada's energy intensity and efficiency improved over this period. The reduction in energy intensity reflects an overall improvement in energy efficiency or how effectively energy is being used in producing one unit of GDP. At the same time, the improvement in energy efficiency indicates how effectively energy is being used to provide a certain level of service or output.

FIGURE 1-3

Energy Intensity and the Energy Efficiency Effect, 1990 to 2006



Source: Natural Resources Canada, Residential, Commercial/Institutional, Transportation, Industrial End-Use Models, Ottawa, 2008.

As illustrated in Figure 1-3, intensity underestimates the efficiency effect in Canada in the early 1990s and overestimates its impact in the latter part of the period. Before 1998, intensity improvements appear to be modest because colder weather (1992–1997) and a shift toward more energy-intensive industries (1990–1996) masked energy efficiency progress. In 2000, the intensity index dipped below the index for the energy efficiency effect. A switch to less energy-intensive industries, which began in the mid-1990s, combined with energy efficiency improvements accelerated the decline in energy intensity.

TRENDS IN ENERGY EFFICIENCY

NRCan regularly publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use and GHG emissions and the contributions of the following key factors to these changes (see Table 1-1):

- 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.

TABLE 1-1

Explanation of Changes in Secondary Energy Use, 1990 to 2006

	Sectors					
	Residential	Commercial/ Institutional	Industrial	Transportation	Total*	Change (%)
1990 energy use (PJ)	1286.2	867.0	2721.8	1877.9	6952.1	
2006 energy use (PJ)	1347.3	1092.6	3270.6	2492.0	8413.3	
Change in energy use (PJ)	61.1	225.6	548.8	614.1	1461.2	21.0
Explanatory factor (change due to)						
Activity	373.5	273.8	1197.2	750.4	2585.4	37.2
Weather	61.6	23.3	n/a	n/a	84.9	1.2
Structure	7.4	1.4	392.4	186.8	210.8	3.0
Service level	76.9	93.4	n/a	n/a	170.3	2.4
Energy efficiency	-335.1	-116.3	-347.3	255.9	1049.6	15.1
Other factors					50.8	0.7

*Total also includes energy use for agriculture.

Sources: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0
oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

- **Service level** refers to the penetration rate of electrical devices and equipment, for example, the use of auxiliary equipment in commercial/institutional buildings and appliances in homes or the amount of floor space cooled.

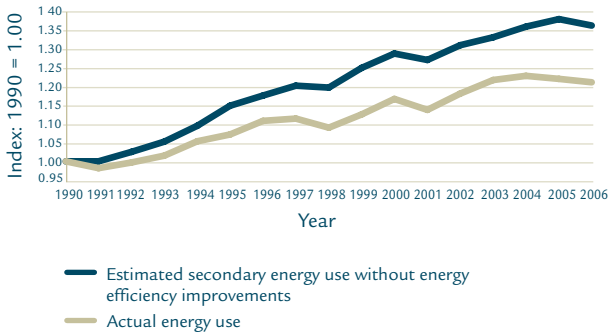
- **Energy efficiency** effect indicates how effectively energy is being used, for example, the degree to which less energy is being used to provide the same level of energy service. Energy efficiency gains occur primarily with improvements in technology or processes. An example of such an improvement would be replacing incandescent lights with compact fluorescent lamps.

In this report, changes in energy efficiency are the net result after allowing for changes in energy use due to activity, weather, structure and service level. However, other factors, such as individual consumer choice, may affect energy use and are not captured by the above standardized factors. The effects of activity, weather, structure and service level may overstate or understate the "actual" change in energy use and energy efficiency improvements.

Between 1990 and 2006, secondary energy use in Canada increased from 6952 to 8413 PJ. Without improvements in energy efficiency, increases attributable to activity, weather, structure and service level would have led to an energy increase of 36 percent. However, as a result of a 15 percent (1049 PJ) improvement in energy efficiency,[4] actual secondary energy use increased by only 21 percent (to 8413 PJ). This improvement in energy efficiency is estimated to have reduced GHG emissions by 59.6 Mt and decreased energy expenditures by $20.7 billion in 2006. The change in energy use between 1990 and 2006, actual and without energy efficiency improvements, is shown in Figure 1-4.

FIGURE 1-4

Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

TRENDS IN RENEWABLE ENERGY

Canada is a leader in the production of renewable energy, with over 16 percent of its primary energy supply coming from renewable sources in 2007. Although renewable energy is often associated with electricity, renewable energy sources also produce thermal energy (heat) and transportation fuels. Renewable energy sources in Canada include inland and ocean water, wind, solar, geothermal and biomass.

Canada has a significant renewable electricity supply due primarily to the widespread use of hydroelectricity. In 2007, 59 percent of Canada's electricity generation was provided by conventional and small hydroelectric plants, which generated more than 364 terawatt hours (TWh) of electricity, up from 349 TWh in 2006. Small hydro plants (less than 50 megawatts [MW]), with installed generating capacity of 3301 MW, provided about 2 percent of the total electricity generation in Canada.

Several provinces are taking steps to support the development of the next generation of ocean renewable energy technologies, which use waves, ocean currents and tides to generate electricity.

The Fundy Ocean Resource Centre for Energy, a technology demonstration facility, will test three

[4] Based on the OEE Index.

technologies with a total capacity of 4 MW by 2010. Wave and tidal-current technologies are also being tested off the coast of British Columbia, and a commercial facility for generating electricity may be feasible within the next decade.

Although technical, regulatory and financial challenges remain, ocean energy has the potential to provide Canada with an abundant source of renewable energy.

Non-hydro renewable sources accounted for an estimated 2 percent of Canada's electricity generation. With 1578 MW of installed capacity in 2007, biomass (waste and virgin biomass and landfill gas) is the main non-hydro renewable energy source in Canada.

However, wind energy is growing rapidly, with an increase in capacity from 139 MW in 2000 to 2369 MW in 2008. Wind power may soon be moving to the offshore, with large projects planned on submerged lands off the coast of British Columbia and in the Great Lakes.

Solar photovoltaic energy also experienced high rates of capacity growth – about 20 percent annually between 1993 and 2006 – although it started from a low baseline. In 2007, 25.8 MW of solar photovoltaic systems were installed in Canada, representing an increase of 5.3 MW from the previous year.

As described in Chapter 5, NRCan is carrying out two initiatives, ecoENERGY for Renewable Power and ecoENERGY for Renewable Heat, to increase the use of renewable energy in Canada.

TRENDS IN RESIDENTIAL SECTOR

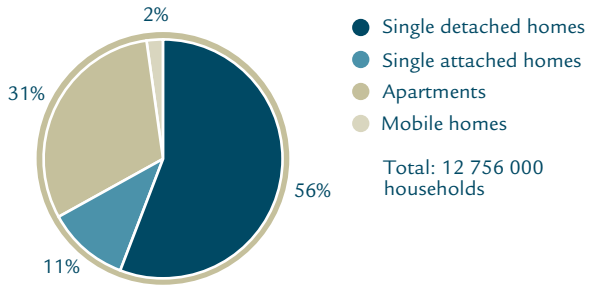
Energy Use and Greenhouse Gas Emissions

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; water heating; and the operation of appliances, electronic equipment and lights. In 2006, this sector accounted for 16 percent (1347 PJ) of secondary energy use and 14.5 percent (69.6 Mt) of GHGs emitted in Canada, continuing a downward trend in energy use and emissions since 2004.

Most dwellings in Canada are single detached houses. The next largest type of dwelling is apartments, followed by single attached dwellings and mobile homes (see Figure 1-5). The OEE's ecoENERGY Retrofit – Homes and ecoENERGY for Buildings and Houses programs aim to improve the energy efficiency of single detached and attached houses.

FIGURE 1-5

Canadian Households by Type of Dwelling, 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

Between 1990 and 2006, residential energy use increased by 4.8 percent, or 61 PJ. However, since 2004, residential energy use has been decreasing at a significant rate.

For the same period between 1990 and 2006, GHG emissions increased by only 0.4 percent, mainly due to the significant reductions in GHG emissions that occurred since 2004.

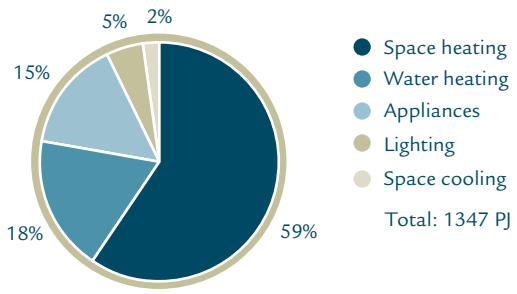
GHG intensity decreased 21.5 percent despite the average household operating more appliances, becoming larger and increasing its use of space cooling. Space and water heating constituted 77.3 percent of residential energy use (which exhibited a small drop in space heating energy use), followed by operating appliances, lighting and space cooling (see Figure 1-6).

Five main factors influenced residential energy use between 1990 and 2006 – activity, weather, structure, service level and energy efficiency effect:

- Activity – The increase in the number of households and the size of dwellings (the principal measures of residential activity) increased energy use by 29.0 percent (373.5 PJ).
- Weather – The winter in 2006 was much warmer compared with the winter in 1990, as was the summer (yet cooler than in 2005). The result was a 4.8 percent (61.6 PJ) decrease in energy use in 2006.
- Structure – The relative share of households by dwelling type (single detached, apartments, etc.) changed over the period. This change contributed to an increase in energy use of 0.6 percent (7.4 PJ) in 2006.
- Service level – The increased market penetration rate of appliances and increased floor space cooled by space-cooling units increased energy use by 6.0 percent (76.9 PJ).
- Energy efficiency effect – Improvements to the thermal envelope of houses and to the efficiency of residential appliances and space- and water-heating equipment led to an overall gain in energy efficiency and decreased energy use by 26.1 percent (335.1 PJ).

FIGURE 1-6

Residential Energy Use by End-Use, 2006



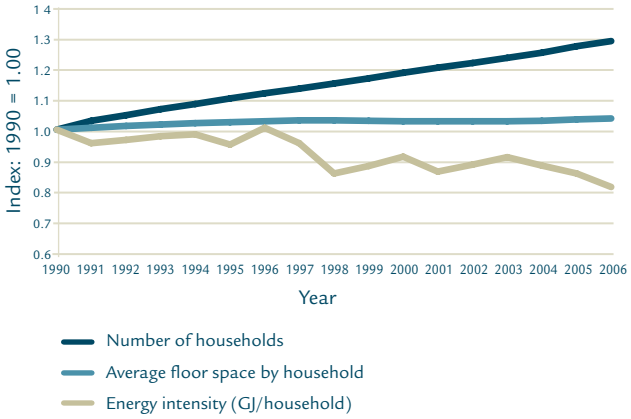
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Growth in residential energy use was driven in large part by growth in activity. This growth in activity – 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 1-7).

These increases were partially offset by significant improvements in energy efficiency. Structural changes also contributed to growth in energy use, because 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 more Canadians cooled their homes during the summer months in 2006 than in 1990 and Canadians operated more appliances in 2006 than they did in 1990.

FIGURE 1-7

Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

Energy Efficiency

The change in residential energy use between 1990 and 2006 and the estimated energy savings due to energy efficiency measures are shown in Figure 1-8.

Overall energy efficiency upgrades – including improvements to the thermal envelope (insulations, windows, etc.) and more energy-efficient appliances,

furnaces and lighting – resulted in significant monetary savings for each Canadian household.

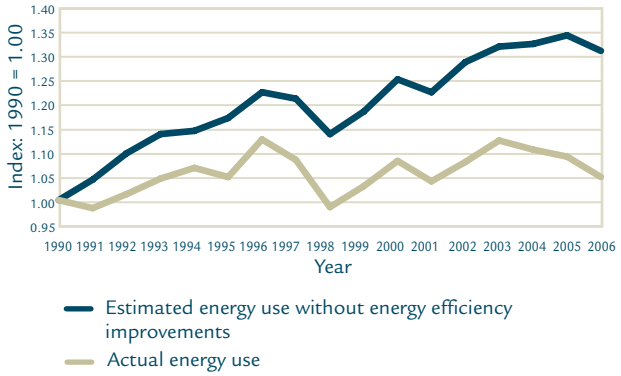
The 26.1 percent improvement in energy efficiency between 1990 and 2006 translated into $6.6 billion in energy savings in 2006.

Figure 1-9 shows how energy consumption differs for houses built in different periods, reflecting improvements in building construction.

Figure 1-10 shows how average energy consumption of new appliances has improved, by comparing 1990 and 2006 models.

FIGURE 1-8

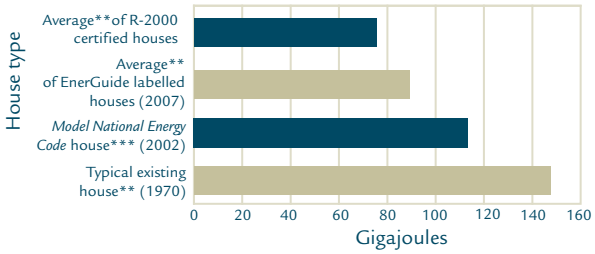
Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2008.

FIGURE 1-9

Annual Heating* Consumption for Houses Constructed to Different Standards

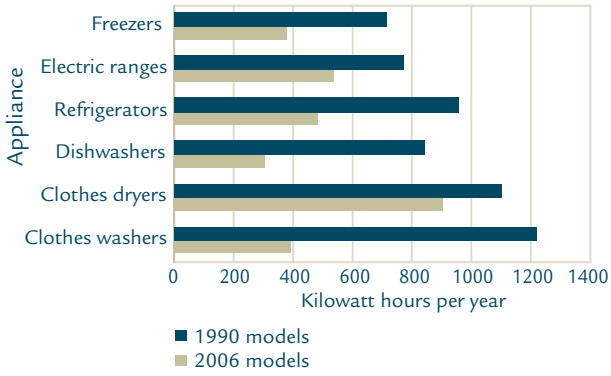


*DHW and space heating
**National average
***198-m^2, two-storey, single detached house heated with natural gas in Ottawa, Ontario

Source: NRCan national housing database and internal data.

FIGURE 1-10

Average Energy Consumption of New Electric Appliances, 1990 and 2006 Models



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2008.

NRCan carries out the following initiatives to increase energy efficiency in the residential sector:

- ecoENERGY Retrofit – Homes
- ecoENERGY for Buildings and Houses
- Clean Energy Systems for Buildings and Communities
- ecoENERGY for Equipment (see Chapter 2)

TRENDS IN COMMERCIAL/ INSTITUTIONAL SECTOR

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, operation of auxiliary equipment, space cooling, lighting, motive power for such services as pumping and ventilation in buildings, and street lighting.

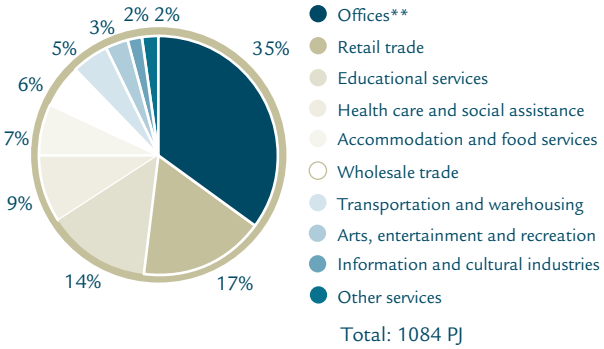
In 2006, the commercial/institutional sector accounted for 13 percent (1093 PJ) of secondary energy use and 12.6 percent (60.4 Mt) of GHG emissions in Canada. Between 1990 and 2006, commercial/institutional energy use (including street lighting) increased by 26 percent, or 226 PJ.

However, GHG emissions from the sector rose by 27 percent in the same period. The increase in use of GHG-intensive fuels, such as heavy oil and light fuel oil, explains why GHG emissions grew at a faster pace than energy use.

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 1-11). In 2006, offices accounted for 35 percent of the sector's energy demand. Retail trade, educational services, health care and social assistance, and accommodation and food services accounted for another 47 percent of that demand.

FIGURE 1-11

Commercial/Institutional Energy Use by Activity Type,* 2006



* Excludes street lighting.

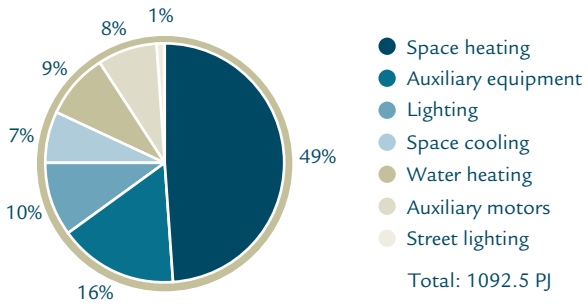
**"Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Energy is used for seven purposes in commercial/institutional activities. As illustrated in Figure 1-12, in 2006, the largest of these was space heating, which accounted for almost half of the energy use in the sector. The remaining six uses of energy accounted for between 1 and 16 percent of energy demand in the sector.

FIGURE 1-12

Commercial/Institutional Energy Use by Purpose, 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Five main factors influenced commercial/institutional energy use between 1990 and 2006 – activity, weather, structure, service level and energy efficiency effect:

- Activity – More floor space increased energy use in the sector by 28 percent and caused a 274-PJ increase in energy use.
- Weather – The winter of 2006 was warmer compared with the winter of 1990, as was the summer. The net result was a 3 percent decrease in energy use (23 PJ) for space heating and cooling.
- Structure – The impact of structural changes (mix of building types) was marginal but produced a decrease of 1.4 PJ in energy use.
- Service level – An increase in the service level of auxiliary equipment (e.g. computers, photocopiers) and space cooling caused an 11 percent increase in energy use (93 PJ).
- Energy efficiency effect – A 14 percent improvement in energy efficiency saved 116 PJ of energy.

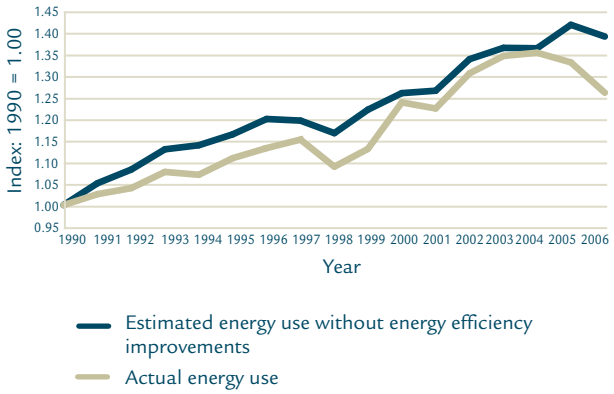
Energy Efficiency

Gains in energy efficiency were made through improvements to the thermal envelope of buildings (insulation, windows, etc.) and increased efficiency of energy-consuming items, such as furnaces, auxiliary equipment and lighting, which slowed the rate of increase in energy use. Without improvements in energy efficiency, energy use in the commercial/institutional sector would have increased by 39 percent. However, between 1990 and 2006, actual energy use increased by only 26 percent, resulting in energy savings of $2.5 billion in 2006.

During this period, energy efficiency in the commercial/institutional sector improved by 14 percent. The change in energy use between 1990 and 2006, as well as the estimated energy savings due to improvements in energy efficiency, are shown in Figure 1-13.

FIGURE 1-13

Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006



Source: Natural Resources Canada, Commercial/Institutional End-Use Model, Ottawa, 2008.

NRCan carries out the following initiatives to increase energy efficiency in the commercial/institutional sector:

- ecoENERGY Retrofit – Small and Medium Organizations
- ecoENERGY for Buildings and Houses
- Clean Energy Systems for Buildings and Communities
- ecoENERGY for Equipment (See Chapter 2)

TRENDS IN INDUSTRIAL SECTOR

Energy Use and Greenhouse Gas Emissions

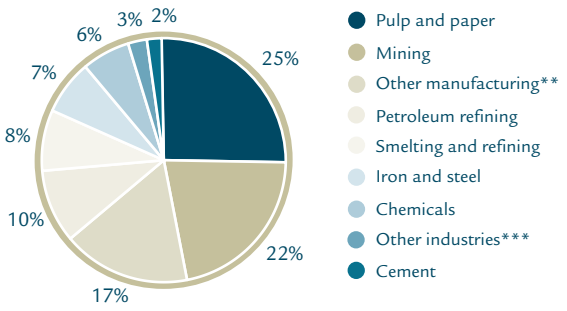
The industrial sector includes all manufacturing industries, all mining activities (including oil and gas extraction), forestry and construction. However, it excludes electricity generation. This sector uses energy in industrial processes as a source of motive power and to produce heat or generate steam.

Overall, industrial energy demand in 2006 accounted for 39 percent (3271 PJ) of secondary energy use and 34 percent (162 Mt) of GHG emissions (including electricity-related emissions). Between 1990 and 2006, actual industrial energy use increased by 20 percent (549 PJ). This increase was caused by a 44 percent increase in industrial activity, measured as a combination of physical units of production, gross output and GDP.

In the industrial sector, energy was consumed primarily in pulp and paper production, mining, petroleum refining, and in the smelting and refining industries. Pulp and paper production alone accounted for 25 percent of total industrial energy demand in 2006 (see Figure 1-14).

FIGURE 1-14

Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2006



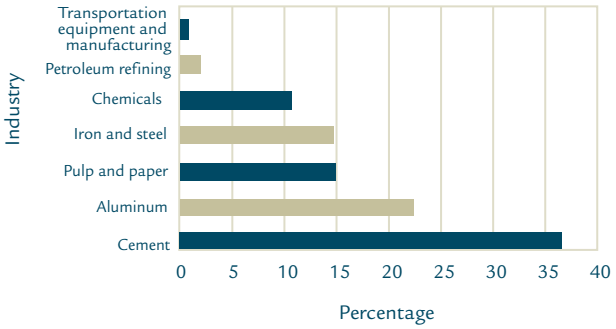
*The above subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.
**"Other manufacturing" comprises more than 20 manufacturing industries.
***"Other industries" includes construction and forestry.

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_agg_ca.cfm

In most industries, energy purchases accounted for only a small portion of total expenditures. However, for some relatively energy-intensive industries – cement, aluminium, pulp and paper, iron and steel, and chemicals – this share was higher than 11 percent (see Figure 1-15). For cement, in particular, the share was 37 percent.

FIGURE 1-15

Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2006



Source: Statistics Canada, CANSIM Table 301-0006.

Between 1990 and 2006, industrial GHG emissions, including electricity-related emissions, increased by 14 percent. Excluding electricity-related emissions, industrial GHG emissions increased by 9 percent. Most of this increase in direct GHG emissions occurred in the upstream oil and gas industry. The mining, manufacturing and construction industries, however, achieved a 10 percent decrease in GHG emissions.

Three main factors influenced industrial energy use between 1990 and 2006 – activity, structure and energy efficiency effect:

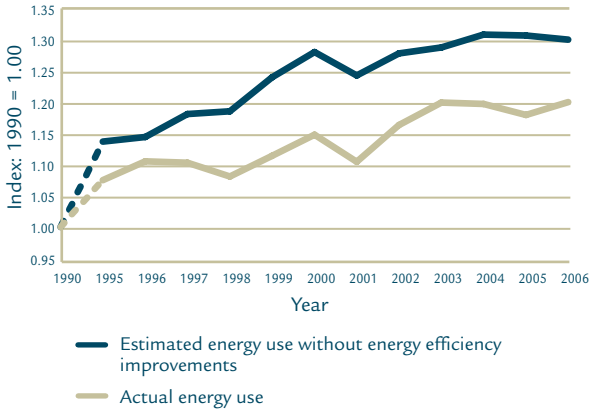
- Activity – Increases in the physical units of production, gross output and GDP contributed to a 44 percent increase in industrial activity, resulting in an 1197.2-PJ increase in energy use.
- Structure – The shift in the mix of activity toward less energy-intensive industries caused a 392-PJ decrease in energy use.
- Energy efficiency effect – Owing to a 9 percent improvement in energy efficiency, the industrial sector avoided 256 PJ of energy use.

Energy Efficiency

The change in energy use between 1990 and 2006 and the estimated energy savings attributed to energy efficiency are shown in Figure 1-16.

FIGURE 1-16

Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006



Source: Natural Resources Canada, Industrial End-Use Models, Ottawa, 2008.

Energy efficiency improvements in the form of more efficient capital and management practices are important factors in managing energy use and decreasing energy intensity.

Between 1990 and 2006, energy efficiency in the industrial sector improved 9 percent. In 2006, Canadian industry saved $2.9 billion in energy costs. This gain was largely the result of improvements in energy intensity, representing the shift toward less energy-intensive activities. However, the energy savings from the energy efficiency improvements made by some industries were offset by increases in consumption by the upstream oil and gas, fertilizer and forestry subsectors.

NRCan carries out the following initiatives to increase energy efficiency in the industrial sector:

- ecoENERGY Retrofit – Small and Medium Organizations
- ecoENERGY for Industry
- Clean Energy Systems for Industry
- ecoENERGY for Equipment (see Chapter 2)

TRENDS IN TRANSPORTATION

Energy Use and Greenhouse Gas Emissions

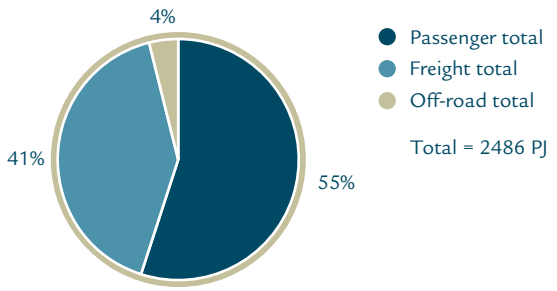
In 2006, transportation was second to the industrial sector in terms of energy use, accounting for 30 percent (2492 PJ) of Canada's total secondary energy use and the largest portion of Canadian end-use GHG emissions at 36 percent (172.4 Mt).

Transportation accounts for a greater share of GHG emissions because the main fuels used by the sector are more GHG-intensive than those used in other sectors of the economy.

The transportation sector consists of three subsectors: passenger, freight and off-road. In 2006, passenger and freight transportation accounted for 55 percent and 41 percent of transportation energy use respectively, while off-road represented only 4 percent (see Figure 1-17). Owing to limitations in the available data and the small percentage it accounts for, the off-road subsector is not analysed in further detail.

FIGURE 1-17

Transportation Energy Use by Mode, 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

The passenger subsector has three modes: road, rail and air. The freight subsector, as defined by NRCan, is composed of road, rail, air and marine modes. Within these two subsectors, road transport uses the most energy, accounting for 78 percent of total transportation energy use in 2006.

All of NRCan's transportation energy use programs focus on the energy used in road transportation. Total transportation energy use increased by 33 percent (614 PJ) between 1990 and 2006. Within the transportation sector, passenger transportation energy use increased by 16 percent (186 PJ), while freight transportation energy use increased by 60 percent (382 PJ).

Three main factors influenced transportation energy use between 1990 and 2006 – activity, structure and energy efficiency effect:

- Activity – Increases in population, air transportation and economic activity (e.g. free trade) caused increased transportation activity.[5] The change in activity increased transportation energy use by 39 percent (741 PJ). Contributing to this increase were the freight and passenger segments, which increased by 62 percent and 28.9 percent respectively.

- Structure – Shifts between modes of transport within both the freight and passenger segments caused an increase of 9.4 percent in transportation energy use (176 PJ). Specifically, an increase in international trade and customer requirements for just-in-time delivery and the popularity of minivans and sport utility vehicles (SUVs) contributed to a rise in energy use.

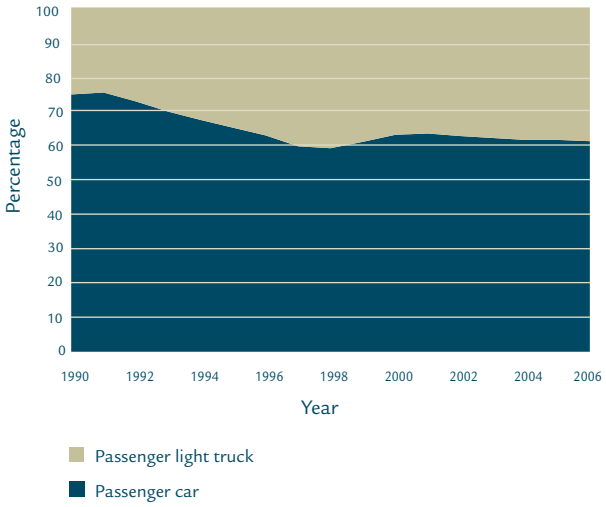
- Energy efficiency effect – Improvements in the energy efficiency of passenger and freight transport decreased energy use by 18.2 percent (342.2 PJ).

[5] Measured as passenger-kilometres for passenger transportation and tonne-kilometres for freight transportation.

Figure 1-18 shows how the market share of new light trucks increased in the 1990s, reflecting the increase in popularity of minivans and SUVs. Recently, however, this trend seems to have stabilized, with the share of light trucks remaining steady over the past few years. The higher share of heavier and more powerful passenger vehicles has had a significant effect on the increase in passenger energy use.

FIGURE 1-18

Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2006



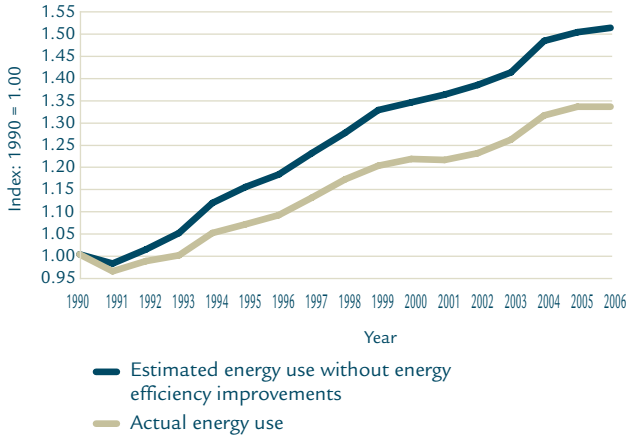
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

Energy Efficiency

Without improvements in energy efficiency, increases attributable to activity and structure would have led to an increase in transportation energy use of 50 percent. However, between 1990 and 2006, actual energy use increased by 33 percent. During this period, energy efficiency in the transportation sector improved by 18.2 percent, leading to a savings of $8.7 billion in 2006. This change in energy use between 1990 and 2006 and the estimated energy savings due to energy efficiency improvements are shown in Figure 1-19.

FIGURE 1-19

Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006

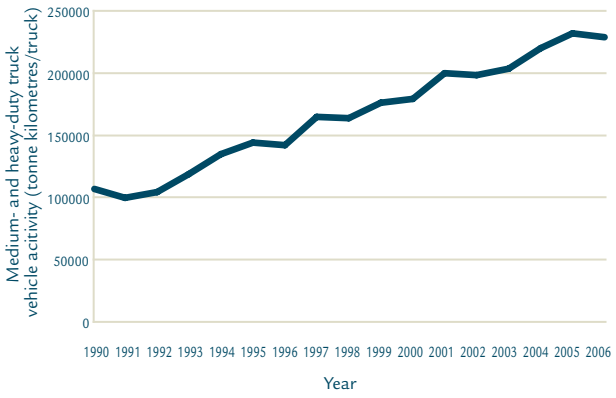


Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

Figures 1-20 and 1-21 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2006. 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.

FIGURE 1-20

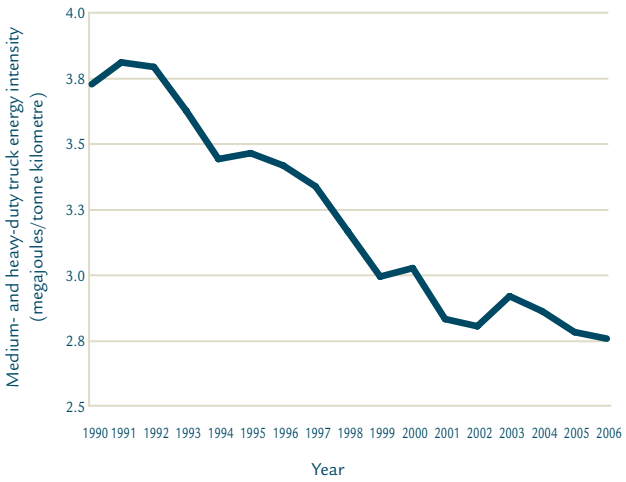
Average Activity per Truck, 1990 to 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

FIGURE 1-21

Trucking Energy Intensity, 1990 to 2006



Source: Natural Resources Canada, Transportation End-Use Models, Ottawa, 2008.

NRCan carries out the following initiatives to increase the efficiency of motor vehicle use:

- ecoENERGY for Personal Vehicles
- ecoENERGY for Fleets
- Clean Transportation Energy

TRENDS IN ALTERNATIVE AND RENEWABLE FUELS

Alternative and Renewable Fuels

Alternative fuels are fuels used for transportation other than petroleum-based gasoline and diesel. Some alternative transportation fuels, such as ethanol and biodiesel, are renewable; others, such as propane and natural gas, are non-renewable. Other possible alternative transportation fuels include next-generation biofuels, coal-to-liquids, electricity and hydrogen.

Renewable fuel is a broad term covering a range of fuels made from renewable energy sources that are naturally replenished in a relatively short period. The sources include biomass, hydropower, geothermal energy, wind energy and solar energy.

Biofuel is a well-known category of renewable fuel and can be produced from a variety of sources. Two commercially available biofuels are ethanol and biodiesel. Conventional ethanol is produced from sugars or starches, and biodiesel production typically uses vegetable oils and animal fats. In Canada, ethanol is typically produced from corn and wheat, while canola oil, soy oil and tallow are relevant biodiesel feedstocks.

Gasoline vehicles manufactured since the 1980s can use up to 10 percent ethanol in gasoline. An increasing number of original equipment manufacturers are endorsing the use of lower biodiesel blends, for example, up to 5 percent in diesel engines. Under development are next-generation biofuels, such as cellulosic ethanol. These biofuels could be made from non-conventional sources, such as agricultural residues, forest residues and waste materials.

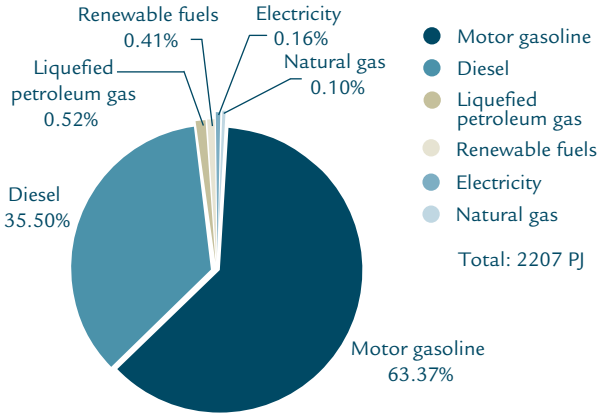
Renewable Fuels Production

Renewable fuels production in Canada has increased since the emergence of ethanol in Manitoba in the 1980s. Between 2005 and 2008, domestic renewable fuel production capacity increased by approximately 1.3 billion litres (L), from 211 million L to 1.5 billion L. By the end of the 2008–2009 fiscal year, ethanol production capacity was 1.4 billion L and biodiesel production capacity was over 100 million L. For the 2008 calendar year, 814 million L of ethanol and approximately 85 million L of biodiesel were produced.

In 2006, renewable fuels used in the transportation sector represented less than 0.5 percent of fuel used, as shown in Figure 1-22. The renewable fuel consumed was predominately ethanol blended with gasoline in lower-level ethanol blends.

FIGURE 1-22

Shares of On-Road Transportation Fuel, 2006



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

Regulations under development by Environment Canada will require 5 percent renewable content based on the gasoline pool by 2010 and 2 percent renewable content in diesel and heating oil by 2012, upon successful demonstration of renewable diesel fuel use under the range of Canadian conditions.

NRCan carries out initiatives to increase the use and production of renewable and alternative fuels under the following programs:

- ecoENERGY for Biofuels
- National Renewable Diesel Demonstration Initiative
- Sustainable Development Technology Canada's NextGen Biofuels Fund™

CHAPTER 2

Equipment, Standards and Labelling

INTRODUCTION

Natural Resources Canada's (NRCan's) wide range of energy efficiency initiatives includes standards and labelling programs that are based on the requirements of 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 that prescribe standards and labelling requirements for energy-using products that are imported to Canada or shipped across provincial borders for lease or sale. The *Energy Efficiency Regulations* came into effect in February 1995, after extensive consultations with provincial governments, affected industries, utilities, environmental groups and others. Since then, the Regulations have been amended a number of times.

The performance standards contained in the Regulations and accompanying labelling requirements and programs make a major contribution to the government's Clean Air Regulatory Agenda (CARA).

Regulations have now been established for more than 40 products including major household appliances, water heaters, heating and air-conditioning equipment, automatic icemakers, dehumidifiers, dry-type transformers, electric motors, commercial refrigeration and some lighting products. The Regulations apply to these products even if they are incorporated in a larger unit or machine that is not regulated.

As announced by the Government of Canada in October 2006, the Regulations will be amended to prescribe standards for 20 new products and increase the stringency of existing standards for 10 products by 2010. When these standards are implemented, there will be a standard in place for products that use 80 percent of the energy consumed in the residential and commercial/institutional sectors.

NRCan regularly amends the Regulations to strengthen the minimum energy performance requirements for prescribed products when the market has achieved 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 and labelling requirements.

In addition, 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 are 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 determine how the proposed change will affect the market. 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 the Regulations, as well as on their practical application in the marketplace.

The Act and the Regulations also support labelling initiatives. These are designed to help consumers and the commercial/industrial procurement community identify and purchase energy-efficient

equipment that will save them money and reduce greenhouse gas (GHG) emissions over the life of the product.

The Act and the Regulations require that an EnerGuide label be displayed on major electrical household appliances and room air conditioners or, as in the case of the newly implemented requirement for light bulb labelling, on the product packaging. 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 is published on the back page of the manufacturer's brochure. These ratings include the annual fuel utilization efficiency rating for oil and gas furnaces, the fireplace efficiency rating for gas fireplaces and the seasonal energy efficiency ratio for central air conditioners.

The ENERGY STAR® Initiative in Canada works with and complements the Regulations and comparative EnerGuide label. 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 significantly 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 efficiency levels trigger the development of new minimum energy performance standards.

STANDARDS

As a world leader in the use of energy efficiency standards, NRCan is committed to harmonizing 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 the five Canadian provinces that currently regulate energy-using equipment manufactured and sold within their borders. This alignment is achieved because governments support and participate in the development of national, consensus-based performance standards by accredited standards-writing organizations, such as the Canadian Standards Association.

Such standards include testing procedures that are used to determine a product's energy performance and are usually referenced federally and provincially. NRCan works closely with provinces throughout the regulatory process to ensure that the federal and provincial standards regimes are harmonized to the maximum extent possible. Because the North American market is highly integrated, Canada's energy performance requirements for many products are similar to regulations in the United States.

Canada is an active participant in international and regional forums, such as the Security and Prosperity Partnership of North America, involving the United States and Mexico, and the Asia-Pacific Partnership on Clean Development and Climate. Both these efforts contribute to regional co-operation on harmonization issues. Trade and investment liberalization and facilitation are high on the agenda of these working groups.

NRCan supports Canadian representation on committees of the International Organization for Standardization and the International Electrotechnical Commission.

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 imposing 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.

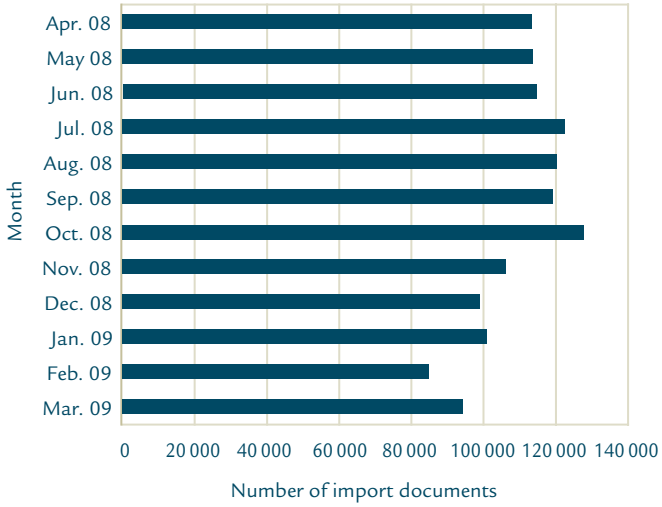
To monitor compliance with the Regulations, NRCan captures information from energy efficiency reports and import documents. Section 5 of the Act requires dealers to provide energy efficiency reports when they market a new product model. The required information includes the energy performance of each 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 (i.e. type of product, brand name, model number, name and address of dealer and purpose of import). A customs document contains 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 confirm that all products entering Canada meet the required energy performance levels and can take action when necessary.

NRCan processed more than 1 316 893 records (records from April 1, 2008, to March 31, 2009) relating to the importation of regulated energy-using products to Canada in 2008–2009.

Figure 2-1 illustrates the volume of import documents received per month during the 2008–2009 fiscal year.

FIGURE 2-1
Volume of Monthly Import Documents



Source: OEE equipment database.

More than 1 078 965 new or revised model numbers were submitted to NRCan for entry into NRCan's equipment database (records from April 1, 2008, to March 31, 2009) from dealers' energy efficiency reports.

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 from the 10 amendements will cause a reduction of 26 megatonnes (Mt) in aggregate annual emissions by 2010 (see Table 2-1).

TABLE 2-1
Estimated Impact of *Energy Efficiency Regulations*, 2010 and 2020 (aggregate annual savings)

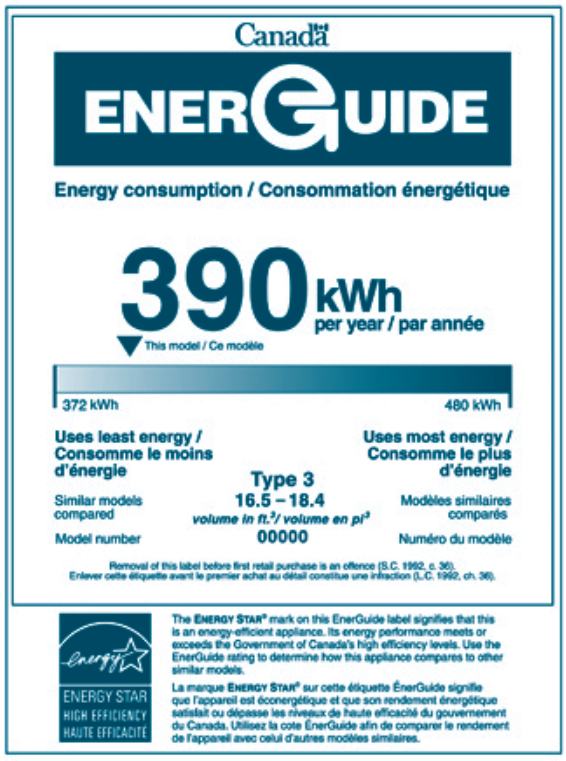
Product (amendment number in brackets)	**Energy savings** (PJ)		**CO_2 reductions** (Mt)	
	2010	**2020**	**2010**	**2020**
Residential appliances (1)	117.20	133.84	13.26	15.60
Lamps – fluorescent/incandescent (2)	11.60	13.40	7.55	9.80
Motors (3)	16.30	17.70	2.03	2.14
Commercial HVAC (4)	6.40	7.50	0.43	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)	1.57	5.35	0.16	0.53
General service lighting, commercial and industrial gas unit heaters, traffic and pedestrian signals, ceiling fan lighting, torchiere lamps, commercial clothes washers, residential wine chillers, commercial ice-makers, residential dishwashers, residential dehumifiers, residential gas furnaces (10)	6.09	88.10	0.40	9.67
Total	**184.24**	**328.96**	**26.00**	**43.96**

*Values are different from Regulatory Impact Analysis Statement due to a change in the emission factor to 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



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. Online 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.

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, and manufacturers were asked to include EnerGuide ratings for fireplace efficiency in their brochures. These changes coincided with the mandatory requirement in the Regulations to test, verify and report on fireplace efficiency.

Major distributors of these products for sale in Canada report the verified energy performance rating of their products, as tested against the standards in the Regulations. In addition, participants in the voluntary 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.

Given that the equipment products listed above are typically purchased from a brochure or catalogue, a consumer would probably not read the EnerGuide label before making a decision to buy. Accordingly, manufacturers are encouraged to include an EnerGuide rating in product brochures and catalogues, so consumers can compare the efficiency of products when they are in the buying process. To date, manufacturers of 85 percent of eligible products on the market voluntarily participate in the EnerGuide rating program and publish the ratings in their brochures.

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 joins other international ENERGY STAR program participants: Australia, New Zealand, Japan and Taiwan, and the European Union, which 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 on the basis of their technical potential for high efficiency. This is a voluntary program. However, organizations must demonstrate that products meet the eligibility 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 United States, including the following:

- major electrical appliances
- heating, cooling and ventilation
- consumer electronics
- office equipment
- windows, doors and skylights (Canadian levels)
- selected lighting products – compact fluorescent lamps (CFLs), fixtures, decorative light systems and solid-state lighting
- selected commercial equipment, including commercial refrigeration products

Canada has also integrated ENERGY STAR with the EnerGuide label for qualified 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.

ENERGY STAR is used as the basis for incentives by many electrical and gas utilities across Canada. For example, Hydro-Québec promotes ENERGY STAR qualified refrigerators, freezers, clothes washers and CFLs as part of its *Mieux Consommer* program and provides incentives for these product categories. Enbridge Gas and Manitoba Hydro have developed point-of-sale and incentive programs around ENERGY STAR qualified gas-fired heating systems.

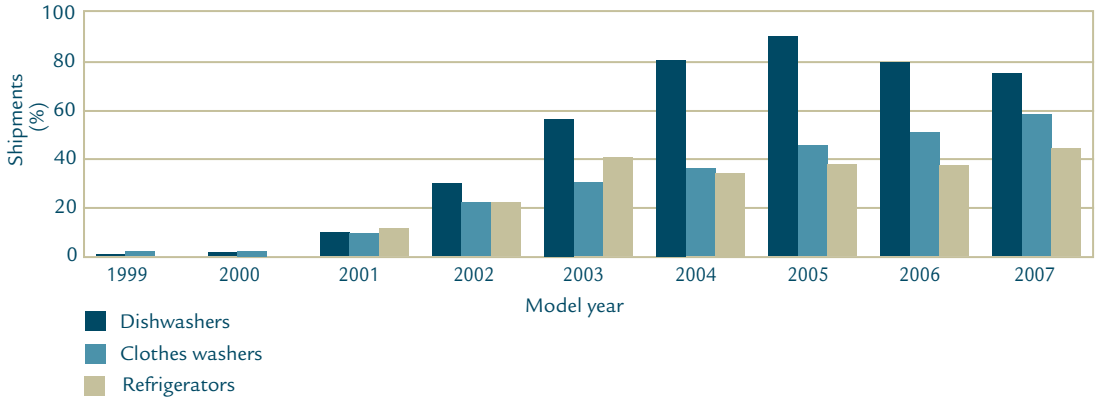
ENERGY STAR is also the qualifying criterion for sales tax exemptions in British Columbia for heating and cooling equipment; in Saskatchewan for the purchase of furnaces and boilers; and in Ontario for a variety of ENERGY STAR qualified products. Organizations across Canada have used ENERGY STAR as a 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 2007 show an increase in market penetration from almost nil in 1999 to 44 percent for refrigerators, 58 percent for clothes washers and 76 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 manufacturers' willingness to raise the efficiency of their products to qualifying levels.

ENERGY STAR specifications and levels are periodically updated as product saturation is

FIGURE 2-4

ENERGY STAR Qualified Appliances as a Percentage of Total Category Shipments in Canada, 1999 to 2007



Source: Energy Consumption of Major Appliances Shipped in Canada, Summary Report. Trends for 1990–2007.

reached, to encourage industry to strive for more efficient products and thus maintain the relevance and credibility of the brand.

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

Canada continues to promote ENERGY STAR guidelines in its contacts with the procurement community. It has updated an interactive cost calculator that compares energy cost savings and GHG emissions reductions associated with the purchase of ENERGY STAR qualified products. Workshops were held across Canada to make governments and institutions 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 range of product types included in its ENERGY STAR agreement. Canada led the way in the development of a technical specification for decorative light strings (also known as Christmas lights) and implemented this specification for Canada. In addition, Canada recently included fixtures, solid state lighting and external power supplies in its agreement with the Government of the United States. Finally, Canada is developing an ENERGY STAR specification for heat recovery ventilators.

NRCan developed a rating and labelling system for efficient refrigeration applications in ice and curling rinks under the name CoolSolution.[6] An ice rink application is qualified CoolSolution if it achieves a rating higher than 50 percent. An incentive program to encourage the adoption of CoolSolution and reduce the initial payback of the first applications started in November 2006. Partnerships to accelerate the program have been successful.

CoolSolution designates innovative technologies and practices and consists of three main elements:

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

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

- adaptation to the Canadian climate by taking advantage of the naturally occurring cold temperatures. This is done by varying the temperature of the heat 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 using natural refrigerants or by confining the synthetic refrigerant to the mechanical room and using environmentally friendly fluids to remove and distribute heat.

ecoENERGY FOR EQUIPMENT

Objective

To exclude the least efficient energy-using equipment from the market and to influence consumers to select – and manufacturers to produce – energy-efficient products that perform above minimum standards.

Description

The ecoENERGY for Equipment program is focused on accelerating the introduction of energy-efficient products in Canada's equipment stock. The program implements minimum energy efficiency performance standards that restrict the importation and interprovincial shipment of the least efficient products for sale in Canada. It also carries out initiatives to increase the market share of more efficient products.

ecoENERGY for Equipment also supports labelling programs that encourage the introduction of more efficient technologies. This involves the establishment and promotion of high-efficiency performance criteria, such as ENERGY STAR, and the engagement of stakeholders to promote products that meet these criteria. As products are adopted in the marketplace, the ENERGY STAR or equivalent performance level will become the basis for new, more stringent standards.

In addition, ecoENERGY for Equipment maintains a multilayered compliance and enforcement program to ensure that products meet prescribed standards and to ensure that other regulatory requirements, such as labelling, are met.

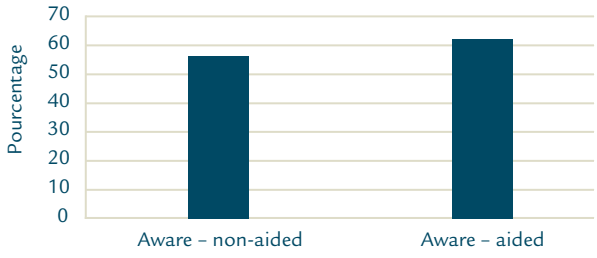
Program components include the following:

- regulations under the *Energy Efficiency Act* requiring dealers to ship only products that meet the prescribed energy efficiency standards

- the EnerGuide program, which rates and labels the energy efficiency of major household electrical appliances and heating, ventilating and air-conditioning equipment, assisting consumers in making energy-wise purchases

- the ENERGY STAR high efficiency program, which is an international initiative that identifies the most energy-efficient products in their class (see Figure 2-5)

FIGURE 2-5
ENERGY STAR Awareness Levels in Canada, 2007



Source: Tracking Study: Awareness of ENERGY STAR/EnerGuide Symbols 2007, Ipsos Reid.

Key 2008–2009 Achievements

- Introduced amendments to the *Energy Efficiency Act* into Parliament that give Canada the legislative authority to introduce comprehensive standards to regulate the amount of standby power consumed by many products – such as computers, battery chargers, CD players and televisions – when they are not in use.

- Published Amendment 10 to the *Energy Efficiency Regulations*. This amendment introduces standards for seven previously unregulated products and increases the stringency of existing standards for four products. The amendment includes standards for general service light bulbs that are scheduled to begin coming into effect in 2012. Standards in the amendment will reduce annual GHG emissions by an estimated 9.67 Mt in 2020.

- Conducted the analysis and consultation necessary to pre-publish Amendment 11 to the *Energy Efficiency Regulations*. Amendment 11 includes standards for six previously unregulated products and increases in the stringency of the existing standards for seven products.

- Delivered four specialized workshops on ENERGY STAR to the procurement and institutional community.

- Updated and maintained a comprehensive database of ENERGY STAR qualified products and information that assists utilities and other organizations across Canada in their energy efficiency programs (rebates, incentives and tax exemptions).

- Published and implemented 10 new ENERGY STAR technical specifications.

- Undertook 10 market assessments.

For more information:
oee.nrcan.gc.ca/corporate/about-us.cfm?attr=0

CHAPTER 3

Energy Efficiency and Alternative Transportation Fuels

Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) aims to strengthen and expand Canada's commitment to energy efficiency in all sectors and increase the production and use of alternative transportation fuels in Canada. The OEE is the manager of the ecoENERGY Efficiency Initiative, under the ecoENERGY suite of programs initiated on April 1, 2007. The ecoENERGY Efficiency Initiative includes the following programs:

- ecoENERGY Retrofit
- ecoENERGY for Buildings and Houses
- ecoENERGY for Industry
- ecoENERGY for Personal Vehicles
- ecoENERGY for Fleets
- ecoENERGY for Biofuels
- ecoENERGY for Equipment (see Chapter 2)

In addition to ecoENERGY, the OEE manages the Federal Buildings Initiative and the National Renewable Diesel Demonstration Initiative (NRDDI).

This chapter describes the objective of each of the aforementioned programs and outlines key achievements.

ecoENERGY RETROFIT

Objective

To provide incentives for energy efficiency improvements in homes and in small and medium-sized organizations in the institutional, commercial and industrial sectors. The program has two components:

- ecoENERGY Retrofit – Homes
- ecoENERGY Retrofit – Small and Medium Organizations

For more information:
ecoaction.gc.ca/retrofit

ecoENERGY RETROFIT – HOMES

Objective

To assist homeowners and owners of existing low-rise properties make smart energy retrofit decisions that will result in significant energy savings and a cleaner environment.

Description

Initiated on April 1, 2007, the ecoENERGY Retrofit – Homes program is investing $460 million over four years, providing federal grants to property owners for improving the energy efficiency of their homes and reducing their home's impact on the environment. ecoENERGY Retrofit – Homes offers a professional evaluation by a qualified energy advisor of the energy efficiency characteristics of a house, including a diagnostic test to determine air leakage.

The energy advisor prepares a detailed personalized checklist of recommended upgrades for the property owner, including the EnerGuide pre-retrofit energy rating of the house. The checklist shows the recommended, most effective upgrades. The property owner chooses which upgrades to have done.

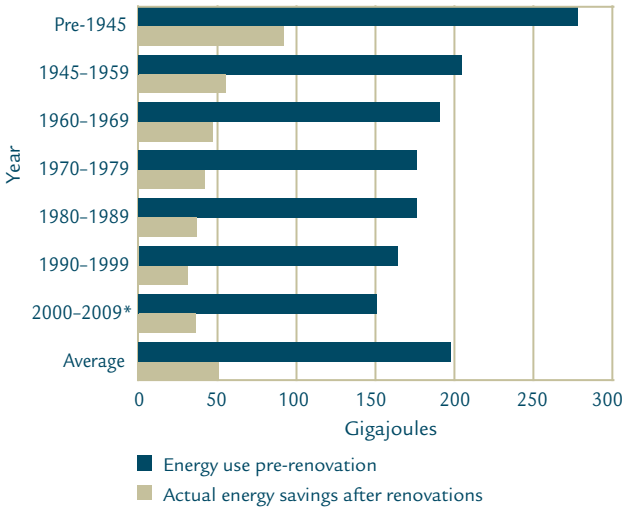
After the retrofit work is complete, the advisor performs a post-retrofit energy evaluation and assigns a new energy-rating label. After the required improvements have been made, the property owner is entitled to a grant.

The program was expanded in 2009 to support as many as 200 000 additional homeowners in making energy efficiency retrofits to their homes. The expanded program includes a $300-million increase in funding over two years, well as a 25 percent increase in the grant amount (up to $5,000 per unit).

It is expected that the ecoENERGY Retrofit – Homes incentives will promote smart energy use in more than 340 000 homes and will yield an average 23 percent reduction in energy use.

FIGURE 3-1

Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000–2009



*Data for 2007 are from ecoENERGY Retrofit – Homes (previous data source was EnerGuide for Houses).

Figure 3-1 illustrates the energy use and savings gained per household before and after renovations.

Key 2008–2009 Achievements

- From April 1, 2007, to the end of the 2008–2009 fiscal year, grants were made to 94 000 homeowners to support energy efficiency upgrades that will reduce their annual energy consumption.
- Over the same time period, 19 000 grants were paid for more energy-efficient renewable technologies and products, including water conservation equipment, wood burning appliances, ground-source heat pumps, solar domestic hot water systems and drain water treatment recovery pipes (representing 20 percent of program participants).
- All regions of Canada, except one province and one territory, have matching programs from which homeowners can get seamless access to both federal and provincial/territorial government support for home retrofits.
- At the end of the 2008–2009 fiscal year, agreements had been signed with nine provinces and two territories.
- The ecoENERGY Retrofit – Homes program will help participants reduce their annual energy consumption by about 23 percent and GHG emissions by approximately 3.4 tonnes (t) per house per year.
- Since program inception, a reduction of approximately 0.32 megatonnes (Mt) of greenhouse gas (GHG) emissions can be attributed to the ecoENERGY Retrofit – Homes program.

ecoENERGY RETROFIT – SMALL AND MEDIUM ORGANIZATIONS

Objective

To encourage building owners and managers of commercial and institutional buildings and industries to implement energy efficiency projects.

Description

Initiated on April 1, 2007, ecoENERGY Retrofit – Small and Medium Organizations is investing $40 million over five years, providing financial incentives to implement energy retrofit projects in buildings and industrial equipment and processes. Industrial facilities with fewer than 500 employees and commercial and institutional buildings of less than 20 000 square metres may be eligible for funds through contribution agreements with the program.

ecoENERGY Retrofit will provide up to 25 percent of the cost of a project, to a maximum of $50,000, based on estimated energy savings resulting from the project. Recipients of funding in this category may also qualify for funding support from utilities and/or other levels of government. To qualify, eligible organizations must submit an application detailing the energy efficiency project, including the total budget, timeframe for completion and expected results, based on a certified technical assessment of the building's or industry's energy use.

Key 2008–2009 Achievements

- Webinars and information sessions hosted 460 participants.
- 279 small and medium-sized organizations had their planned retrofit projects approved for financial assistance.
- Since program inception, the program has approved projects that will save approximately 0.08 Mt of GHG emissions.

ecoENERGY FOR BUILDINGS AND HOUSES

Objective

To encourage the construction and operation of more energy-efficient buildings and houses through a range of complementary activities, such as rating, labelling and training.

Description

Initiated on April 1, 2007, the ecoENERGY for Buildings and Houses program is investing $60 million over four years and includes the following activities for the buildings sector:

- implementing new design tools and training, such as the Dollars to $ense workshop, so designers, builders, owners and operators can learn about and use best practices and new technologies for energy-efficient buildings
- updating building energy ratings and promoting labelling systems for housing, including the EnerGuide Rating System, the R-2000 Standard[7] and ENERGY STAR® for New Homes, to encourage consumers to invest in energy-efficient upgrades during the construction planning phase of building a new home (see Figure 3-2)
- supporting the National Research Council financially in updating the *National Energy Code for Buildings*
- engaging in ongoing dialogue and co-operation with provincial and territorial programs to encourage other levels of government to adopt more stringent building energy codes
- providing training and implementing outreach and communication strategies to increase awareness and build capacity among builders, building owners, managers and consumers to support the adoption of sustainable energy efficiency programs

[7] R-2000 is an official mark of Natural Resources Canada.

- establishing and maintaining partnerships to reduce energy use and improve energy efficiency information

FIGURE 3-2
Number of R-2000 Housing Certifications, 1990 to 2008

Source: NRCan national housing database and internal data.

Key 2008–2009 Achievements

- Issued more than 260 000 housing labels for new and existing houses.
- Seven building labelling pilot projects were underway with organizations across Canada, covering 320 buildings.
- More than 1800 building professionals took part in technical support workshops, and more than 4300 housing professionals, builders and energy advisors were trained.
- As of the end of the 2008–2009 fiscal year, six provinces (B.C., Man., Ont., Que., N.B., N.S.) had announced changes to their building codes to achieve the ERS80 level by 2012. All but two provinces and territories participate in the Building Energy Code Collaborative.
- National Research Council is on schedule to complete the update of the *National Energy Code for Buildings* in 2011.
- Since program inception, an estimated 0.77 Mt of GHG emissions were saved as a result of the ecoENERGY for Buildings and Houses program.

For more information:
ecoaction.gc.ca/ecoenergy-ecoenergie/buildingshouses-batimentshabitations-eng.cfm

ecoENERGY FOR INDUSTRY

Objective

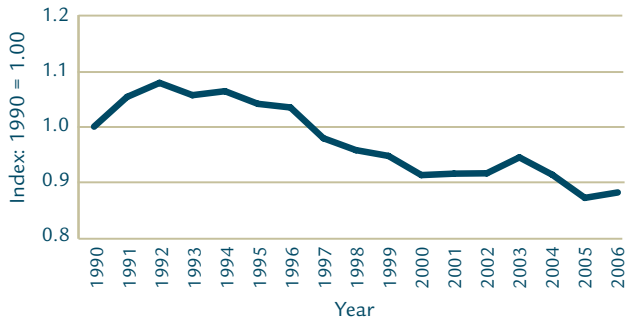
To improve industrial energy intensity and reduce energy-related industrial GHGs and air pollution.

Description

Initiated on April 1, 2007, the ecoENERGY for Industry program is investing $18 million to accelerate energy-saving investments and the exchange of best-practices information within Canada's industrial sector. The program helps industry become more energy efficient by providing it with tools and services for overcoming the technical, management and financial barriers to project implementation.

ecoENERGY for Industry is an industry-government partnership delivered through the Canadian Industry Program for Energy Conservation (CIPEC). CIPEC is committed to promoting and encouraging energy efficiency improvements, as well as reductions in GHG emissions through voluntary action across Canada's industrial sectors. The estimated CIPEC energy intensity index is shown in Figure 3-3.

FIGURE 3-3
CIPEC Energy Intensity Index, 1990 to 2006

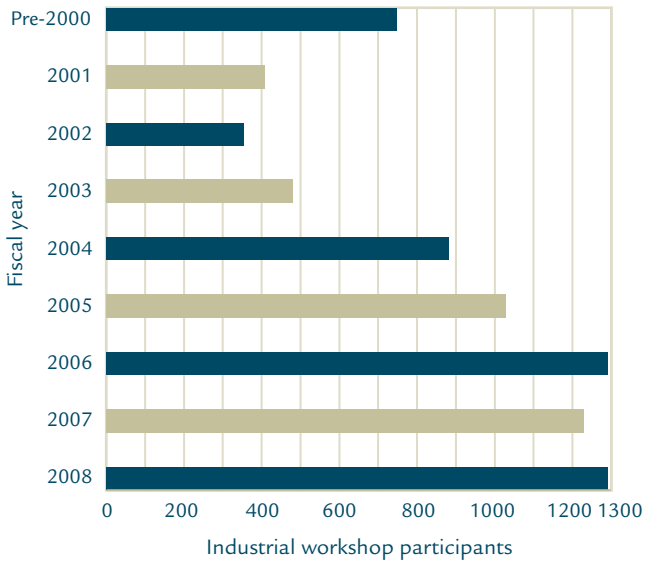


Source: CIPEC Annual Report 2008.

Program components include the following:

- the Dollars to $ense energy management workshops, which teach industry members how to improve operational efficiency, create a better work environment and reduce GHG emissions (see Figure 3-4)
- the ecoENERGY Assessment Incentive for Industry, which offers a financial incentive to help industrial companies conduct state-of-the-art process integration and computational fluid dynamics studies that identify opportunities to increase energy efficiency and improve production processes
- the CIPEC Leaders network, which demonstrates the industrial sector's commitment to reducing energy use, gives members recognition, networking opportunities for best-practice sharing and eligibility for financial incentives

FIGURE 3-4
Industrial Dollars to $ense Participants, Pre-2000 to 2008



Source: CIPEC.

Key 2008–2009 Achievements

- Delivered Dollars to $ense energy management workshops for 760 industrial participants.
- Six benchmarking studies, technical guides and other tools were developed, leading to improved energy efficiency in Canadian industry.
- Welcomed 191 new members to the CIPEC Leaders network, which has 1800 members, and held 77 network meetings.
- Since program inception, ecoENERGY for Industry helped Canadian industry avoid approximately 0.74 Mt of GHG emissions.

For more information:
ecoaction.gc.ca/ecoenergy-ecoenergie/industry-industrie-eng.cfm

ecoENERGY FOR PERSONAL VEHICLES

Objective

To facilitate and support improvements in energy efficiency by encouraging Canadians to buy, drive and maintain their vehicles with fuel efficiency in mind.

Description

Initiated April 1, 2007, the ecoENERGY for Personal Vehicles program is investing $21 million over four years to provide Canadians with helpful information, tips and decision-making tools to assist them in changing their buying, driving and maintenance behaviours in order to reduce fuel consumption and GHG emissions from their personal vehicle use. It does so through the following:

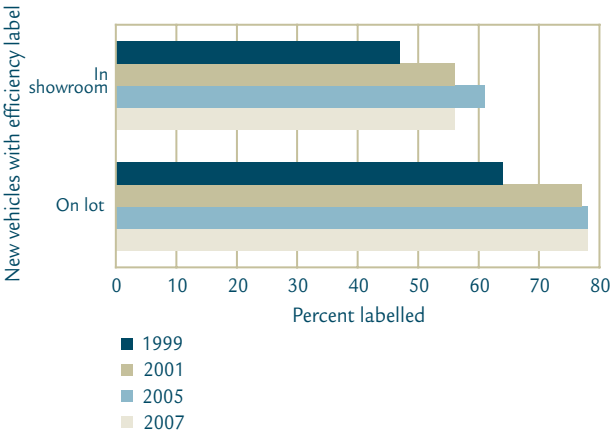
- decision-making information and tools, such as the annual *Fuel Consumption Guide*, labels and vehicle awards
- "Eco" driver education and training
- idle-free and tire inflation campaigns
- collaborative ventures with community groups and industry stakeholders

ecoENERGY for Personal Vehicles also facilitates work with the vehicle industry to implement and monitor the voluntary memorandum of understanding (MOU) between the Government of Canada and the auto industry to reduce automobile GHG emissions.

Program components include the following:

- the EnerGuide labelling system, which places fuel consumption labels on all new light-duty vehicles sold in Canada (see Figure 3-5)
- the 2005 MOU between the Government of Canada and the Canadian auto industry, which provides a framework for automakers to produce more fuel-efficient and lower-GHG-emission vehicles by 2010 (see Figure 3-6)
- the annual ecoENERGY for Vehicles Awards, which recognize and identify for consumers, the most fuel-efficient light-duty vehicles in their classes available in Canada
- the Auto$mart driver education series, which teaches drivers how to drive safely, save fuel and money, and protect the environment by using fuel-efficient driving techniques
- idle-free and tire maintenance campaigns that use educational materials and outreach activities to encourage drivers to embrace fuel-efficient practices

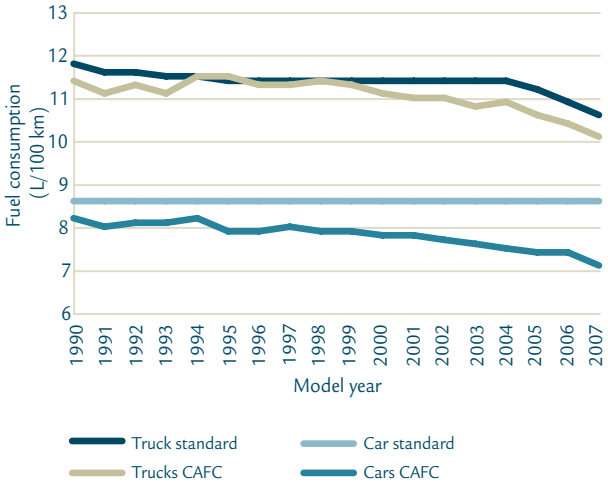
FIGURE 3-5
New Vehicle Fuel Efficiency Labelling



Source: Corporate research Associates, *2007 EnerGuide Label for Vehicles and Fuel Consumption Guide Audit Survey: Final Overall Report*, May 2007.

FIGURE 3-6

Company Average Fuel Consumption (CAFC) Versus Canadian Voluntary Standards, 1990 to 2007*



*2003–2007 data are estimates.

Source: www.tc.gc.ca/eng/programs/environment-fcp-cafctargets-385.htm

Key 2008–2009 Achievements

- Distributed more than 350 000 copies of the *Fuel Consumption Guide*, including 186 000 to 3386 new car dealerships and 53 000 to Canadian Automobile Association offices.
- Trained more than 440 000 new drivers annually in fuel-efficient driving practices.
- The "Be Tire Smart" campaign educated more than 7 million people about the environmental and fuel economy benefits of proper tire inflation and regular maintenance.
- Influenced 4 million drivers with the idle-reduction campaign.
- To date, the estimated GHG emission reductions associated with idle reduction and tire maintenance campaigns and with new driver training are 0.06 Mt.

For more information:

vehicles.nrcan.gc.ca

ecoENERGY FOR FLEETS

Objective

To achieve reductions in fuel use and related costs, air contaminants and GHG emissions through a wide range of measures targeting operators and managers of Canada's commercial and institutional road vehicle fleets.

Description

Initiated April 1, 2007, the ecoENERGY for Fleets program is investing $22 million over four years to promote the adoption of existing and emerging new technologies, such as energy-efficient vehicle components and hybrid technologies, and best practices, such as fuel management techniques.

ecoENERGY for Fleets is aimed at the commercial/institutional fleet transportation sector and provides information, workshops, technical demonstrations and training programs on fuel-efficient practices for fleet vehicles.

Program components include the following:

- the "Idle-Free Quiet Zone" campaign, which uses educational materials and incentives to encourage truck drivers to turn off their vehicles at truck stops
- Fuel Management 101 workshops, which assist fleet managers with the preparation, implementation and monitoring of a fuel management plan
- SmartDriver training programs, which offer knowledge sharing and on-the-road instruction to drivers of various types of fleets for the purpose of reducing fuel consumption

Key 2008–2009 Achievements

- Completed three idling awareness campaigns.
- Included 170 fleets in 12 Fuel Management 101 workshops to promote greater uptake of transportation energy efficiency practices.
- Trained 451 school bus drivers under the SmartDriver for School Bus program.
- Since program inception, a reduction of approximately 0.05 Mt of GHG emissions can be attributed to the ecoENERGY for Fleets program.

For more information:
fleetsmart.gc.ca

ecoENERGY FOR BIOFUELS

Objective

To support the production of renewable alternatives to gasoline and diesel and encourage the development of a competitive domestic renewable fuel industry.

Description

ecoENERGY for Biofuels is investing up to $1.5 billion over nine years to support the production of renewable alternatives to gasoline and diesel in Canada and encourage the development of a competitive domestic industry for renewable fuels.

Initiated on April 1, 2008, the program makes investments in production facilities more attractive by partially offsetting the risks associated with fluctuating feedstock and fuel prices.

The program provides an operating incentive to producers of renewable alternatives to gasoline, such as ethanol, and renewable alternatives to diesel, such as biodiesel, under conditions where industry requires support to remain profitable. In order to receive an incentive, eligible recipients must have signed a Contribution Agreement with NRCan and must have met the requirements of the *Canadian Environmental Assessment Act* and comply with all other applicable federal, provincial and municipal environmental legislation.

ecoENERGY for Biofuels is a key component of Canada's renewable fuels strategy, which aims to

- reduce the GHG emissions resulting from fuel use
- encourage greater production of biofuels
- accelerate the commercialization of new biofuel technologies
- provide new market opportunities for agricultural producers and rural communities

Key 2008–2009 Achievements

- The ecoENERGY for Biofuels program received 46 applications.
- The program deemed 24 applicants eligible for funding, and NRCan signed contribution agreements with 22 companies, representing a total commitment of $938 million and a domestic production of 1.6 billion litres (L) of biofuels (1.4 billion L of ethanol and 0.229 billion L of biodiesel).
- Seven information sessions were conducted across Canada in May and June 2008.

For more information:
ecoaction.gc.ca/biofuels

FEDERAL BUILDINGS INITIATIVE

Objective

To assist Government of Canada organizations in implementing energy efficiency upgrades that lead to reduced energy and water use, GHG emissions and operating costs.

Description

The Federal Buildings Initiative (FBI) is an energy efficiency program targeting federal departments and agencies and Crown corporations. The FBI provides a range of products and services required by an organization to implement comprehensive energy efficiency improvement projects in its facilities.

The products 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. FBI services include facilitation such as energy management technical advice, program policy advice and procurement services to assist organizations in making energy efficiency improvements.

Other levels of government, institutions and private sector firms also draw on the FBI's experience for help in designing their own energy efficiency programs. Since its inception in 1991, the FBI helped upgrade thousands of square metres of federal building floor space, representing one third of the total federal floor space, saving $43 million in energy bills and reducing the risks associated with climate change.

Key 2008–2009 Achievements

- DFAIT Washington Embassy and PWGSC Place du Portage are proceeding with energy efficiency retrofit projects that are expected to save from 15 to 20 percent in annual energy costs.
- To date, the private sector has made new and incremental investments of $320 million in FBI projects.

For more information:
oee.nrcan.gc.ca/communities-government/buildings/federal/federal-buildings-initiative.cfm

NATIONAL RENEWABLE DIESEL DEMONSTRATION

Objective

Initiated in December 2008, the National Renewable Diesel Demonstration Initiative (NRDDI) will address questions from industry and end-users about renewable diesel use by demonstrating how it will perform under Canadian conditions.

Description

The Government of Canada is committed to expanding the production and use of a range of cleaner, renewable biofuels, including renewable diesel. The intent is to reduce GHG emissions that result from fuel use, encourage greater production of biofuels, accelerate the commercialization of new biofuel technologies and provide new market opportunities for agricultural producers and rural communities.

In December 2006, the Government announced its intention to develop a regulation requiring an average annual 2 percent renewable fuel content in diesel fuel and heating oil, upon successful demonstration of renewable diesel fuel use under the range of Canadian conditions.

Renewable diesel has been tested in a variety of vehicle engines under driving conditions in many parts of Europe and the United States. Renewable diesel has also been tested in certain applications in Canada, such as trucks, buses and marine vessels.

During consultation, Canadian industry sectors and end-users have raised questions related to large-scale integration of renewable diesel into fuel distribution networks. The NRDDI aims to address these remaining questions in advance of the proposed regulation coming into effect.

Non-repayable contributions will be provided to approved projects that demonstrate aspects of renewable diesel use and/or distribution in Canada. Funded projects may demonstrate one or more of the following:

- the use of various blend levels
- the use of fuels produced from various feedstocks
- the use of renewable diesel in various applications that diesel fuel is likely to encounter in Canada
- the infrastructure for renewable diesel storage and distribution

Funding will be available to facilitate demonstration projects of different scales in both the on-road transportation and off-road sectors.

Key 2008–2009 Achievements

- Consultations were conducted with industry stakeholders on program design to ensure program effectiveness.
- Program roll-out was completed, including online materials, application forms and a contribution agreement template.
- Reviewed initial proposals and started drafting the first contribution agreements.

For more information:

oee.nrcan.gc.ca/transportation/fuels/biodiesel/NRDDI

CHAPTER 4

Energy Science and Technology

INTRODUCTION

Natural Resources Canada (NRCan) invests in the research, development and demonstration (R,D&D) of new and emerging energy science and technology (S&T) that produces economic, social and environmental benefits for Canadians. NRCan's Office of Energy Research and Development (OERD) and CanmetENERGY lead the federal government's energy S&T operations.

The OERD oversees the management of the Program of Energy Research and Development (PERD) and the ecoENERGY Technology Initiative. These programs allocated more than $86.5 million in the 2008–2009 fiscal year. The funds help find new, long-term, cleaner and more efficient solutions to reducing environmental emissions by developing and disseminating new knowledge and new technologies through R, D&D initiatives. Slightly more than 75 percent of the programs and activities allocated by the OERD are managed and carried out by the Department (including CanmetENERGY). The six departmental priorities listed under CanmetENERGY also apply to OERD.

CanmetENERGY generates and provides knowledge and technologies to advance the development and use of innovative solutions contributing to the well-being of Canadians and to progress toward meeting Canada's economic, social and environmental policy objectives. It works with industry, academia, utilities, associations, non-governmental organizations and other governments to develop and demonstrate energy-efficient, alternative and renewable energy technologies and processes.

CanmetENERGY undertakes projects and activities in the following areas of expertise:

- clean energy systems for buildings and communities
- clean electric power generation
- clean energy systems for industry
- clean transportation energy
- environmentally sustainable oil and gas development
- sustainable bioenergy

This chapter describes in detail the programs, activities and 2008–2009 key achievements of the OERD, CanmetENERGY and other partners in energy S&T.

For more information:
nrcan.gc.ca/eneene/science/index-eng.php
canmetenergy.nrcan.gc.ca

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.

Description

The PERD supports R&D activities within nine portfolios, comprising oil sands and offshore

regulatory issues, sustainable bioenergy, reducing air impacts and improving efficiency in electricity as well as integration of alternative and renewable energy into the grid, and improving efficiencies in end-use, with focus on transportation, buildings and industry. Efficiencies are sought in energy production, distribution and end-use. Examples of funded projects are included in the areas of the program described in this chapter.

The portfolios are managed holistically and encompass the entire innovation spectrum, from basic research to applied research, pilot plants and demonstrations, ensuring faster deployment of technologies developed with federal funds.

The PERD budget for the 2008–2009 fiscal year was approximately $53.6 million. Of that amount, $16.7 million was allocated to 12 federal departments and agencies that are PERD partners, mostly to improve the science supporting Canadian regulations related to energy production and use. The remaining $36.9 million is allocated to energy R&D programs managed and performed in NRCan, more than 70 percent of which contributed to improved energy efficiency and the integration of renewable energy sources in Canada.

ecoENERGY TECHNOLOGY INITIATIVE

Objective

To support the development of next-generation energy technologies needed to break through to emissions-free fossil fuel production, as well as for producing energy from other clean sources, such as renewables and bioenergy and to advance the development and use of new clean energy technologies in end-use sectors.

Description

The ecoENERGY Technology Initiative is a component of ecoACTION, the government's actions toward clean air and greenhouse gas (GHG) emission reductions. It is a $230-million investment in clean energy science and technology. The funding helps in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use.

Part of the funding has been allocated to the demonstration of carbon capture and storage. Eight projects have been selected in this area. Spending in the 2008–2009 fiscal year was nearly $31 million.

CLEAN ENERGY SYSTEMS FOR BUILDINGS AND COMMUNITIES

Objective

To develop, demonstrate and promote – in domestic and foreign markets – technologies, practical decision-making tools, processes, codes, standards and best practices that help communities select more efficient and cost-effective energy, waste and water technologies and design solutions to support a sustainable energy future based on reduced energy consumption and GHG emissions.

Description

CanmetENERGY plays a leadership role in the R,D&D of energy-efficient and renewable energy technologies for houses, buildings and communities by

- fostering the commercialization of new technologies
- identifying and developing opportunities for integration of technologies
- developing infrastructure to support innovation, such as codes, policies and standards
- developing linkages between utilities, industry and academia
- supporting training and education
- disseminating results and findings

- facilitating the export of Canadian technologies to international markets

- engaging in international co-operation

Specific work includes the development of design, modelling and analysis tools and integrated design approaches, such as building energy simulation software making it possible to achieve greater energy efficiency to be implemented at minimal incremental costs. CanmetENERGY develops, distributes and supports building energy simulation software for the Canadian construction industry and Government of Canada ecoACTION programs.

CanmetENERGY is active in conceiving, developing and optimizing energy-efficient space and water heating, ventilation, air-conditioning and refrigeration technologies, and micro-cogeneration systems including standards development, energy efficiency labelling, heat recovery systems, combined heat and power and energy conversion and storage systems, integration of technologies and adaptation to the Canadian context.

CanmetENERGY assists in increasing the use of solar thermal and solar photovoltaic energy technologies in Canada by developing technologies, standards, policies and programs to create a Canadian-based, globally competitive solar industry. Other work includes community energy systems, daylighting, intelligent building controls and commissioning/recommissioning of buildings.

CanmetENERGY's partnerships with industry help to build advanced residential and commercial buildings that incorporate a wide array of innovative technologies and consume significantly less energy than their conventional counterparts. Under cost-sharing arrangements to accelerate the development and commercialization of a new generation of advanced and energy-efficient technologies, CanmetENERGY is helping the Canadian residential and commercial building industry produce some of the most environmentally advanced structures on the planet.

Key 2008–2009 Achievements

- CanmetENERGY is helping to update the *National Energy Code for Buildings*, the revised version of which will be released in 2011. The Standing Committee on Energy Efficiency in Buildings was formed with five task groups. CanmetENERGY is a member of three Task Groups: HVAC and Service Water Heating Systems, Building Envelope, and Building Energy Performance Compliance.

- CanmetENERGY facilitated the integrated design process of NRCan's new Materials Technology Laboratory at McMaster University in Hamilton, Ontario. The integrated design process is a new approach to designing net-zero energy buildings. This LEED® Platinum building is designed for 70 percent energy savings and more than 20 percent renewable energy supply.

- The first extensive study of residential hot water heating system performance in Canada is leading to a revision of performance test standards in Canada and the United States. Results of field testing tankless and conventional hot water tanks by CanmetENERGY highlight the need for updating current test methods to better reflect real use performance and efficiencies of these systems, while fostering development of more efficient technologies.

- CanmetENERGY research into residential and commercial combustion systems contributed to updates in Canada's *Energy Efficiency Regulations* requiring, by the end of 2009, that only highly energy-efficient condensing furnaces can be manufactured in and imported to Canada. This regulatory update followed years of CanmetENERGY research contributions to condensing technology development, Canadian Standards Association standards, and the Office of Energy Efficiency and ENERGY STAR® labelling programs in Canada.

- The Drake Landing Solar Community in Okotoks, Alberta, North America's first solar seasonal storage community, is meeting 65 percent of space heating needs with solar energy in its second year of operation. After it is fully charged, the solar storage system is expected to achieve a world record of meeting 90 percent of heating needs.

- CanmetENERGY increased the number of users of the RETScreen® Clean Energy Project Analysis Software to more than 193 000 people in 222 countries, adding an average of 1000 new users every week (see Figure 4-1). More than 170 colleges and universities worldwide are now using RETScreen for education. As well, CanmetENERGY released a new RETScreen Clean Energy Legal Toolkit that includes sample legal documents freely available from various organizations, newly created Finance Agreements for clean energy projects and an e-Textbook chapter and training slides on the legal aspects of clean energy projects.

- Working with Maisons Alouette Homes and solar building research network partners, CanmetENERGY supported the evaluation and demonstration of the first net-zero energy home project to be completed in Canada. In 2008, Maisons Alouette Homes received the Reconnaissance – Recherche et développement en habitation award. This exceptional prize was awarded to Maisons Alouette Homes out of 1250 eligible businesses, for its EcoTerra™ project.

- CanmetENERGY was instrumental in revising the new Canadian Standards Association (CSA) B52S1-09, Supplement No. 1 to B52-05 to the *Mechanical Refrigeration Code*. This modification will facilitate widespread deployment of carbon dioxide (CO_2) refrigeration systems. CO_2 is a natural refrigerant with a Zero Ozone Depletion Potential and a Greenhouse Warming Potential of 1 compared with 1000 to 4000 for fluorocarbon refrigerants. It is therefore a significant improvement over past chlorofluorocarbon and present fluorocarbon refrigerants.

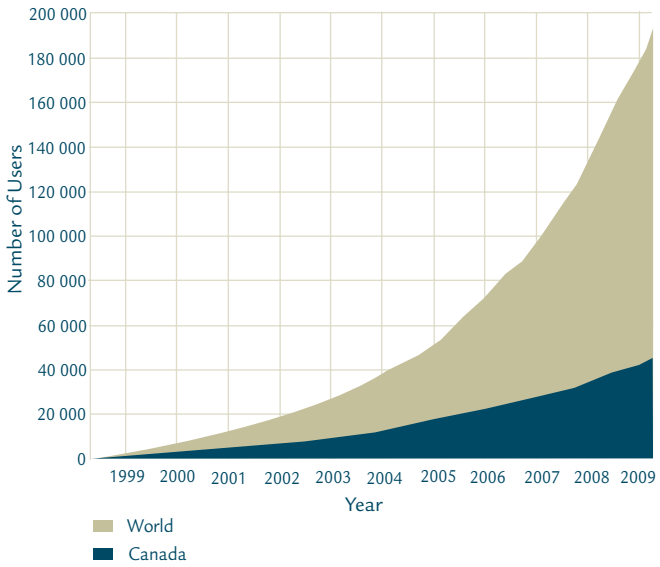
- Through NRCan scientific expertise, the Loblaws Superstore in Scarborough, Ontario, is operating Canada's first low-temperature display cases using CO_2 as a secondary refrigerant. NRCan also worked with the Technical Standards & Safety Authority and the CSA to obtain all the necessary approvals. The project is expected to reduce building energy consumption by 25 percent, synthetic refrigerant leaks by 95 percent and GHG emissions by 50 percent compared with a conventional supermarket.

- NRCan supported the development of an innovative refrigeration system that is installed in all Vancouver Olympic Games facilities requiring a refrigeration system. These technologies have become the preferred environmental solution for reducing the energy use, operating costs and carbon footprint when compared with conventional systems. These systems aim to reduce the total energy consumption of ice rinks, refrigerant quantities, refrigerant leaks and GHG emissions by 50 percent.

- CanmetENERGY has increased the number of qualified recommissioning (RCx) service providers (to about 100) by delivering a Canadian Advanced 3.5-day Retrocommissioning course (available in French and in English). CanmetENERGY also promotes its RCx methodology through its RCx guide. The RCx courses are part of CanmetENERGY's commitment to develop methodology, training programs, tools and case studies to help create awareness, promote standard practices and improve the performance of buildings systems.

FIGURE 4-1

RETScreen Software: Cumulative Growth of User Base



Source: NRCan/RETScreen Customer Database.

For more information:

canmetenergy.nrcan.gc.ca/eng/buildings_communities.html

CLEAN ELECTRIC POWER GENERATION

Objective

To develop and apply technologies for renewable electricity production and for cleaner power generation from fossil fuels, with the goal of increasing efficiency and achieving the reduction and, ultimately, the elimination of emissions of acid rain precursors, GHGs, particulates and identified priority substances, such as mercury, trace elements and organic compounds.

Description

CanmetENERGY's work on clean electric power generation focuses on improving the economics and efficiency of renewable energy technologies, including wind energy, solar power, small and low-head hydro, marine energy and energy storage.

CanmetENERGY's S&T supports the growth of the renewable energy industry in Canada by

- fostering the development of new technologies
- identifying and developing opportunities for building a smart power grid of renewable energy
- developing infrastructure to support innovation, such as codes, policies and standards
- developing linkages between utilities, industry and academia
- conducting nationwide resource assessments and mapping

CanmetENERGY also focuses on improving the performance of, and reducing emissions from, existing fossil fuel power plants. Moreover, it focuses on developing new advanced cycles for the conversion of fossil fuels to electricity with complete or near-complete capture and elimination of CO_2 and other emissions. Additional research includes work on issues associated with the transport and storage of CO_2. Through advanced tools and technologies, CanmetENERGY assists major industrial energy consumers in reducing the energy intensity of their operations and in reducing GHG emissions and emissions of other air pollutants, while enhancing competitiveness and profitability.

CanmetENERGY's work on emerging technologies in clean power includes new forms of power generation, such as wind, solar photovoltaics, small hydro, marine, natural gas combined-cycle plants and advanced fluidized bed combustion. Significant R&D also focuses on CO_2-neutral combustion systems, CO_2 sequestration, CO_2 injection for enhanced oil recovery, advanced power generation cycles, clean coal technologies and distributed energy resources. CanmetENERGY also conducts leading-edge work in the burgeoning priority area of decentralized energy resources, where renewable energy sources are becoming more localized and integrated into the main power grid.

CanmetENERGY

- addresses the technical, institutional and regulatory barriers to clean power by promoting power grid integration, developing standards, generating knowledge and transferring important information to Canadian decision-makers
- provides stakeholders with the necessary information to make informed decisions, coordinates various research projects
- participates in international committees that establish standards and codes
- develops and hosts workshops and conferences
- develops publications and produces training tools
- capitalizes on its sector expertise by carrying out projects in collaboration with key research consortia, including industry, universities, research groups, public services and other departments and governments

Key 2008–2009 Achievements

- Working with industry partners, CanmetENERGY prepared and delivered a course called Integrating Distributed Generation: *Theory, Experience and Best Practices*. This course bridges the gap in knowledge by relating theory through the use of illustrative case studies. Integrating renewable and distributed power generation projects from independent power producers in Canada requires a change in the way the electricity distribution system is managed. And the integration must be done ensuring the safety, reliability and efficiency of the system and ensuring that local utility customers are not adversely affected.
- Working with the CSA, NRCan provided the technical support for the development of a second national interconnection standard: CSA C22.3 No. 9, "Interconnection of distributed resources with electricity supply systems – Interconnection of distributed resources to electricity supply systems up to 50 kV." This standard complements an earlier national standard NRCan helped develop and is helping advance the deployment of distributed electricity sources across Canada.
- CanmetENERGY, in cooperation with Advanced Engine Technology Ltd., Kubota Canada Ltd. and Cummins Onan, developed a 6 kilowatt-electric (kWe) natural gas-fuelled diesel engine for micro-cogeneration applications. Compared with 100 percent diesel operation, nitrous oxide emissions were reduced by 60 percent and CO_2 emissions by more than 12 percent. Rugged, heavy-duty diesel engines fitted with asynchronous generators can create a high-efficiency, long-life micro-cogeneration system at about half the cost of currently available micro-cogeneration systems. As a result of this work, the Saskatchewan Research Council is planning further testing to advance the system toward commercialization.
- CanmetENERGY hosted the First International Conference and Workshop on Micro-Cogeneration Technologies and Applications in cooperation with the International Energy Agency (IEA) and industry partners. The successful conference and workshop, attended by 98 delegates from 14 countries in Europe, Asia and North America, was an excellent forum for technology transfer and international collaboration. The event also served as the final communication exercise for the IEA Annex 42 on micro combined heat and power (micro-CHP) modelling and simulation.
- CanmetENERGY carried out preliminary studies on a micro-cogeneration technology utilizing Stirling engine technology supplied by Whisper Tech Limited of New Zealand. Testing was done at the Canadian Centre for Housing Technology and at the CanmetENERGY laboratories in

Ottawa, and residential pilots were initiated in Calgary, Ottawa and Toronto. Each pilot system generates electricity, produces domestic water heating and contributes heat for space heating. Each project demonstrates a different type of space heating integration, including a single-family detached home with radiant floor heating, a townhouse with multizone forced-air heating with a geo heat pump and a duplex with multizone forced-air heating with partial radiant heat floors.

- NRCan supported the first installation of the Honda Motor Co., Inc.-Climate Energy, LLC system in a Canadian home. The project will help bring this technology to Canada with NRCan advancing the codes and standards necessary. Long-term data collection will identify the benefits of this micro-cogeneration system, which include offsetting a homeowner's electrical costs by up to 60 percent while providing year-round domestic hot water and seasonal space heating. The project will deliver a green co-generation solution with an overall efficiency of approximately 90 percent that replaces the current residential space and water heating systems and adds backup power. The micro-CHP system is powered by natural gas with only approximately 0.3 kilograms (kg) of CO_2 emissions per kilowatt hour (kWh), whereas a coal-fired power plant emits approximately 1.1 kg/kWh of CO_2.

- CanmetENERGY worked with Acumentrics Canada in Kingston, Ontario, to support performance testing of a 1-kW test stand that operates with natural gas, hydrogen or anhydrous ammonia. This project could lead to a new paradigm for distributed energy in which carbon can be captured on a large scale, economically, as part of the manufacturing of the fuel. The resulting carbon-free fuel can then be used to generate electricity locally, at efficiencies rivalling the best large-scale power plants.

- The industry-led, government-supported Wind Technology Roadmap exercise identified key technical issues and action items for the increased deployment of wind energy in Canada. CanmetENERGY managed and provided technical expertise into consultations and workshops that benefited from the input of over 75 industry, academic and government stakeholders. The resulting roadmap document is an important tool in strategic planning for industry and government.

- CanmetENERGY commissioned and released the first pan-Canadian study of Canadian marine energy technologies, representative international technologies and Canada's research and development capacity within this emerging industry. The report provides policy makers, decision-makers and other stakeholders with baseline information on Canada's ability to compete in the marine energy technology market.

- CanmetENERGY research in micro-cogeneration led to an agreement between Ottawa-based Advanced Engine Technology Ltd. and the Saskatchewan Research Council to develop a micro-cogeneration system for small businesses, farms and multi-unit residential buildings. This distributed generation system will allow users to safely generate their own electricity, on- or off-grid, while also providing heat. Micro-cogeneration will displace coal-based electricity by using clean natural gas, help unload the power grid in critical areas or at critical times of the day and increase overall energy efficiency by a factor of nearly three.

For more information:

canmetenergy.nrcan.gc.ca/eng/clean_fossils_fuels.html

canmetenergy.nrcan.gc.ca/eng/renewables.html

CLEAN ENERGY SYSTEMS FOR INDUSTRY

Objective

To identify, encourage and support the development and application of leading-edge, energy-efficient and environmentally responsible processes, practices, products, systems and equipment in Canadian industry to improve its energy efficiency, productivity, competitiveness and profitability, while reducing GHG emissions and other environmental impacts.

Description

CanmetENERGY works with industry to co-manage and share the costs of development and commercialization of a range of technologies, including process integration, learning-based expert systems, combustion systems and controls, manufacturing processes, and environmentally friendly and energy-efficient processes for energy-intensive industries. CanmetENERGY's S&T in the industry sector focuses on plant-wide industrial process analysis techniques and advanced process control systems that identify and correct inefficiencies in plant operation and design while taking into account energy, economic and environmental aspects.

CanmetENERGY's S&T also includes the development and testing of semi-pilot-scale plants, pilot plants, prototypes and full-scale field trials. This research evaluates operating performance, energy efficiency and environmental impacts and emerging concepts in chemical and energy conversion, including hydrogen production from hydrocarbon and renewable sources. In addition, CanmetENERGY disseminates technical information to encourage adoption of these techniques and practices in targeted energy-intensive sectors of Canadian industry.

CanmetENERGY clients are from a variety of industries, including pulp and paper, gas, oil upgrading and refining, petrochemicals, engine manufacturing, steel, chemicals, food and drink, solid wood, waste oil recycling and rendering, and specialty ceramic manufacturing. Its other clients are gas and electric utilities, equipment manufacturers and other governments.

Key 2008–2009 Achievements

- CanmetENERGY research engineers developed a decision-support tool for lumber mills in partnership with Laval University, Québec, Quebec. Lumber-mill production managers can now use this software tool to better plan air-drying operations before kiln drying, with a future impact of improving overall mill energy efficiency and product quality. AbitibiBowater Inc. recently deployed this tool to better plan its sawmills' operations, including shipping lumber between mills throughout the country.

- CanmetENERGY and its partner, Acumentrics of Kingston, Ontario, have modified a hydrogen fuel cell by adding a catalytic surface developed at CanmetENERGY and operating the fuel cell on ammonia. The catalyst performed as well as at the bench scale, and there were no ammonia or nitrous oxide emissions. Ammonia fuel cells can take advantage of the large amount of ammonia currently being incinerated in industrial wastewater treatment. As well, the industrial production of ammonia creates pure CO_2. Ammonia is also an industrial and agricultural product with some infrastructure capacity.

- CanmetENERGY supported the renewal of the NSERC Chair in Environmental Design Engineering in co-operation with the Natural Sciences and Engineering Research Council of Canada (NSERC), Kruger Inc., White Birch Paper Company, Papier Masson Ltd., NewPage Corporation, Cascades Canada, Ltd,. Tembec

Inc. and the École Polytechnique de Montréal. Cost-effective and energy-efficient designs for the pulp and paper industry will be developed through this collaborative research program.

- CanmetENERGY has signed an agreement with NOVA Chemicals Corporation to undergo an energy-efficient retrofit of two of its largest olefin production facilities. This work features the development and application of a new thermodynamically based design methodology for distillation process debottlenecking through hybridisation with advanced separation technologies.

- CanmetENERGY established a five-year collaboration with the Agence de l'efficacité énergétique to help Quebec industrial facilities maximize heat recovery and reduce their petroleum products use and corresponding air emissions cost-effectively. These improvements will be achieved through the use of a plant-wide energy management approach called process integration. This collaboration includes activities to expand the capacity of Quebec engineering firms to undertake global energy analyses in order to uncover substantial efficiency gains.

For more information:
canmetenergy.nrcan.gc.ca/eng/industrial_processes.html

ENVIRONMENTALLY SUSTAINABLE OIL AND GAS

Objective

To provide S&T for the continued, secure supply of affordable, cleaner, and more efficient fossil fuels, with little or no adverse environmental impact on GHG and Criteria Air Contaminants (CAC) emissions, and thereby help resolve oil sands environmental issues (including water) and clean air issues for the upstream oil and gas industry.

Description

CanmetENERGY conducts fundamental and applied research to develop knowledge and implement leading-edge technologies for the oil sands sector. Knowledge gained is used to inform energy policy development and industry decisions that will improve the quality of life for Canadians.

CanmetENERGY fosters innovation in oil sands and heavy oil technology through activities ranging from fundamental science to commercial-scale technical support. CanmetENERGY's strength lies in its staff's fundamental understanding of the chemistry, physics and engineering of oil sands and heavy oil processes, coupled with sophisticated analytical instrumentation and pilot-scale units providing proof of concept for technologies.

S&T is a key tool used by NRCan to make significant progress toward meeting its water and tailings, GHG and other air emissions challenges in the oil and gas sector. Major improvements need to be made in the entire process chain of oil sands and heavy oil development, from the initial extraction to the production of petroleum products.

CanmetENERGY's international client base and partnerships with provincial and territorial governments, industry and academia ensure that the best available technologies in the world can be applied to the resource. Its partnerships also ensure there are strong synergies and fast-track deployment of new technologies, innovations and knowledge dissemination.

Key 2008–2009 Achievements

- CanmetENERGY, in collaboration with the U.S. Department of Energy's National Renewable Energy Labs (Oakridge National Lab and Pacific North-West Lab), is working to increase the value of Canadian bitumen. Activities included the employment of both conventional

and newly developed techniques for the characterization of hydrocarbon streams. This characterization is essential for evaluating the suitability of fuels for advanced combustion engines. CanmetENERGY scientists identified deficiencies in current chemistry analysis of diesel fuel, specifically, the need for advanced two-dimensional gas chromatography. As a result, the U.S. Department of Energy (U.S DOE) is expanding its efforts to understand the influence of fuel chemistry on the effectiveness of modern engines.

- In the attempt to demonstrate a tailings technology that will reduce the water requirements for producing a barrel of oil, CanmetENERGY conducted the first field tests of the dry stackable tailings at Syncrude's oil sands mine.

- In anticipation of the impact California's low-carbon fuel standards will have on Canadian bitumen, CanmetENERGY completed a life-cycle analysis on oil sands-derived fuels. CanmetENERGY, in collaboration with Petroleum Technology Alliance Canada, organized a workshop on a fuel-cycle model called U.S. DOE Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation. Subsequently, two studies funded by the Alberta Energy Research Institute were initiated as a result of this workshop.

- CanmetENERGY, through the National Centre for Upgrading Technology, has worked with a small enterprise, ETX Systems Inc., to provide a proof of concept for a new upgrading technology that reduces the negative environmental impact while producing higher quality liquids compared with existing benchmarks.

For more information:
canmetenergy.nrcan.gc.ca/eng/clean_fossils_fuels.html

CLEAN TRANSPORTATION ENERGY

Objective

To develop and deploy, in partnership with industry, academia and the provinces and territories, leading-edge hydrogen, fuel cell and transportation energy technologies that reduce GHG emissions and minimize urban air pollution.

Description

CanmetENERGY works with stakeholders in domestic and international hydrogen and transportation industries. These industries include original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial and territorial governments, research organizations, universities, other federal departments, the U.S. DOE, the International Energy Agency and the International Partnership for the Hydrogen Economy. Together, in these partnerships, projects are well leveraged – typically at a 50:50 ratio.

Transportation research, development and deployment activities at CanmetENERGY are grouped into three principal technology areas: hydrogen and fuel cells, hybrid and electric vehicles, and advanced fuels and technologies. All three technology areas are highly involved in domestic and international outreach, and safety, codes and standards for technology adaption and integration.

Since the early 1980s, CanmetENERGY's partnerships with industry have been playing a significant role in establishing Canada as a world leader in fuel cell and hydrogen-refuelling technologies.

Today near-term accomplishments are being made in the transportation and materials handling sectors. Research and development in production, storage and utilization continue to lower costs and improve the performance of the hydrogen technologies. Hydrogen fuelling stations and hydrogen-powered

forklifts, airport baggage-tuggers, personal vehicles and shuttle buses continue to be deployed across Canada. In addition to vehicles and fuelling stations, developments in waste hydrogen capture and purification, production, distribution and storage are building the hydrogen infrastructure.

As well, applications in markets outside the transportation sector are being realized, such as micro fuel cells/portable applications (e.g. laptops and cellular phones) and stationary applications (e.g. off-grid and backup power for computers and buildings).

Electricity as an alternative transportation fuel is also becoming a near-term reality for Canada. Hybrid and electric vehicle technologies offer energy-saving advantages over current vehicle technologies that run solely on conventional fuels such as gasoline or diesel.

CanmetENERGY is involved in research and development of on-board energy-storage and power systems, such as batteries and fuel cells. In 2008, CanmetENERGY took on the Government of Canada lead for the *Electric Vehicle Technology Roadmap for Canada*, which it completed in 2009.

Advanced fuels and technologies encompass all fuels and technologies in addition to hydrogen and fuel cells and hybrid and electric vehicles – examples are biodiesel, natural gas and ethanol. CanmetENERGY supports research and development for testing advanced fuels and fuel usage, as well as engine performance and components.

This area of research and development is serving to strengthen a Canadian industry that is now exporting commercial products. International collaborative efforts are helping to leverage Canada's research funding – particularly for the evaluation of fuels and hardware performance and in developing standards.

Key 2008–2009 Achievements

Research and Development

- A hydrogen and fuel cell laboratory was established at CanmetENERGY's Bells Corners Complex in Ottawa, Ontario. The lab is now fully operational for processing and characterizing new materials for fuel cells and nanomaterials for storage. The CanmetENERGY lab will provide research expertise to external partners and access to unique facilities to meet joint technical targets.

- A prototype lightweight hydrogen storage energy pack was developed through a CanmetENERGY partnership with Angstrom Power Inc. The prototype hydrogen storage unit is the same size as four D-cell batteries but offers nearly 50 percent greater energy density and run-time compared with the current D-cell battery technology. This prototype development strengthens the competitive advantages of hydrogen and fuel cells over batteries for portable applications.

- CanmetENERGY supported Hyteon Inc. to develop a new fuel cell-powered combined heat and power (CHP) system. This CHP system uses high temperature proton exchange membrane fuel cell technology to generate electricity and heat for residential applications. When combined with a common heat exchanger, residual heat from the CHP system can be used to heat domestic water. This new CHP system significantly improves operation efficiency and is made from low-cost, lightweight materials. Fuel-cell CHP systems present a viable option to reduce natural gas use.

- CanmetENERGY contributed to the development of the Directory of Electric Mobility Resources for Canada. The directory will assist the entire electric vehicle community, including government agencies, academic institutions and the private sector, in finding the right resources

to forge partnerships and to increase business development. The directory is available to the public from the Electric Mobility Canada Web site at www.emc-mec.ca.

- Through NRCan expertise, the ISO 1611 standard was published under a United Nations subcommittee that deals with the transportation of dangerous goods. Prior to this standard, shipping hydrogen storage assemblies was very costly and time consuming. This standard makes this process much more efficient because ISO 1611 sets the basic requirement for the safe shipment of hydrogen stored in metal hydride assemblies.

Demonstration

- Four stationary fuelling stations and one mobile fuelling station are operating in British Columbia as part of the Hydrogen Highway™. The five Ford Focus fuel-cell cars successfully completed their fourth year of on-road testing and evaluation in the Vancouver and Victoria areas, accumulating 270 000 kilometres of use.

- Two Ford hydrogen internal combustion engine shuttle buses, along with their hydrogen fuelling infrastructure, have been running successfully in regular transit in Charlottetown, Prince Edward Island. Field testing of the buses has collected data on the viability of these technologies, and more than 50 first responders were trained on hydrogen safety. Hydrogen produced from wind power at North Cape will be integrated next year. This project demonstrates utilization of hydrogen and renewable energy in the transportation sector.

- In 2008, CanmetENERGY was involved in two demonstrations programs supporting the mandate proposed by the Government of Canada of a 2 percent annual average renewable diesel content in the Canadian diesel pool by 2012. CanmetENERGY provided technical expertise for the Alberta Renewable Diesel Demonstration – Canada's largest cold-weather study of renewable diesel fuels. The program successfully demonstrated the on-road use of low-level renewable diesel blends in a range of Canadian climatic conditions. CanmetENERGY also helped design the program structure for the National Renewable Diesel Demonstration Initiative and continues to provide technical advice to the program.

For more information:
canmetenergy.nrcan.gc.ca/eng/transportation.html

SUSTAINABLE BIOENERGY

Objective

To assist Canadian industry in the R,D&D of bioenergy technologies, thereby increasing the production and use of bioenergy, which generates environmental and economic benefits.

Description

CanmetENERGY supports the R,D&D of bioenergy technology through cost-shared agreements, promotes bioenergy as a renewable and sustainable energy source, advocates the need for proper policies and programs relating to bioenergy, and raises the public's and policy makers' awareness of the benefits of bioenergy.

CanmetENERGY's biomass energy conversion technology expertise covers the following main processes:

- combustion – converting forestry, agricultural and municipal residues into heat and power under environmentally sound conditions

- gasification – converting forestry, agricultural and municipal residues into syngas

- pyrolysis – converting forestry and agricultural residues into bio-oils and value-added products

- fermentation – converting the starch and cellulose components in biomass into bio-ethanol

- transesterification – converting a variety of new and used vegetable oils, tallow and yellow grease into bio-diesel

- anaerobic digestion – converting manures and food-processing and municipal wastes into methane-rich biogas

Activities focus on improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics to potential users, and helping industry demonstrate its products in domestic and foreign markets.

Initiatives include R,D&D, technical and socio-economic studies, end-use demonstrations and testing, feasibility studies, process analysis, verification, testing and improvement, standards development, emissions reductions, modelling, conference and workshop support, information dissemination, International Energy Agency collaboration and committees, stakeholder education, and standards development.

CanmetENERGY plays a leadership role in the Canadian Biomass Innovation Network, a multidepartmental working group formed to direct federal R&D on bioenergy and bioproducts. Clients include the agricultural and forestry sectors (biomass producers and bioenergy consumers), municipalities and industrial partners.

Key 2008–2009 Achievements

- Several energy technologies are being fast-tracked through the National Bioproducts Program, a joint initiative of National Research Council Canada (NRC), Agriculture and Agri-Food Canada (AAFC) and CanmetENERGY. One of these is the production of renewable diesel fuel from marine algae, which is based upon R&D performed by NRC on the selection and growing of algae, combined with CanmetENERGY R&D researching the conversion of the algae oil and residue to energy products. Another technology is based on NRC and AAFC developing crops that produce residues suitable for conversion to energy products in CanmetENERGY's pilot facilities, a technical challenge based on the wide variation of feed properties and the production of heat and power consistent with industrial and commercial expectations.

- CanmetENERGY is working with the producers of wood pellets and power utilities to develop the codes and standards needed to safely and efficiently burn wood pellets in existing coal-powered generating stations. The issues to be addressed include the different flammability properties of wood pellets compared with coal and how to control the ash. Utilities are planning to switch fuels from conventional coal to biomass and are relying on these codes and standards for their planning.

- CanmetENERGY has joint initiatives with provincial departments of agriculture on helping greenhouses adjust to the high cost of natural gas by developing the control technologies to burn biomass. This initiative includes developing a biomass fuels protocol that includes a database of biomass residues properties and guidelines for emissions standards. R&D activities include the development of optimized controls for biomass boilers and flue gas cleaning so that CO_2 can be used in the greenhouses to encourage growth.

For more information:
canmetenergy.nrcan.gc.ca/eng/bioenergy.html

CANADIAN BIOMASS INNOVATION NETWORK

Objective

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

Description

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

CBIN is a horizontal program developed and managed by five departments: AAFC, Environment Canada, Industry Canada, NRC and NRCan. CBIN coordinates and manages two federal government bio-based R&D initiatives:

- the PERD Bio-Based Energy Systems and Technologies program ($3.3 million in 2008–2009)
- the ecoENERGY Technology Initiative Bio-Based Energy Systems ($2.2 million in 2008–2009)

Key 2008–2009 Achievements

- NRCan funding promotes the better utilization of fast-growing plantations as part of new sustainable forest management strategies being developed across Canada. It also increases social pressure to manage native forests in a sustainable and ecological manner, which reinforces the necessity of developing alternatives to traditional forestry (i.e. harvesting natural forests).
- In 2008, the Quebec department of agriculture (le ministère de l'Agriculture, des Pêcheries et de l'Alimentation) recognized all energy-dedicated crops, including short-rotation plantation/agroforestry systems, as agricultural crops. This change was supported by the findings of two reports funded by the Technology and Innovation Research and Development Initiative, and will grant Quebec producers of short-rotation woody biomass a legal status similar to that of farmers, with the associated financial benefits.
- A new type of woody crop harvester was developed by AAFC through the previous Technology and Innovation Research and Development Initiative. The prototype, called the "bio-baler" (patent pending in Canada, the United States and Brazil), was based on a modified conventional agricultural baler. This high-efficiency, high-volume biomass compactor and baler is versatile and powerful. It transforms vegetal and woody biomass into compressed round bales designed for industrial use. This innovative equipment has the potential to accelerate the availability of woody crops from various land types, including marginal and fallow fields. It is both less expensive and more effective than conventional technologies.
- Combustion testing of municipal biosolids at an NRCan lab provided the performance and environmental data required by the City of Buffalo, Minnesota, to install a combustor from KMW Energy Inc. of London, Ontario, in its wastewater treatment facility. Since its successful start-up, the facility has received an engineering award from the Minnesota American Council of Engineering Companies.

For more information:
www.cbin.gc.ca

CHAPTER 5

Renewable Energy

RENEWABLE ENERGY USE

In 2007, renewable sources accounted for approximately 62 of Canadian installed electricity capacity (see Table 5-1). Most of the renewable energy used in Canada comes from either hydroelectricity or thermal energy from biomass, such as wood-waste sources (see Table 5-2).

TABLE 5-1

Electricity Generation Capacity From Renewable Sources (includes hydroelectricity)

Year	Renewable electricity generation capacity (megawatts)	Total capacity (percent)	Percent change
1990	59 557	58	_
1991	61 116	58	3.0
1992	62 895	58	2.9
1993	63 114	56	0.3
1994	63 175	56	0.1
1995	66 542	57	5.3
1996	67 101	59	0.8
1997	68 202	61	1.6
1998	68 340	62	0.2
1999	68 614	61.8	0.4
2000	69 031	62	0.6
2001	68 845	61.2	-0.3
2002	71 032	61.8	3.2
2003	72 275	61.8	1.7
2004	72 947	60.4	0.9
2005	74 368	61.2	1.9
2006	75 812	61.3	1.9
2007	76 890	61.8	1.4

Source: Statistics Canada, Electric Power Generating Stations (Cat. No. 57-206-XIB).

TABLE 5-2

Renewable Energy Markets and Technologies Used in Canada

Electricity – Commercial	**Mechanical Power**
Hydroelectric dams	Wind water pumps
Tidal barrages	
In-stream current devices	**Thermal Energy**
Biomass (e.g. wood waste)	Biomass (e.g. roundwood, pellets, wood chips)
Biogas (e.g. methane from landfill sites)	Ground-source heat pumps (i.e. earth energy)
Wind turbines	Solar air-heating systems
Photovoltaic systems	Solar hot water systems
Electricity – In development	**Transportation**
Wave systems	Biodiesel
Tidal systems	Ethanol from biomass

Hydroelectricity

Hydroelectricity is a renewable form of electricity 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 59 percent of the electricity generated in 2007. Canada's hydro supply is dominated by large-scale projects that were developed by electric utilities. Of the 72 436 megawatts (MW) of installed hydro capacity, 3301 MW come from small hydro sites (capacity less than 50 MW), equal to about 2.7 percent of Canada's total installed electricity capacity. Significant potential remains for additional hydroelectric development in most provinces and territories.

Biomass

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

Biomass supply typically takes the following forms:

- 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

Approximately 4.6 percent of Canada's total energy supply comes from bioenergy, second only to hydro power (which generates 11.5 percent of Canada's energy). Most of the bioenergy produced is in the form of industrial process heat, electricity and residential space heating.

The pulp and paper industry is Canada's major producer and user of bioenergy. In 2007, more than 657 MW of biomass power came from spent pulping liquor used in the pulp and paper industry, representing approximately 42 percent of the total biomass generating capacity.

Heat and electricity produced by industry, electricity generated by independent power producers, and residential wood heat are considered commonplace in Canada's energy mix. For example, approximately 3 million Canadian households use wood for home heating. Roundwood is typically used but alternatives include wood chips and pellets. Wood for home heating is usually burned in 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.

Use of 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.

In 2007, the biomass installed capacity was 1578 MW, of which approximately 10 percent was from landfill gas plants (119 MW) and municipal solid waste plants (35.7 MW). 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. Canada has the potential to increase its bioenergy production in a sustainable manner.

Earth Energy

As a result of the sun heating the surface of the planet, and because of the insulating qualities of the earth itself, the temperature 1 or 2 metres below the surface remains fairly constant – between 5°C and 10°C. This temperature is warmer than that of the air during the winter and cooler than that of the air in the summer.

A ground-source heat pump takes advantage of this temperature difference by using the earth or groundwater 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 31, 2008, 2369 MW of wind power were installed in Canada. This makes Canada the thirteenth country that has reached the 1000-MW milestone and the country with the twelfth-largest installed wind energy capacity.

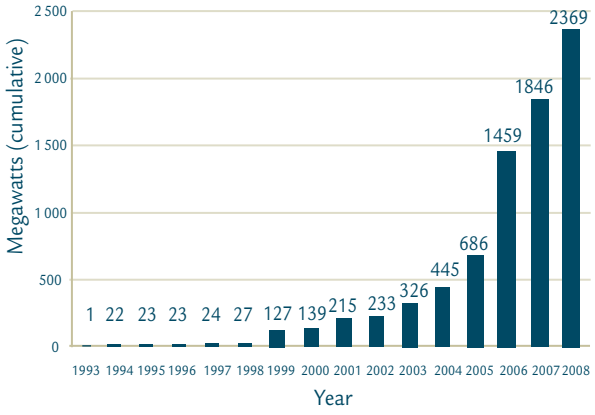
In 2008, Canadian wind power grew to 2369 MW – a 28 percent increase from the 2007 level (1846 MW) (see Figure 5.1). Proposals to build Canada's first offshore wind farms on submerged lands near British Columbia and in Lake Ontario are proceeding through the permitting stage.

Federal and provincial policies continue to spur growth in the Canadian wind industry. Wind energy accounted for approximately 1.1 percent of Canada's total electricity generation in 2008, up from 0.9 percent in 2007.

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 5-1

Canadian Wind Power Capacity, 1993 to 2008



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 [PV]) systems – solar radiation is used to produce electricity

The Canadian active solar thermal installed capacity in 2007 was 544 000 square metres (m^2), or 380 $MW_{thermal}$. The domestic market increase has averaged 13 percent annually since 1998. In 2007, the solar thermal collector market in Canada was 60 900 m^2, compared with 61 800 m^2 in 2006, but revenues were up by 7 percent. This is likely due to increased domestic sales of glazed and evacuated tube collectors and reduced sales of unglazed air heating collectors in this period.

Canada's PV installed capacity in 2007 was 25.8 MW, with a sustained unsubsidized domestic market growth that has averaged 25 percent annually since 1992. In 2007, the PV module market in Canada was 5.92 MW, compared with 3.75 MW in 2005.

Ocean Renewable Energy

Ocean renewable energy refers to the use of ocean waves, current and tides to generate electricity. Devices that capture ocean or tidal currents can also be deployed in rivers and streams.

Since 1984, Canada has had the only commercial tidal energy facility in North America — the 20-MW plant in Annapolis, Nova Scotia. However, like wave and current devices, the next generation of tidal power generators is in an early stage of development, and as yet no commercial facilities have been proposed.

Canada is well poised to become a leader in global technology development and deployment. Canadian technology developers are planning and testing devices, and several demonstration projects are underway.

Natural Resources Canada carries out two initiatives to increase the use of renewable energy in Canada: ecoENERGY for Renewable Power and ecoENERGY for Renewable Heat. The two programs are outlined below.

ecoENERGY FOR RENEWABLE POWER

Objective

To encourage the production of 14.3 terawatt hours (TWh) of electricity from low-impact renewable energy sources (about 4000 MW of new capacity), such as wind, hydro, biomass, solar PV and ocean energy, between April 1, 2007, and March 31, 2011.

Description

The ecoENERGY for Renewable Power program provides an incentive of one cent per kilowatt hour to an eligible low-impact renewable energy project for up to 10 years. Eligible recipients include businesses, institutions/organizations, independent power producers, public and private utilities, and co-operatives that install qualifying renewable power systems. Qualifying projects must have a total rated capacity of 1 MW or greater.

Key 2008–2009 Achievements

- At March 31, 2008, 52 contribution agreements were signed with proponents, representing about $900 million in federal funding over 10 years and 2700 MW of renewable power capacity.
- After all 52 projects are commissioned, the expected greenhouse gas (GHG) emission reductions from full-year operations are expected to be about 4.2 megatonnes per year.

For more information:
ecoaction.gc.ca/ecorp

ecoENERGY FOR RENEWABLE HEAT

Objective

To increase the use of renewable energy technologies, develop thermal energy industry capacity and contribute to the reduction of harmful emissions. This four-year program was launched April 1, 2007.

Description

The ecoENERGY for Renewable Heat program supports renewable thermal technologies used for space heating and cooling and water heating, through a mix of deployment incentives, residential pilot projects and industry capacity-development funding:

- deployment incentive – providing a financial contribution to encourage the deployment of solar thermal units in the industrial, commercial and institutional sectors

- residential pilot projects – providing financial contributions to test, through collaborative ventures, various approaches to for the deployment of solar water-heating units in the residential sector

- industry capacity-development – providing financial contributions to develop technology standards, certification procedures for solar thermal technologies, human resources skills and tools for renewable thermal technologies and to provide public information on renewable thermal energy technologies

Key 2008–2009 Achievements

- Installed 297 solar thermal systems in the industrial and commerical/institutional sectors.

- Signed contribution agreements with 11 partners (utilities, developers and buyers' groups) to run pilot projects that will test ways to deploy solar-heated water in the residential sector. Under the pilot projects, up to 6100 solar water-heating systems will be installed in Canadian homes by 2010.

- Established a partnership with one provincial government, bringing the number of arrangements with provincial governments for complementary programs to three.

- Entered into partnerships with two renewable energy industry associations and two other groups to improve training and certification of solar and geoexchange industry professionals.

- Nine contribution agreements were signed with companies for the certification of solar domestic packaged water-heating systems.

- The estimated GHG reduction from systems installed under the program during 2008–2009 is expected to be 5.5 kilotonnes (kt). After including the GHG reductions from projects completed in 2007–2008, program's estimated cumulative GHG reductions are 8.8 kt.

For more information:
ecoaction.gc.ca/heat

CHAPTER 6

Co-operation

INTRODUCTION

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

Municipal governments and agencies participate in NRCan's EAE measures as clients (for training workshops, as recipients of financial incentives, etc.) and as partners (e.g. in idle-free projects).

At the same time, NRCan participates in ventures led by municipal organizations, such as the Green Municipal Fund (see accompanying textbox), and by provincially and territorially regulated electricity utilities and provincially regulated natural gas utilities.

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. Their main objectives are to facilitate access to data on energy use in the industry, transportation and building sectors; monitor the quality of data; and investigate methods of improving data collection and analysis.

There are two national consultative bodies in the area of energy efficiency: the Assistant Deputy Minister Steering Committee on Energy Efficiency (ASCEE), established under the Council of Energy Ministers; and the Office of Energy Efficiency's (OEE's) National Advisory Council on Energy Efficiency (NACEE).

Green Municipal Fund

The Government of Canada endowed the Federation of Canadian Municipalities (FCM), a non-profit organization, with $550 million to establish the Green Municipal Fund (GMF) for the purpose of providing a long-term, sustainable source of funding for municipal governments and their partners. The GMF invests in plans, studies and projects that offer the best examples of municipal leadership in sustainable development and that can be replicated in other Canadian communities.

Under the GMF agreement, the Government of Canada (represented by NRCan and Environment Canada) participates in governance of this revolving 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 in light of the council's recommendations. As of March 31, 2009, the GMF had approved more than $402 million for 735 plans, studies and projects with a total project value of $2.6 billion.

ASSISTANT DEPUTY MINISTER STEERING COMMITTEE ON ENERGY EFFICIENCY

In 2004, federal, provincial and territorial energy ministers established the ASCEE and tasked it with establishing a coordinated, complementary agenda for energy efficiency in the built environment, industry and transportation sectors. The ASCEE held three meetings in the 2008–2009 fiscal year, with members representing the federal, provincial and territorial governments.

There are three working groups under the auspices of the ASCEE. In 2007, these groups contributed to the development of the Council of Energy Ministers' document *Moving Forward on Energy Efficiency in Canada: A Foundation for Action*.

Responding to Ministers' direction, the three ASCEE working groups are undertaking actions to develop concrete energy efficiency initiatives based on the themes and ideas in *Moving Forward on Energy Efficiency in Canada.* These may be delivered by multiple jurisdictions and in conjunction with key stakeholders.

- Formed in 2003, the Demand Side Management Working Group (DSMWG) has members representing NRCan, industry and all provinces and territories. DSMWG has subcommittees performing collaborative tasks in the following areas:

  - *National Energy Code for Buildings*
  - building energy benchmarking
  - commissioning and recommissioning of buildings
  - energy-efficient equipment
  - integrated community energy solutions
  - lower-income-household energy efficiency options
  - accelerated penetration of energy-efficient home retrofits

- The ASCEE sponsored the formation of the Transportation Working Group on Energy Efficiency (TWGEE) in 2005. Its mandate is to assess the status and enhance the alignment of transportation energy efficiency activities across federal, provincial and territorial jurisdictions and to investigate opportunities for further collaboration and new initiatives. The TWGEE comprises government officials from federal, provincial and territorial energy and transportation departments and ministries. In the 2008–2009 fiscal year, TWGEE members worked to identify four technology areas affecting heavy-duty intercity transport trucks that have the potential to improve fuel efficiency and thereby reduce greenhouse gas emissions. These areas are aerodynamics, idle reduction, low-rolling resistance tires and long-combination vehicles. Work is underway to develop collaborative actions that may be undertaken by federal, provincial and territorial governments in the first three technology areas.

- The Industry Working Group on Energy Efficiency was formed in 2006. It promotes 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.

NATIONAL ADVISORY COUNCIL ON ENERGY EFFICIENCY

NACEE was created in April 1998 to assist the OEE as an innovative government organization by

- assessing and advising on the OEE's strategic approach to meeting federal policy objectives

- advising the OEE on its performance and business planning and reporting on progress

- considering issues related to accelerating growth in energy efficiency in the Canadian economy

NACEE membership is drawn from across Canada. It includes representatives from various levels of government, academia, economic sectors, energy utilities and advocacy groups. NACEE met three times during the 2008–2009 fiscal year.

FEDERAL-PROVINCIAL AND FEDERAL-TERRITORIAL CO-OPERATION

Interest continues to grow in energy efficiency as a means of maximizing services based on the existing energy supply capacity in the country. In addition to general co-operation on energy efficiency, provincial and territorial governments helped to deliver tools, or employed tools provided by federal EAE programs, to reduce energy costs, address climate change, increase competitiveness, improve air quality and create economic opportunities. Coordination between the federal and provincial/territorial levels avoids duplication and ensures efficient program delivery.

All provinces and territories engage in energy efficiency activities and/or deliver energy efficiency programs in their jurisdictions. In some provinces and territories, specific organizations are mandated to promote energy efficiency.

For example, one of the objectives of Alberta's Climate Change Central is to focus on information and action on energy efficiency and conservation in the province.

The Office of the Fire Commissioner of Manitoba is engaging stakeholders in a review of the Energy Code Advisory Committee recommendations, the introduction of water efficiency in the plumbing code and the identification of barriers in the *Manitoba Building Code* to energy and water efficiency in buildings.

The Ontario Power Authority's Conservation Bureau provides leadership in planning and coordinating measures for electricity conservation and load management.

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.

Recently, there has been a greater focus on energy efficiency in the Maritime provinces, as evidenced by the creation of three agencies: Efficiency NB, Conserve Nova Scotia and Prince Edward Island's (P.E.I.'s) Office of Energy Efficiency.

Efficiency NB's mandate is to promote efficient energy use, help control energy expenses and lessen the impact of energy use on the environment, while P.E.I.'s Office of Energy Efficiency provides advice and programs to promote sustainable energy use.

Other regional organizations of note are the Arctic Energy Alliance in the Northwest Territories, the Nunavut Energy Centre and the Agence de l'efficacité énergétique du Québec.

Use of Federal EAE Program Tools by Utilities, Provinces and Territories

Provincial and territorial governments and utilities use federal EAE program tools to complement their own energy efficiency programs. Here are some examples:

- Homeowners in all regions of Canada, except one province and one territory, can access both provincial/territorial and federal home retrofit programs through a single energy evaluation offered under ecoENERGY Retrofit – Homes. The ecoENERGY evaluation and its criteria are also used by these jurisdictions to determine eligibility for incentives.

- Canadians in most provinces and territories can benefit from rebates and sales tax exemptions on selected ENERGY STAR® products. The ENERGY STAR program is administered by the OEE and is used by a number of provinces and utilities as a qualifying criterion.

- NRCan's R-2000 Standard is used by utilities in Manitoba, New Brunswick, and Nova Scotia as a qualifying criterion for incentives and rebates designed to encourage the construction of energy-efficient new homes.

- All the provincial and territorial bodies (with the exception of Nunavut) responsible for driver education use the Auto$mart Driver Education Kit, developed by the OEE, to educate young drivers on fuel efficiency. For example, Manitoba Public Insurance has recently incorporated an Auto$mart component into its curriculum, and many provinces display the OEE's publications in their licensing bureaus.

- The OEE works in co-operation with many provincial organizations, such as Conserve Nova Scotia, to fund and implement actions to reduce energy use and greenhouse gas emissions from personal vehicles by improving the buying, driving and maintenance practices of Canadians.

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 is made up of representatives from provincial/territorial code and energy ministries, departments and agencies; NRCan; and the Canadian Codes Centre. The objectives of the BECC are as follows:

- 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), which is now called the *National Energy Code for Buildings* (NECB), by responsible authorities

- work in co-operation with the provinces and territories and the Canadian Commission on Building and Fire Codes toward a national consensus on establishing energy efficiency in the code process

- explore other regulatory and/or program instruments for increasing energy efficiency in new housing, including updating the MNECB

- seek support from the federal government and the energy and building code ministries in the provinces and territories and engage their representatives in the process

NRCan and BECC prepared a business plan for updating the 1997 MNECB and presented it to the Canadian Commission on Building and Fire Codes. Commission members unanimously approved the following motion at its annual meeting in Calgary in February 2007: ". . . that the updating of the MNECB as a progeny document based on the BECC Business Plan be approved."

NRCan then prepared and signed a memorandum of understanding (MOU) with the National Research Council (NRC). NRCan is contributing up to $5 million over four years to support the

technical development of the new code and is providing technical expertise to the NRC team tasked with developing national codes. The NRC launched the project, and the Standing Committee on Energy Efficiency in Buildings held its first meeting on updating the code in Ottawa in December 2007.

The updated MNECB will be published by 2011 in an objective-based format. It will complement objective-based model national construction codes published in 2005.

Co-operation Agreements

NRCan's memorandum of agreement (MOA) on EAE with the Agence de l'efficacité énergétique du Québec provides for consultation and sharing of information between the two governments, the coordination of EAE activities in Quebec and the creation of opportunities for joint projects. Further, the management committee established under the MOA reviews policy and program developments, progress on joint program initiatives and areas for further co-operation. NRCan is working with the Agence de l'efficacité énergétique to deliver services under the ecoENERGY programs.

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

- management of the licensing agreement for local delivery of ecoENERGY Retrofit – Homes
- NRCan's Buildings Division's continued processing of payments for the former EnerGuide for Existing Buildings and Commercial Building Incentive programs under a letter of co-operation (LOC) with the Agence de l'efficacité énergétique that covers the 2007–2008 fiscal year and the 2008–2009 fiscal year. Though the two programs are closed, payments, which can be made only when the client proves to NRCan that work has been completed, are still being processed.
- management of an agreement on 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 ice rinks

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

These projects include the Canada–Yukon Energy Solutions Centre in Whitehorse. The Centre provides access to technical services and programs for the Yukon population and undertakes outreach and public education activities.

NRCan works with the Office of the Fire Commissioner of Manitoba, a special operating agency of Manitoba Labour and Immigration, to engage Manitoba stakeholders in a review of the Energy Code Advisory Committee recommendations.

Manitoba is also consulting stakeholders on introducing water efficiency in the plumbing code and identifying barriers in the *Manitoba Building Code* to energy and water efficiency in buildings. The result will be a stakeholder consultation report provided to Manitoba's Minister of Labour and Immigration and Minister of Science, Technology, Energy and Mines.

NRCan works with Ontario's Ministry of Small Business and Consumer Services, the Independent Electricity System Operator and local distribution companies to provide energy management training to companies across Ontario 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 several stakeholders, including the Government of Alberta.

Sustainable Development Technology Canada – NextGen Biofuels Fund™

The NextGen Biofuels Fund™ is a $500-million program scheduled to run from 2008 to 2017. Responsibility for the program is held jointly by NRCan and Environment Canada. The fund is managed under the auspices of Sustainable Development Technology Canada (SDTC).

The NextGen Biofuels Fund™ aims to facilitate the establishment of first-of-a-kind, large, demonstration-scale facilities for the production of next-generation biofuels and co-products in Canada; improve the sustainable development impacts arising from the production and use of biofuels; and encourage retention and growth of technology expertise and innovation capacity for the production of next-generation biofuels.

Next-generation renewable fuels are derived from non-traditional renewable feedstocks – such as forest biomass, fast-growing grasses and agricultural residues – and are produced with non-conventional conversion technologies. An eligible project must use feedstocks that are or could be representative of Canadian biomass, and the technology must have been demonstrated at the pre-commercial pilot scale. SDTC will support up to 40 percent of eligible project costs.

INTERNATIONAL CO-OPERATION

NRCan co-operates with several international organizations and foreign governments in EAE program areas. Canada benefits from this co-operation by

- learning about improved ways of designing and delivering EAE programs to meet policy objectives
- working with others on the harmonization of energy efficiency tests and performance standards to reduce barriers to trade in energy-using products (in this regard, NRCan provides input, as requested, to Foreign Affairs and International Trade Canada on prospective free trade agreements and on technical barriers to trade)
- participating, along with other international partners, including the U.S. Department of Energy, in the development of an ISO[8] 50001, an Energy Management Standard that will help guide industry on best management practices and technical practices to reduce energy waste. Work on the standard started in the fall of 2008, and the expected release date is 2010.

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 runs a comprehensive program of energy co-operation among its 26 member countries, including Canada. IEA member governments have committed to sharing energy information, coordinating energy policies and co-operating on the development of rational energy programs incorporating energy security, economic development and environmental protection. The IEA and its governing board are assisted in their work by several standing groups

[8] International Organization for Standardization.

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 SLT's Energy Efficiency Working Party (EEWP) provides advice on and direction to the IEA's work on specific energy efficiency issues. 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. Canada participates in 11 of the IEA's 40 implementing agreements on R&D collaboration programs. NRCan spent $738,000 on IEA implementing agreements in 2008–2009, in addition to personnel and travel expenditures. In many programs, this work has helped to accelerate technology development in Canada, generating benefits that far outweigh the direct costs of collaboration.

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

Group of Eight

At the Group of Eight (G8) summit in 2007 in Heiligendamm, Germany, the leaders of the G8 countries and Brazil, China, India, Mexico and South Africa agreed to initiate a topic-driven dialogue under the "Heiligendamm Process." The Process has four pillars, and working groups have been formed around each one.

Energy, with a special focus on energy efficiency, is one of the pillars. The Energy Working Group has explored the common ground available for building international support for new ideas and approaches for increasing energy efficiency. It has focused on energy security, development of a sustainable buildings network, energy efficiency in existing power plants, and alternative sources of energy and renewable energy. Canada, represented by the OEE, is co-chair with India. The Working Group met twice in 2008–2009.

NRCan facilitated the development of the agreement for an International Partnership on Energy Efficiency Cooperation (IPEEC), which was initiated by the European Union in June 2007, during the Heiligendamm Summit and finalized in 2008, during the Japanese G8 presidency. The partnership will support the on-going energy efficiency work of the participating countries and relevant international organizations. The IPEEC members will also develop public-private partnerships for improving energy efficiency.

Asia-Pacific Economic Cooperation

At the 2007 Asia-Pacific Economic Cooperation (APEC) Economic Leaders' Meeting, leaders highlighted the importance of improving energy efficiency in the Sydney APEC Leaders' Declaration on Climate Change, Energy Security and Clean Development. The declaration endorsed an APEC-wide regional aspirational goal of a reduction in energy intensity of at least 25 percent by 2030 (with 2005 as the base year).

The OEE is a member of the APEC Expert Group on Energy Efficiency and Conservation (EGEE&C), which reports to APEC's Energy Working Group. One of the tasks of the EGEE&C is updating and maintaining the APEC Energy Standards Information System (ESIS). ESIS provides public, up-to-date information on appliance and equipment energy standards and regulations. It also provides links to experts and information related to standards and regulations used by APEC and other economies. NRCan contributes regularly to the database by providing updated information on Canadian equipment standards and labelling and new initiatives, such as the phase-out of incandescent lamps.

The OEE also participates through the Asia Pacific Partnership on Clean Development on a Task Force on Standby Power data in order to internationally coordinate its efforts to reduce standby power consumption.

Asia Pacific Partnership

CanmetENERGY participates in the Asia Pacific Partnership (APP) on four Task Forces: the Buildings and Appliances Task Force (BATF), the Renewable Energy and Distributed Power Generation Task Force (REDGTF), the Cleaner Fossil Energy Task Force and the Power Generation and Distribution Task Force.

Within the BATF and REDGTF, CanmetENERGY proposed the Net Zero Energy Homes (NZEH) initiative. Under this initiative, Canadian delegates will initiate a collaborative dialogue with BATF and REDGTF partners to establish a formal international partnership that will map the path to achieving NZEH.

Through a series of workshops and design charettes, Canada will offer APP member countries an opportunity to set a precedent for housing performance optimization by bringing together the fragmented supply chain to discuss issues facing the sector. Participation from the project leaders of the existing BATF and REDGTF projects will ensure synergies. The workshops will prominently feature the Canadian industry, case studies, R&D and demonstrations, potentially leading to commercial and technology transfer opportunities for Canadian firms.

United Nations

RETScreen® International is managed under the leadership of NRCan's CanmetENERGY Varennes (QC) Research Centre. RETScreen is managed through cost- and task-shared collaborative ventures with other governments and multilateral organizations, and with technical support from more than 300 experts representing industry, government and academia.

Key partners are NASA's Langley Research Center and the Renewable Energy and Energy Efficiency Partnership. Other key international partners include the Energy Branch of the United Nations Environment Programme (UNEP) and the UNEP Solar and Wind Energy Resource Assessment, which is sponsored by the Global Environment Facility.

Mexico

NRCan signed an MOU on EAE co-operation 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 fostering trade, investment, technical and other exchanges related to energy-efficient products, energy management services, and alternative energy goods and services. In October 2008, NRCan organized an energy management workshop in Mexico City, in co-operation with Mexico's National Commission for Energy Savings (CONAE).

In anticipation of future legislation in Canada and abroad that is targeted at the reduction of emissions, NRCan's Office of Energy Research

and Development funded R&D efforts to evaluate methodologies to identify opportunities for energy efficiency increases and fugitive emissions reduction.

In 2008–2009, CanmetENERGY, in collaboration with university researchers, engaged in Mexico-based activities with the national oil and gas company PEMEX, which were jointly supported by the United States Environmental Protection Agency (U.S. EPA), the International Methane to Markets (M2M) Partnership, and the government of Mexico. The outcome of these ongoing collaborative activities resulted in the Mexican government announcing an annual reduction of 13 megatonnes of carbon dioxide equivalent (CO_2e), which was based on the previous research.

United States

In September 2005, NRCan's OEE signed an MOU with the U.S. EPA to share in the common goal of achieving greater energy efficiency and reducing CO_2, particulate matter and oxides of nitrogen emissions through the work of their respective programs: ecoENERGY for Fleets (FleetSmart) and the SmartWay Transport Partnership.

These two programs use a voluntary approach with the on-road freight sector to increase energy efficiency through training, education and reporting initiatives. They are working together to harmonize program efforts in Canada and the United States.

North America

NRCan continues to participate with the United States and Mexico in the Energy Efficiency Experts Group of the North American Energy Working Group (NAEWG) to promote the harmonization of energy efficiency standards and co-operation on energy efficiency labelling programs. In 2008–2009, work under NAEWG primarily involved coordinating the energy sector commitment to the North American Security and Prosperity Initiative.

APPENDIX 1

Natural Resources Canada's Efficiency and Alternative Energy Initiatives and Expenditures, 2008–2009

	(millions of dollars)
Energy Efficiency and Alternative Transportation Fuels[1]	**$248.3**
ecoENERGY for Equipment	
ecoENERGY Retrofit – Homes	
ecoENERGY Retrofit – Small and Medium Organizations	
Federal Buildings Initiative	
ecoENERGY for Buildings and Houses	
ecoENERGY for Industry	
ecoENERGY for Personal Vehicles	
ecoENERGY for Fleets	
ecoENERGY for Biofuels	
National Renewable Diesel Demonstration	
National Energy Use Database	
Energy Efficiency – Energy Science and Technology[2]	**$88.3**
Clean Energy Systems for Buildings and Communities	
Clean Electric Power Generation	
Clean Energy Systems for Industry	
Environmentally Sustainable Oil and Gas Development	
Clean Transportation Energy	
Sustainable Bioenergy	
Canadian Biomass Innovation Network	
Alternative Energy – Renewable Energy Sources	**$72.2**
ecoENERGY for Renewable Heat	
ecoENERGY for Renewable Power	
Wind Power Production Incentive[3]	
Initiative to Purchase Electricity From Emerging Renewable Energy Sources[4]	
Total	**$408.8**

[1] The Energy Efficiency and Alternative Transportation Fuels total does not include the Sustainable Development Technology Canada – NextGen Biofuels Fund™. For details on this fund, see the text box on page 66.

[2] Totals allocated for the Program of Energy Research and Development and the ecoENERGY Technology Initiative in Chapter 4 are reflected in the relevant program entries.

[3] The Wind Power Production Incentive is fully committed, but incentives will be paid to recipients until 2016–2017.

[4] The Initiative to Purchase Electricity From Emerging Rewewable Sources is fully committed, but incentives will be paid until 2011–2012.

APPENDIX 2

Data Presented in the Report

The aggregate energy use data presented in this report are taken from Statistics Canada's *Report on Energy Supply and Demand in Canada* (RESD). 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 2006*. The differences that exist between this report and Canada's *Energy Outlook* relate to the sector allocations of RESD energy-use data.

FIGURE 1-1: Secondary Energy Use by Sector, 2006

Sector	Industrial	Transportation	Residential	Commercial/ Institutional	Agriculture	Total
Energy use (PJ)	3271	2492	1347	1093	210.8	8413.8
Percentage	0.389	0.296	0.160	0.130	0.025	1.000

FIGURE 1-2: GHG Emissions From Secondary Energy Use by Sector, 2006

Sector	Transportation	Industrial	Residential	Commercial/ Institutional	Agriculture	Total
GHG emissions (Mt)	172.4	161.5	69.6	60.4	14.5	478.4
Percentage	0.360	0.338	0.145	0.126	0.030	1.00

FIGURE 1-3: Energy Intensity and the Energy Efficiency Effect, 1990 to 2006

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	0.78
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	0.87	0.84	0.84

FIGURE 1-4: Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Estimated secondary 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	1.36
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	1.21

FIGURE 1-5: Canadian Households by Type of Dwelling, 2006

Dwelling type	Number of households	Percentage
Single detached homes	7 181 000	56
Single attached homes	1 346 000	11
Apartments	3 981 000	31
Mobile homes	248 000	2
Total	**12 756 000**	**100**

FIGURE 1-6: Residential Energy Use by End-Use, 2006

Activity	Energy use (PJ)	Percentage
Space heating	794.0	59
Water heating	247.4	18
Appliances	205.4	15
Lighting	69.9	5
Space cooling	30.6	2
Total	**1347.3**	**100**

FIGURE 1-7: Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2006

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	1.29
Average floor space by household	1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.04
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	0.81

FIGURE 1-8: Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	1.31
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	1.05

FIGURE 1-9: Annual Heating* Consumption for Houses Constructed to Different Standards

House type	ecoENERGY Retrofit Homes annual heating* consumption (GJ)	Sample size	Total consumption (GJ)
Typical existing house** (1970)	146	8661	177.9
Model National Energy Code house*** (2002)	112	1	143.34
Average** of EnerGuide labelled houses (2007)	89	3992	120.68
Average** of R-2000 certified houses	76	520	107.05

*DHW and space heating
**National average
***198-m^2, two storey, single detached house heated with natural gas in Ottawa, Ontario

FIGURE 1-10: Average Energy Consumption of New Electric Appliances, 1990 and 2006 Models

Appliance	1990 models (kWh/yr)	2006 models (kWh/yr)
Clothes washers	1218	390
Clothes dryers	1103	905
Dishwashers	841	305
Refrigerators	956	481
Electric ranges	772	537
Freezers	714	380

FIGURE 1-11: Commercial/Institutional Energy Use by Activity Type,* 2006

Activity type	Energy use (PJ)	Percentage
Offices**	381.2	35
Retail trade	179.2	17
Educational services	149.9	14
Health care and social assistance	103.2	9
Accommodation and food services	83.9	7
Wholesale trade	61.3	6
Transportation and warehousing	46.8	5
Arts, entertainment and recreation	33.0	3
Information and cultural industries	25.9	2
Other services	19.9	2
Total	**1084.3**	**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 1-12: Commercial/Institutional Energy Use by Purpose, 2006

Purpose	Energy use (PJ)	Percentage
Space heating	537.4	49
Auxiliary equipment	177.4	16
Lighting	107.5	10
Space cooling	77.1	7
Water heating	95.2	9
Auxiliary motors	89.5	8
Street lighting	8.4	1
Total	**1092.5**	**100**

FIGURE 1-13: Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	1.39
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	1.26

FIGURE 1-14: Industrial Energy Use by Subsector – Including Electricity Related Emissions,* 2006

Subsector	Industrial energy use (%)	Energy use (PJ)
Pulp and paper	25	823.7
Mining	22	715.6
Other manufacturing**	17	554.0
Petroleum refining	10	314.5
Smelting and refining	8	267.1
Iron and steel	7	238.9
Chemicals	6	202.8
Other industries***	3	82.2
Cement	2	71.7
Total	**100**	**3270.5**

*The Subsectors below reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.
**"Other manufacturing" comprises more than 20 manufacturing industries.
***"Other industries" includes construction and forestry.

FIGURE 1-15: Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2006

Industry	Energy cost of total production cost (%)
Transportation equipment and manufacturing	0.88
Petroleum refining	2.00
Chemicals	10.65
Iron and steel	14.75
Pulp and paper	14.88
Aluminum	22.36
Cement	36.58

FIGURE 1-16: Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006

Index (1990 = 1.00)	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	1.30
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	1.20

FIGURE 1-17: Transportation Energy Use by Mode, 2006

	Energy use (PJ)	Percentage
Passenger light vehicle	1065.3	
Passenger aviation	248.6	
Passenger bus	53.3	
Passenger rail	2.5	
Passenger total	**1369.7**	**55.1**
Freight aviation	7.1	
Freight truck	833.1	
Freight marine	99.5	
Freight rail	78.9	
Freight total	**1018.6**	**41.0**
Off-road total	**97.4**	**3.9**
Total transportation energy use	**2485.7**	**100.0**

FIGURE 1-18: Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2006

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	61.16
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	38.84

FIGURE 1-19: Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2006

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	1.50	1.51
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	1.33

FIGURE 1-20: Average Activity per Truck, 1990 to 2006 (tonne kilometres/truck)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	230 890	227 689

FIGURE 1-21: Trucking Energy Intensity, 1990 to 2006 (megajoules/tonne kilometre)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Medium- and heavy-duty trucks 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	2.78	2.75

FIGURE 1-22: Shares of On-Road Transportation Fuel, 2006

Fuel type	Energy use (PJ)	Percentage
Electricity	3.5	0.16
Natural gas	1.9	0.09
Motor gasoline	1397.5	63.41
Diesel	782.9	35.52
Liquefied petroleum gas	11.6	0.53
Renewable fuels	6.4	0.29
Total	**2203.8**	**100**

FIGURE 2-1: Volume of Monthly Import Documents

Month	Paper	Electronic	Total
Apr. 08	153	113 257	113 410
May 08	362	113 315	113 677
Jun. 08	36	114 626	114 662
Jul. 08	21	122 532	122 553
Aug. 08	113	120 145	120 258
Sep. 08	1	119 302	119 303
Oct. 08	36	127 613	127 649
Nov. 08	128	106 206	106 334
Dec. 08	103	98 846	98 949
Jan. 09	311	100 555	100 866
Feb. 09	81	84 790	84 871
Mar. 09	–	94 361	94 361
Total	**1345**	**1 315 548**	**1 316 893**

FIGURE 2-4: ENERGY STAR® Qualified Appliances as a Percentage of Total Category Shipments in Canada, 1999 to 2007

Appliance	1999 (%)	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)
Dishwashers	0.6	1.6	9.7	29.8	56.5	81.0	90.8	79.7	76.2
Clothes Washers	1.9	2.2	9.2	22.1	30.6	36.2	45.9	50.8	58.4
Refrigerators	–	–	11.4	22.3	40.7	34.2	37.6	37.3	44.3

FIGURE 2-5: ENERGY STAR® Awareness Levels in Canada, 2007

	Percentage
Aware – non-aided	56
Aware – aided	62

FIGURE 3-1: Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000–2009

	Pre-1945	1945–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2009*	Average
Energy use pre-renovation (GJ)	278	205	191	176	176	164	151	198
Actual energy savings after renovations (GJ)	92	55	47	42	37	31	36	51

*Data for 2007 are from ecoENERGY Retrofit – Homes (previous data source was EnerGuide for Houses).

FIGURE 3-2: Number of R-2000 Housing Certifications, 1990 to 2008

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of R-2000 houses	495	699	1196	1299	784	610	416	484	265	213	319	329	428	379	583	500	439	483	557

FIGURE 3-3: CIPEC Energy Intensity Index, 1990 to 2006

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	0.87	0.88

FIGURE 3-4: Industrial Dollars to $ense Participants, Pre-2000 to 2008

Fiscal year	Pre-2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of industrial workshop participants	748	408	353	481	880	1027	1290	1230	1290

FIGURE 3-5: New Vehicle Fuel Efficiency Labelling

Year	On lot	In showroom
2007	78	56
2005	78	61
2001	77	56
1999	64	47

FIGURE 3-6: Company Average Fuel Consumption (CAFC) versus Canadian Voluntary Standards, 1990 to 2007*

Truck model year	Truck standard (L/100 km)	Trucks CAFC (L/100 km)	Car standard (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	11.4	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	10.8	8.6	7.6
2004	11.4	10.9	8.6	7.5
2005	11.2	10.6	8.6	7.4
2006	10.9	10.4	8.6	7.4
2007	10.6	10.1	8.6	7.1

*2003–2007 data are estimates

FIGURE 4.1: RETScreen Software: Cumulative Growth of User Base

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Canada	1421	2966	4527	6650	9754	14 125	18 178	24 005	28 990	36 891	44 987
World	1688	5782	9838	15 292	20 499	27 752	38 270	56 432	78 215	110 264	148 046

FIGURE 5.1: Canadian Wind Power Capacity, 1993 to 2008

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Wind power capacity (MW)	1	22	23	23	24	27	127	139	215	233	326	445	686	1459	1846	2369

Natural Resources Canada's Office of Energy Efficiency

Leading Canadians to Energy Efficiency at Home, at Work and on the Road

Canada