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 2009–2010

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 2009–2010

Cat. no. M141-10/2010E (Print)
ISBN 978-1-100-17531-7

Cat. no. M141-10/2010E-PDF (On-line)
ISBN 978-1-100-17532-4

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 *2009/2010 Report to Parliament on Improving Energy Performance in Canada*. This Government believes that improving energy efficiency is one of the fastest, greenest and most-cost effective ways to save energy, increase domestic jobs, and increase energy security.

Over the past year, through its ecoENERGY initiatives, the Government of Canada has successfully promoted energy efficiency and the use of alternative energy. The goal has been to reduce greenhouse gas emissions and save Canadians money. More than 500,000 individuals and businesses have made the choice to reduce their energy consumption by participating in our ecoENERGY initiatives.

Our Government has also amended the *Energy Efficiency Regulations* to complement the ecoENERGY initiatives. The goal of the Regulations is to eliminate the least energy-efficient products from the Canadian marketplace. Amendment 11 proposes minimum energy performance standards or expanded scope for 14 products such as electronic power supplies, room air conditioners and electric motors. These amendments will help us solidify Canada's position as an international leader in energy efficiency standards.

Under the Economic Action Plan, the Government of Canada expanded the ecoENERGY Retrofit - Homes program budget, resulting in an average energy savings of 22 percent per home and a reduction of three tonnes of greenhouse gas emissions per year, per home.

Energy efficiency is a key element of our Government's plan to fight climate change. The Government's plan will protect the environment and supports Canada's greenhouse gas emission reduction target of 17 percent below 2005 levels by 2020, a target that is aligned with that of the United States.

Canadians are making a conscious effort to improve their energy use. By investing in energy efficiency programs and promoting the use of clean energy by Canadian households and industry, we are creating high-quality jobs for Canadians and helping to protect our environment.

The Honourable Joe Oliver, P. C., M. P.
Minister of Natural Resources

Executive Summary

Canadians spent approximately $166 billion in 2007 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 2007, the latest year for which figures are available, secondary energy use increased by 28 percent.
- In 2007, secondary use accounted for 69 percent of primary energy use and produced 67 percent (501.6 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 16 percent higher.

The industrial sector consumed the most energy, accounting for 39 percent of total secondary energy use in 2007. Transportation was second (29 percent), followed by residential (16 percent), commercial/institutional (13 percent) and agriculture (2 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 report 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 2007 are estimated to have reduced GHG emissions by 63 Mt and saved Canadians $22.8 billion in 2007.

Between 1990 and 2007, the residential sector recorded a 29 percent improvement in energy efficiency. The figures for the transportation (22 percent), industrial (7 percent) and commercial/institutional (16 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 energy sources in 2008.

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 2009–2010 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.

Although the period covered in this report is fiscal year 2009–2010, it is important to note that the Speech from the Throne 2010 and the Budget 2010 both contained references to the need to review the effectiveness of energy efficiency and clean energy programs. At the time of writing this report, the above-noted review is underway.

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. Energy efficiency also positively impacts economic competitiveness and employment.

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 2009–2010 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, 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 (R&D) 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 R&D in the use of forest biomass for energy
- the Policy, Economics and Industry branch of the Canadian Forest Service, which delivers funding for approved green capital projects in pulp and paper mills

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.

With this approach, the demand side of the energy market moves toward more energy-efficient capital stock, production processes and operating

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

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 that prescribe standards and labelling requirements for energy-using products that are imported to Canada or shipped across provincial borders for lease or resale and prescribe standards for products that affect energy use.

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 renewable power and heat, ethanol plants, energy efficiency and renewable energy production at pulp and paper mills, 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.

Information activities include publications, exhibits, advertising, toll-free telephone lines, conferences, Web sites, workshops, training, building-design software and promotional products. One particular outreach program targets youth as the energy consumers of the future and distributes activity booklets to virtually all elementary schools across the country.

Voluntary Initiatives

Companies and institutions work with NRCan voluntarily to set and achieve energy efficiency objectives. NRCan's voluntary EAE initiatives target 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

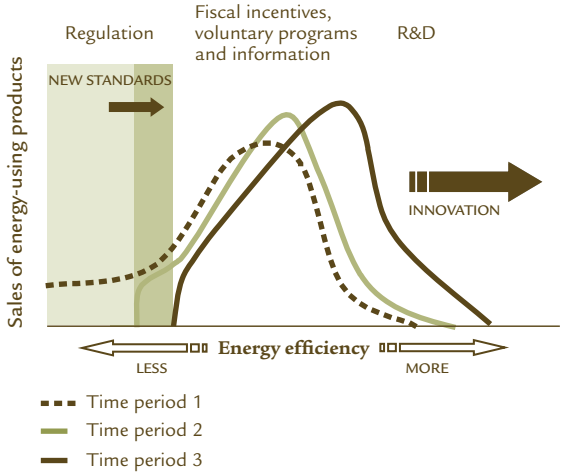


Figure INT-1 shows how these policy instruments work together to increase energy efficiency, that is, how they help to reduce the amount of energy required to complete a task or obtain a certain level of service. Energy performance regulations eliminate less efficient products from the market. Fiscal 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, may serve as an indicator of program effectiveness. Measuring progress toward an immediate market outcome can be difficult for R,D&D programs, which typically take many years to produce results that can be properly assessed.

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 2009–2010, analysis of the residential sector was undertaken for reference year 2007. This analysis forms the basis of reports explaining how and where energy is used in this sector (Survey of Household Energy Use [SHEU]). Data on the transportation sector continue to be collected on a quarterly basis, while industrial and commercial data continue to be collected annually.

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. The DACs are mandated to improve the accessibility and comparability of existing data about trends in energy consumption and their impact on environmental quality, develop expert knowledge and advise on NEUD's data collection activities. Three DACs have been established:

- **transportation** at Université Laval in Québec, Quebec (Centre for Data and Analysis in Transportation [CDAT])
- **industrial** at Simon Fraser University in Burnaby, British Columbia (Canadian Industrial Energy End-Use Data and Analysis Centre [CIEEDAC])
- **buildings** at the University of Alberta in Edmonton, Alberta (Canadian Building Energy End-Use Data and Analysis Centre [CBEEDAC])

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 seventeenth 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 2009–2010 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 $166 billion in 2007 on energy to heat and cool their homes and offices and to operate their appliances, vehicles and industrial processes. This amount is equivalent to almost 12 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 was 12 786 petajoules[3] (PJ) in 2007.

[2] Data in this chapter are presented for 1990–2007. 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.

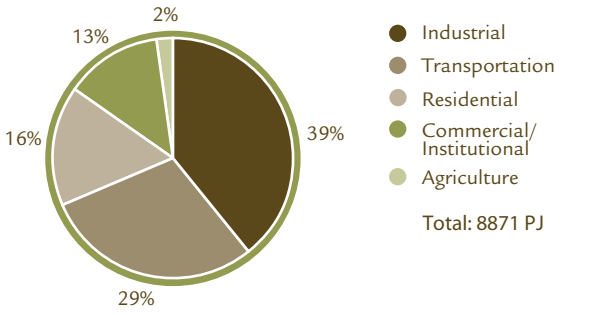
Secondary energy use accounted for 69 percent of primary energy use in 2007, or 8870.5 PJ. It was responsible for 67 percent (501.6 megatonnes [Mt]) of total greenhouse gas (GHG) emissions in Canada, including indirect emissions – those produced by electric utilities to meet end-use electrical demand.

From 1990 to 2007, secondary energy use increased by 28 percent, the Canadian population grew 19 percent, and the GDP increased 58 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 2007. The transportation sector was the second largest energy user at 29 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, 2007



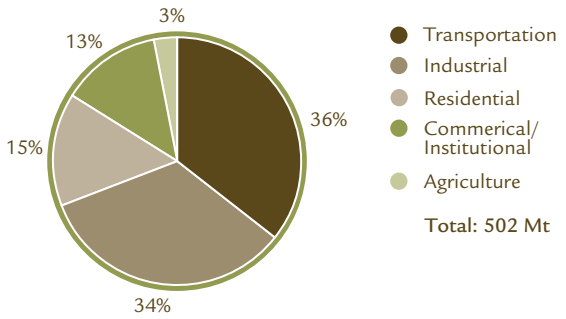
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

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, 2007



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.

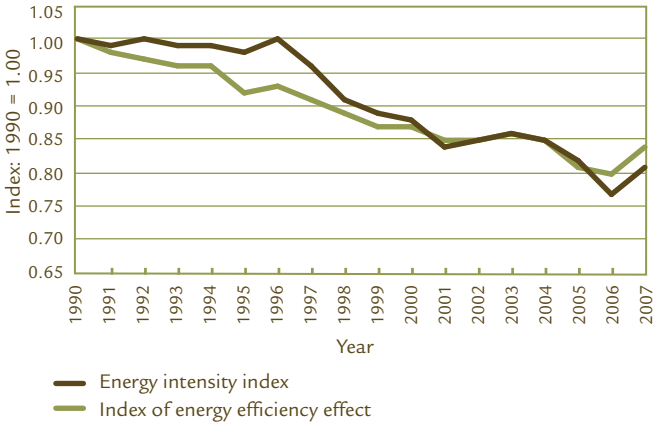
Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar (or better) level of service with less energy consumption on a per-unit basis is considered an improvement in energy efficiency.

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 2007. 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 2007



Source: Natural Resources Canada, Residential, Commercial/Institutional, Transportation, Industrial End-Use Models, Ottawa, 2009.

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 GHG emissions. Activity is defined differently in each sector. For example, in the residential sector, it is defined as the number of households and the floor space of residences. In the industrial sector, it is defined as industrial GDP, gross output and physical industrial output, such as tonnes of steel.
- 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.
- **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

TABLE 1-1

Explanation of Changes in Secondary Energy Use, 1990 to 2007

	Sectors					
	Residential	Commercial/ Institutional	Industrial	Transportation	Total*	Change (%)
1990 energy use (PJ)	1282.3	867.0	2710.0	1877.9	6936.3	
2007 energy use (PJ)	1447.2	1141.6	3471.6	2595.2	8870.5	
Change in energy use (PJ)	164.9	274.6	761.6	717.3	1934.2	27.9
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0						
Explanatory factor (change due to)						
Activity	456.4	294.7	1261.7	853.8	2866.6	41.3
Weather	15.0	15.2	n/a	n/a	30.2	0.4
Structure	0.6	0.3	-315.3	218.5	-95.8	-1.4
Service level	71.1	103.6	n/a	n/a	174.7	2.5
Energy efficiency	-378.2	-138.7	-184.8	-388.0	-1089.7	-15.7
Other factors		-0.5			48.3	0.7

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

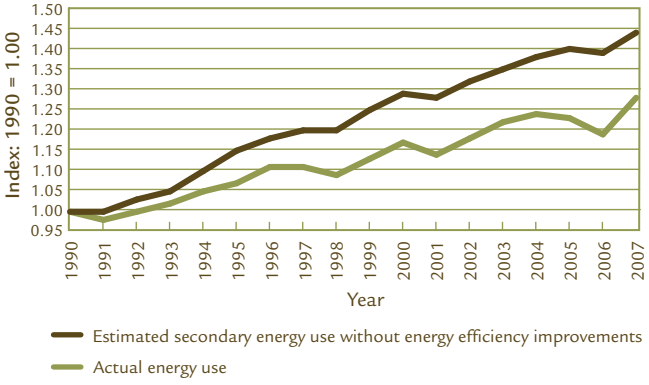
*Total also includes energy use for agriculture.

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 2007, secondary energy use in Canada increased from 6936.3 to 8870.5 PJ. Without improvements in energy efficiency, increases attributable to activity, weather, structure and service level would have led to an energy increase of 44 percent. However, as a result of a 16 percent (1090 PJ) improvement in energy efficiency,[4] actual secondary energy use increased by only 28 percent (to 8870.5 PJ). This improvement in energy efficiency is estimated to have reduced GHG emissions by 63 Mt and decreased energy expenditures by $22.8 billion in 2007. The change in energy use between 1990 and 2007, 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 2007



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 energy sources in 2008. 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 2008, 60.4 percent of Canada's electricity generation was provided by conventional and small hydroelectric plants, which generated more than 376 terawatt hours (TWh) of electricity, up 3.3 percent from 364 TWh in 2007. Small hydro plants (less than 50 megawatts [MW]), with installed generating capacity of 3452 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.

In 2010, the Fundy Ocean Resource Centre for Energy, a technology demonstration facility, started testing three technologies with a total capacity of 4 MW. 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 1516 MW of installed capacity in 2008, biomass (waste and virgin biomass and

[4] Based on the OEE Index.

landfill gas) is one of the main non-hydro renewable energy sources in Canada.

Wind energy is growing rapidly, with an increase in capacity from 139 MW in 2000 to 3319 MW in 2009. 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 (PV) energy also experienced high rates of capacity growth – about 32 percent average growth rate annually between 1992 and 2009 – although it started from a very low baseline. 2009 was the best year so far for solar PV, with approximately 95 MW of solar PV systems installed in Canada, representing an increase of 62 MW from the previous year.

The Canadian active solar thermal installed capacity in 2008 was 720 000 square metres (m^2), which is approximately 500 megawatts thermal (MW_{th}). The domestic market increase has averaged 13 percent annually since 1998. In 2008, the solar thermal collector market in Canada was 139 159 m^2, more than twice the installations in 2007 (60 900 m^2), with revenues up 44 percent from 2007.

In 2008, 15 000 ground-source heat pumps (GSHP) units were installed in Canada. This is a large increase from the 9100 units installed in 2007 and 4217 units installed in 2006. As of December 31, 2009, there were approximately 46 000 GSHPs with 555 MW_{th} of installed capacity producing an estimated 760 gigawatt-hours equivalent annually.

As described in Chapter 5, NRCan is carrying out three initiatives – ecoENERGY for Renewable Power, ecoENERGY for Renewable Heat and the Pulp and Paper Green Transformation Program – to increase the use of renewable energy in Canada.

TRENDS IN RESIDENTIAL SECTOR

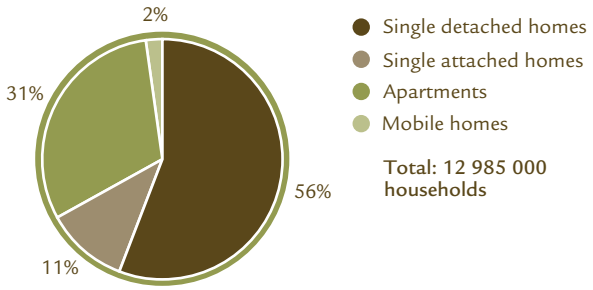
Energy Use and Greenhouse Gas Emissions

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 2007, this sector accounted for 16 percent (1447.2 PJ) of secondary energy use and 15 percent (74.3 Mt) of GHGs emitted in Canada.

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, 2007



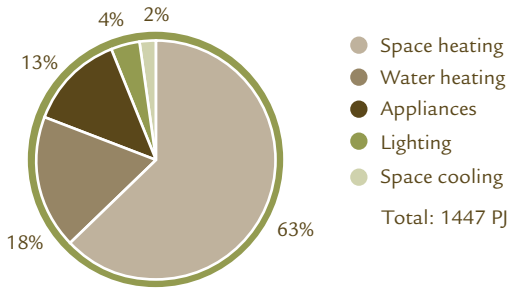
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Between 1990 and 2007, residential energy use increased by 13 percent, or 164.9 PJ. For the same period , GHG emissions increased by 11 percent.

GHG intensity decreased 2 percent despite the average household operating more appliances, becoming larger and increasing its use of space cooling. Space and water heating constituted 81 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).

FIGURE 1-6

Residential Energy Use by End Use, 2007



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

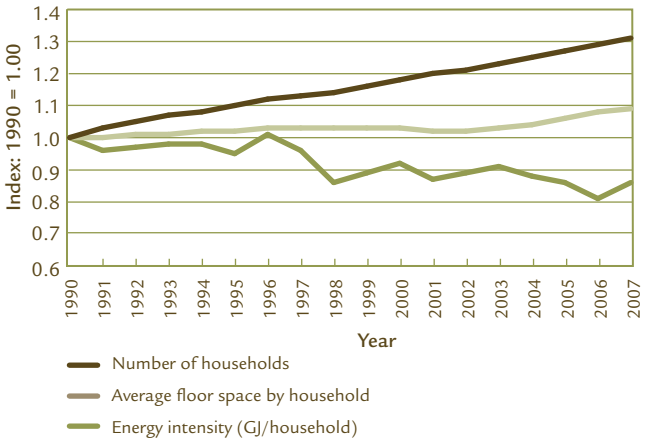
Five main factors influenced residential energy use between 1990 and 2007 – activity, weather, structure, service level and energy efficiency effect:

- Activity – As measured by combining a mix of households and floor space, energy use increased 36 percent (456.4 PJ). Growth in activity was driven by a 44 percent increase in floor area and by a rise of 31 percent in the number of households.
- Weather – In 2007, winter temperatures were similar to those of 1990 but the summer was warmer. The net result was an overall increase in energy demand for temperature control of 15.0 PJ.
- Structure – The increase in the relative share of households by dwelling type resulted in the sector using an additional 0.6 PJ of energy.
- Service level – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 71.1 PJ of the increase in energy.
- Energy efficiency – Improvements to the thermal envelope of houses and to the efficiency of residential appliances and space-and water-heating equipment led to an overall energy efficiency gain in the residential sector. This efficiency gain saved 378.2 PJ of energy.

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).

FIGURE 1-7

Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2007



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

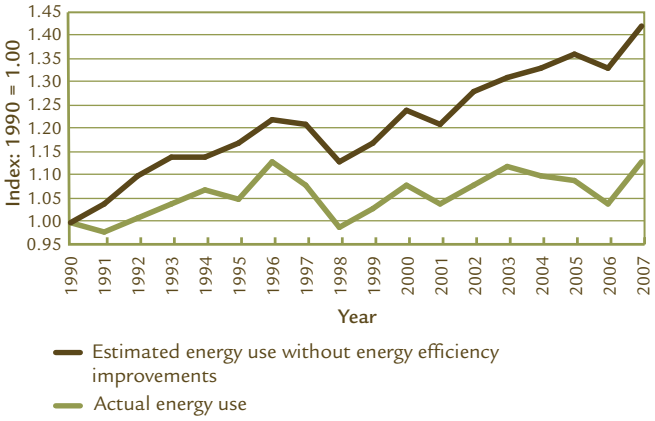
These increases were partially offset by significant improvements in energy efficiency. Service level increased energy demand because more Canadians cooled their homes during the summer months in 2007 than in 1990, and Canadians operated more appliances in 2007 than they did in 1990.

Energy Efficiency

The change in residential energy use between 1990 and 2007 and the estimated energy savings due to energy efficiency measures are shown in Figure 1-8.

FIGURE 1-8

Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2009.

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.

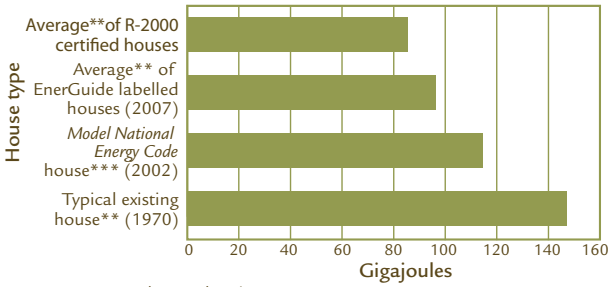
The 29 percent improvement in energy efficiency between 1990 and 2007 translated into $7.4 billion in energy savings in 2007.

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 2007 models.

FIGURE 1-9

Annual Heating* Consumption for Houses Constructed to Different Standards



*DHW and space heating

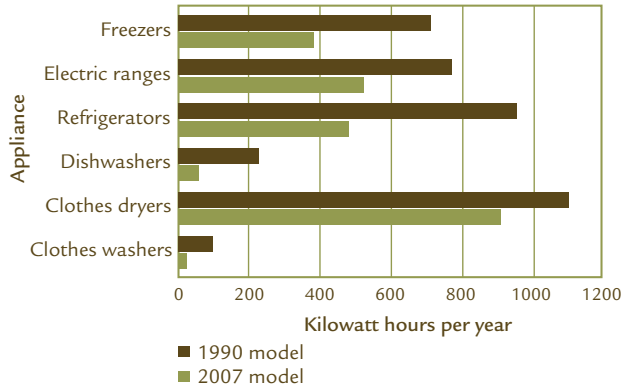
**National average

***198-m², two-storey, single detached house heated with natural gas located in Ottawa, Ontario

Source: NRCan national housing database and internal data.

FIGURE 1-10

Average Energy Consumption of New Electric Appliances, 1990 and 2007 Models



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2009.

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

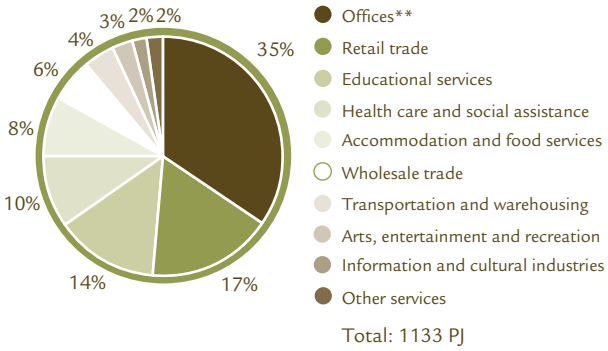
The commercial/institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services, including tourism. This sector uses energy mainly for space and water heating, operation of auxiliary equipment, space cooling, lighting, motive power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

In 2007, the commercial/institutional sector accounted for 13 percent (1142 PJ) of secondary energy use and GHG emissions in Canada. Between 1990 and 2007, commercial/institutional energy use (including street lighting) increased by 32 percent, or 275 PJ. GHG emissions from the sector rose by 36 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 2007, 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 49 percent of that demand.

FIGURE 1-11

Commercial/Institutional Energy Use by Activity Type,* 2007



* Excludes street lighting.

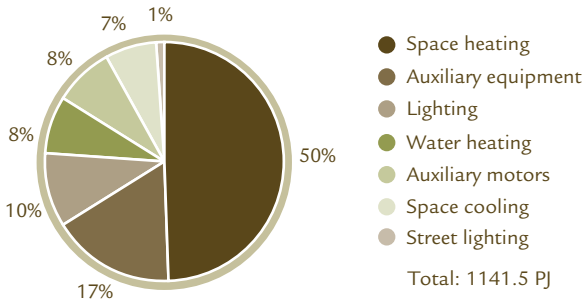
**"Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

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

Energy is used for seven purposes in commercial/ institutional activities. As illustrated in Figure 1-12, in 2007, the largest of these was space heating, which accounted for half of the energy use in the sector. The remaining six uses of energy accounted for between 1 percent and 17 percent of energy demand in the sector.

FIGURE 1-12

Commercial/Institutional Energy Use by Purpose, 2007



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

Five main factors influenced commercial/institutional energy use between 1990 and 2007 – activity, weather, structure, service level and energy efficiency effect:

- Activity – An increase in floor space raised energy use by 34 percent (294.7 PJ) and increased GHG-related emissions by 16.7 Mt.
- Structure – The effect of structure changes in the sector (the mix of activity types) was small and therefore changed GHG-related emissions only marginally.
- Weather – The winter of 2007 was similar to the winter of 1990, but the summer was warmer. The net result was a 15.2-PJ increase in energy demand in the commercial/institutional sector, mainly for space conditioning, which had the effect of increasing GHG-related emissions by 0.9 Mt.
- Service level – An increase in space cooling and in the service level of auxiliary equipment, which is the penetration rates of office equipment (e.g. computers, fax machines and photocopiers), led to a 103.6-PJ increase in energy use and a 5.9-Mt increase in GHG-related emissions.
- Energy efficiency – Improvements in the energy efficiency of the commercial/institutional sector saved 138.7 PJ of energy and 7.8 Mt of related emissions.

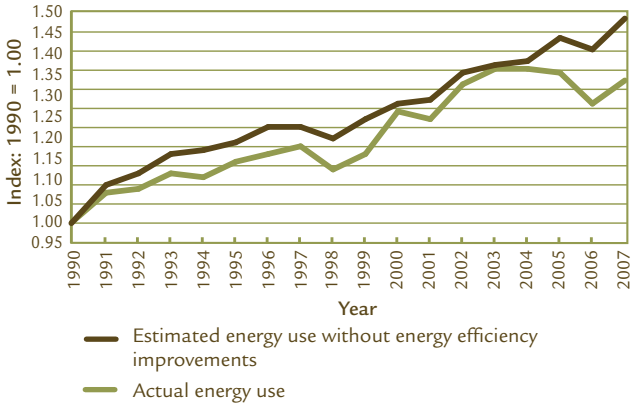
Energy Efficiency

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 48 percent. However, actual energy use increased by only 32 percent between 1990 and 2007, resulting in energy savings of $2.9 billion in 2007.

The change in energy use between 1990 and 2007, 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 2007



Source: Natural Resources Canada, Commercial/Institutional End-Use Model, Ottawa, 2009.

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.

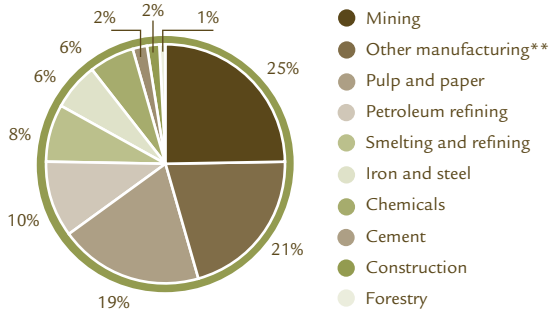
Overall, industrial energy demand in 2007 accounted for 39 percent (3472 PJ) of secondary

energy use and 34 percent (169 Mt) of GHG emissions (including electricity-related emissions). Between 1990 and 2007, actual industrial energy use increased by 28 percent (762 PJ). This increase was caused by the 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 mining, other manufacturing, pulp and paper production, and the petroleum refining industries. Mining alone accounted for 25 percent of total industrial energy demand in 2007 (see Figure 1-14).

FIGURE 1-14

Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2007



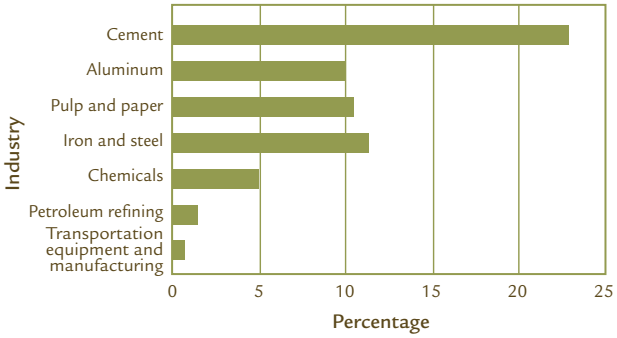
*The above subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.
**"Other manufacturing" comprises more than 20 manufacturing industries.

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, and iron and steel – this share was 10 percent or higher (see Figure 1-15). For cement, in particular, the share was 23 percent.

FIGURE 1-15

Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2007



Source: Statistics Canada, CANSIM Table 301-0006.

Between 1990 and 2007, industrial GHG emissions, including electricity-related emissions, increased by 24 percent. Excluding electricity-related emissions, industrial GHG emissions increased by 19 percent. Most of this increase in direct GHG emissions occurred in the upstream oil and gas industry. The pulp and paper industry, however, achieved a 28 percent decrease in GHG emissions.

Three main factors influenced industrial energy use between 1990 and 2007 – activity, structure and energy efficiency effect:

- Activity – The mix of GDP, gross output and production units (activity measures) increased the energy use by 75 percent, or 1261.7 PJ.
- Structure – The structural changes in the industrial sector, specifically a relative decrease in the activity share of energy-intensive industries, helped the sector reduce its energy use by 315.3 PJ. Note that industries consuming more than 6 megajoules [5] per dollar of GDP (e.g. pulp and paper, petroleum refining, upstream mining) represented 28 percent of industrial GDP in 1990. They accounted for 25 percent in 2007.
- Energy efficiency – Improvements in the energy efficiency of the industrial sector avoided 184.8 PJ of energy use.

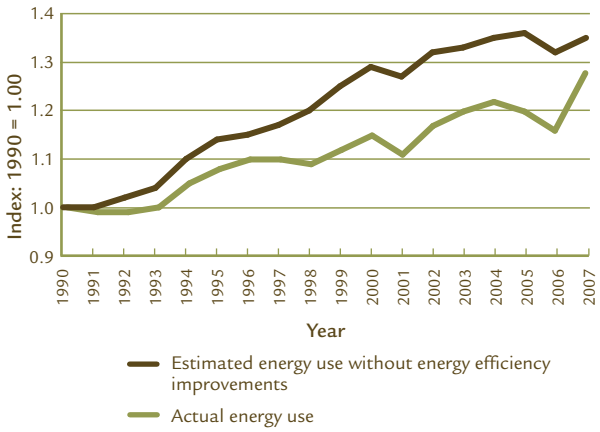
[5] One megajoule equals 1×10^6 joules.

Energy Efficiency

The change in energy use between 1990 and 2007 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 2007



Source: Natural Resources Canada, Industrial End-Use Models, Ottawa, 2009.

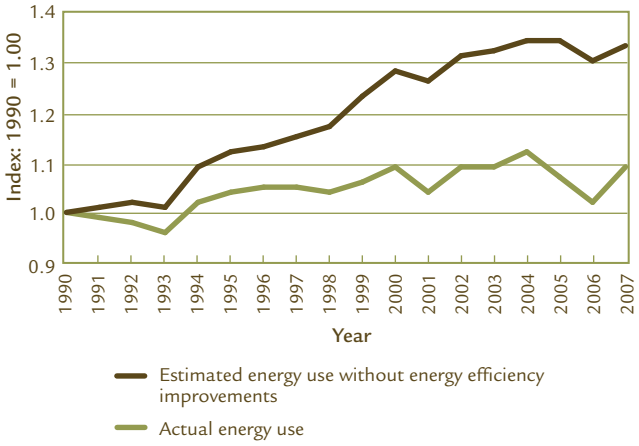
Energy efficiency improvements in the form of more efficient capital and management practices are important factors in managing energy use and decreasing energy intensity.

Between 1990 and 2007, energy efficiency in the industrial sector improved 7 percent. In 2007, Canadian industry saved $2.1 billion in energy costs. This gain was largely the result of improvements in energy intensity, representing the shift toward less energy-intensive activities. However, 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.

From 1990 to 2007, the upstream mining share of industrial energy use grew from 8 percent to 22 percent. This change reflects not only growth in production but also a shift from conventional to the significantly more energy-intensive unconventional oil production. Netting out the upstream mining, Canadian industries improved energy efficiency by 23 percent, which represents 617.7 PJ of savings (see Figure 1-17) and corresponds to $7 billion in avoided energy costs.

FIGURE 1-17

Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2007



Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2009.

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

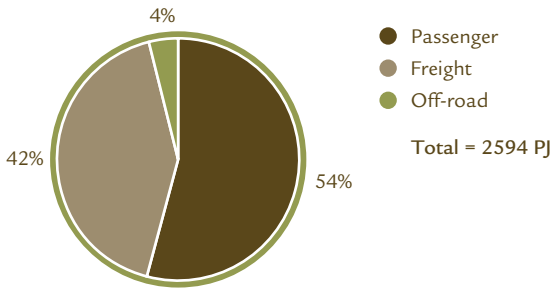
In 2007, transportation was second to the industrial sector in terms of energy use, accounting for 29 percent (2595 PJ) of Canada's total secondary energy use and the largest portion of Canadian end-use GHG emissions at 36 percent (179.4 Mt).

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 2007, passenger and freight transportation accounted for 54 percent and 42 percent of transportation energy use respectively, while off-road represented only 4 percent (see Figure 1-18). 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 1-18

Transportation Energy Use by Mode, 2007



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. All of NRCan's transportation energy use programs focus on the energy used in road transportation. Total transportation energy use increased by 38 percent (717 PJ) between 1990 and 2007. Within the transportation sector, passenger transportation energy use increased by 19 percent (228 PJ), while freight transportation energy use increased by 70 percent (445 PJ).

Three main factors influenced passenger transportation energy use between 1990 and 2007 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. passenger-kilometres [Pkm] travelled) increased energy use by 38 percent, or 433.2 PJ, with a corresponding 29.4-Mt increase in GHG emissions. Light truck and air transportation led the growth in Pkm (and therefore, activity effect), with respective increases of 165 percent and 89 percent.
- Structure – Changes to the mix of transportation modes, or the relative share of Pkm travelled by air, rail and road, are used to measure changes in structure. The popularity of minivans and sport utility vehicles (SUVs) increased the activity share of light trucks compared with other modes, contributing to a 33.8-PJ increase in energy consumption and a 2.3-Mt increase in GHG emissions.
- Energy efficiency – Improvements in the energy efficiency of passenger transportation saved 227.9 PJ of energy and 15.5 Mt of energy-related GHG emissions. Despite the increasing popularity of larger and heavier light-duty vehicles with greater horsepower, the light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation was able to show 172.5 PJ of energy savings.

Three main factors influenced freight transportation energy use between 1990 and 2007 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. tonne-kilometres moved) increased energy use 66 percent, or 420.6 PJ, and caused a corresponding 29.8-Mt increase in GHG emissions. This increase was influenced by greater international trade and the deregulation of the trucking and rail industries.

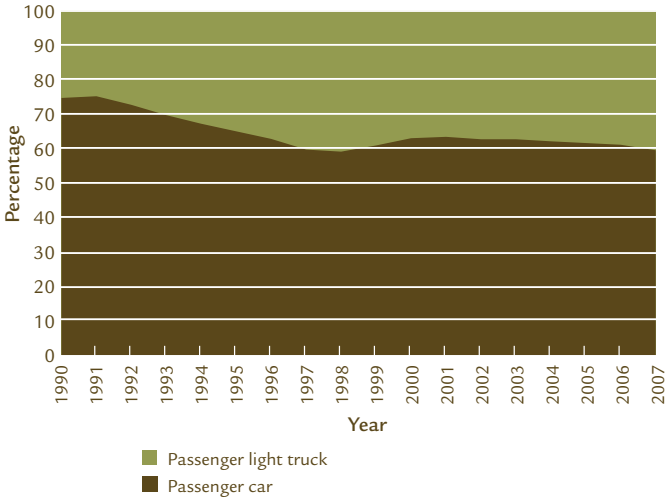
- Structure – Changes in the structure of freight transportation (shifts in activity between modes) stemmed from growth in international trade and customer requirements for just-in-time delivery. The shift between modes was the increase in the share of freight moved by heavy trucks relative to other modes. Because trucks are more energy intensive per tonne-kilometre than other modes, the sector used an additional 184.8 PJ of energy and emitted 13.1 Mt more GHG emissions.

- Energy efficiency – Improvements in the energy efficiency of freight transportation saved 160.1 PJ of energy and 11.3 Mt of GHG emissions. Improvements in freight trucks were a large contributor, saving 101.1 PJ.

Figure 1-19 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 1-19

Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2007



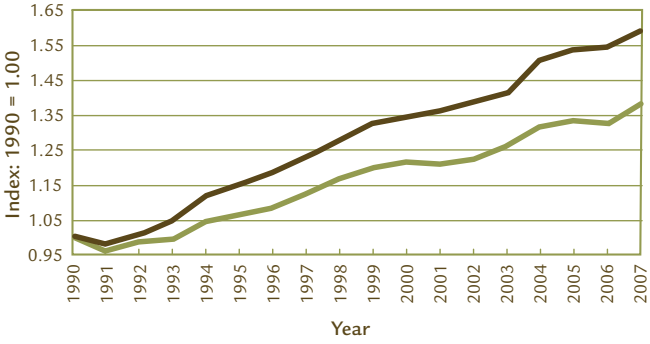
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

Energy Efficiency

Without improvements in energy efficiency, increases attributable to activity and structure would have led to an increase in transportation energy use of 59 percent. However, between 1990 and 2007, actual energy use increased by 38 percent. During this period, energy efficiency in the transportation sector improved by 22 percent, leading to a savings of $10.3 billion in 2007. This change in energy use between 1990 and 2007 and the estimated energy savings due to energy efficiency improvements are shown in Figure 1-20.

FIGURE 1-20

Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

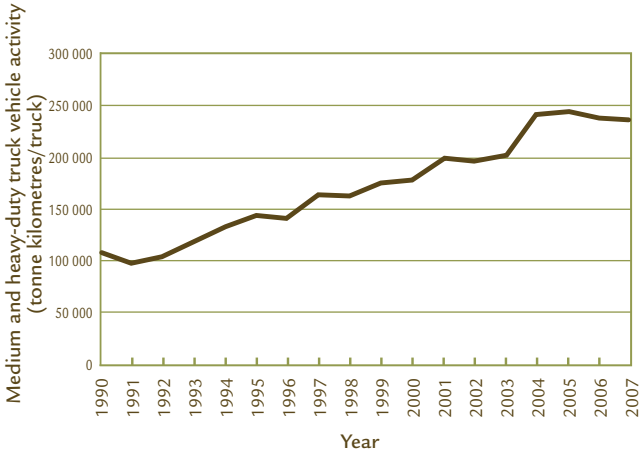


Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

Figures 1-21 and 1-22 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2007. 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 1-21

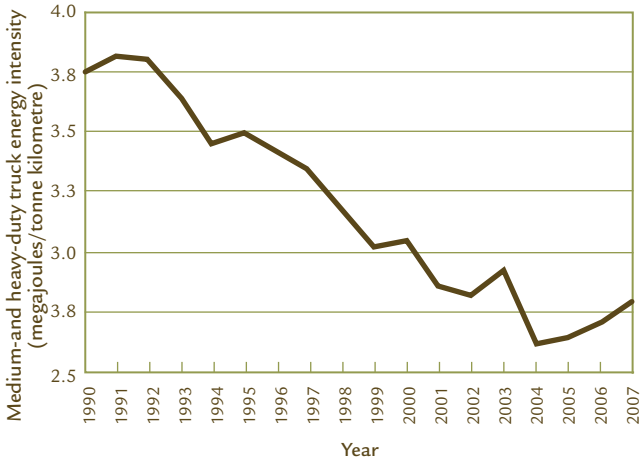
Average Activity per Truck, 1990 to 2007



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

FIGURE 1-22

Trucking Energy Intensity, 1990 to 2007



Source: Natural Resources Canada, Transportation End-Use Model, Ottawa, 2009

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 2009, domestic renewable fuel production capacity increased approximately eightfold, from 211 million litres (L) to 1.65 billion L per year. By the end of 2009, ethanol production capacity was 1.5 billion L and biodiesel production capacity was more than 150 million L. For the 2009 calendar year, 1.1 billion L of ethanol and approximately 102 million L of biodiesel were actually produced.

In 2008, renewable fuels used in the transportation sector represented an estimated 2 percent of fuel used. The renewable fuel consumed was predominately ethanol blended with gasoline in lower-level ethanol blends.

Environment Canada announced that the Renewable Fuels Regulations requiring gasoline producers and importers to have an annual average renewable fuel content of at least five percent based on the volume of gasoline produced and imported came into force on December 15, 2010. The federal government also intends to regulate a 2 percent requirement for renewable content in diesel fuel and heating oil by 2011, subject to technical feasibility.

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 Act was amended in 2009, making it possible to prescribe standards not only for more products that use energy but also for products, such as thermostats, that affect energy use. The 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.

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.

The performance standards contained in the Regulations and accompanying labelling requirements and programs make a major contribution to the Government of Canada's Clean Air Regulatory Agenda. In October 2006, a notice of intent was published for amending the Regulations to prescribe standards for 20 new products and increase the stringency of existing standards for 10 products by 2010. When all the 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 initiatives 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 a comparative 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. The EnerGuide label shows the energy performance of the product and compares it with the most and least efficient models of the same class and size.

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 ENERGY STAR 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 strongly aligned with 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 of 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 is also involved with the International Energy Agency's Efficient Electrical End-use Equipment (4E) initiative that facilitates co-operation among various Organisation for Economic Co-Operation and Development (OECD) countries on specific projects. Canada is participating in a mapping and benchmarking study as well as one on standby power.

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.

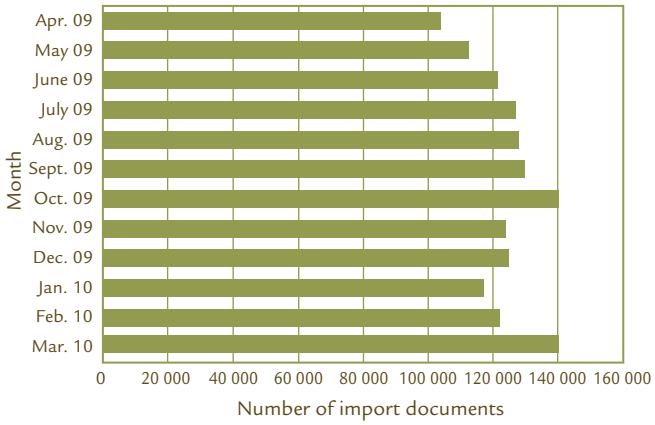
The Regulations require that when importing a regulated product into Canada, dealers provide specific product information on customs documents for all shipments (i.e. type of product, brand name, model number, address of dealer and purpose of import). A customs document contains less information than 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 1 493 214 records (records from April 1, 2009, to March 31, 2010) relating to the importation of regulated energy-using products to Canada in 2009–2010.

Figure 2-1 illustrates the volume of import documents received, in paper form and electronically, per month during the 2009–2010 fiscal year.

FIGURE 2-1

Volume of Monthly Import Documents



Source: OEE Equipment Database.

More than 1 824 516 new or revised model numbers were submitted to NRCan for entry into NRCan's equipment database (records from April 1, 2009, to March 31, 2010) 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 amendments would 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.

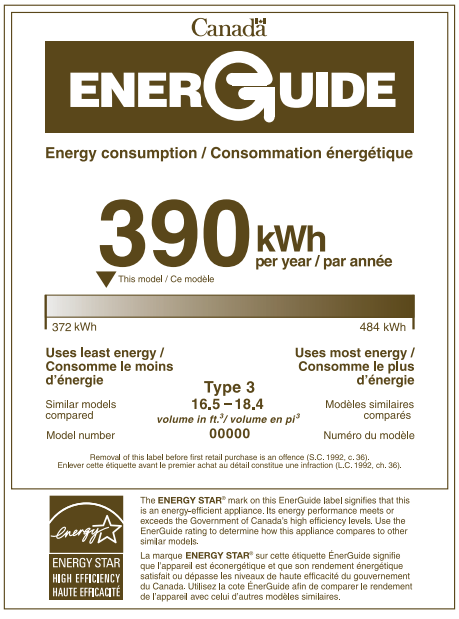
LABELLING AND PROMOTION

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.

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.

FIGURE 2-2

EnerGuide Label



A voluntary EnerGuide rating program was established in 1997 and included gas furnaces, central air conditioners, heat pumps and oil furnaces. In the fall of 2003, gas fireplaces were added to the EnerGuide rating program, 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; Taiwan; and the European Union, which adopted ENERGY STAR for office equipment.

FIGURE 2-3
ENERGY STAR® Symbol

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 developed an incentive program around ENERGY STAR qualified tankless water heaters, and Manitoba Hydro ran an aggressive incentive program for ENERGY STAR qualified commercial kitchen equipment.

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 ENERGY STAR qualified geothermal heating equipment. 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 2008 show an increase in market penetration from almost nil in 1999 to 53 percent for refrigerators, 64 percent for clothes washers and 89 percent for dishwashers (see Figure 2-4). The increase in market penetration indicates growing acceptance of ENERGY STAR as the brand for high energy efficiency and manufacturers' willingness to raise the efficiency of their products to qualifying levels.

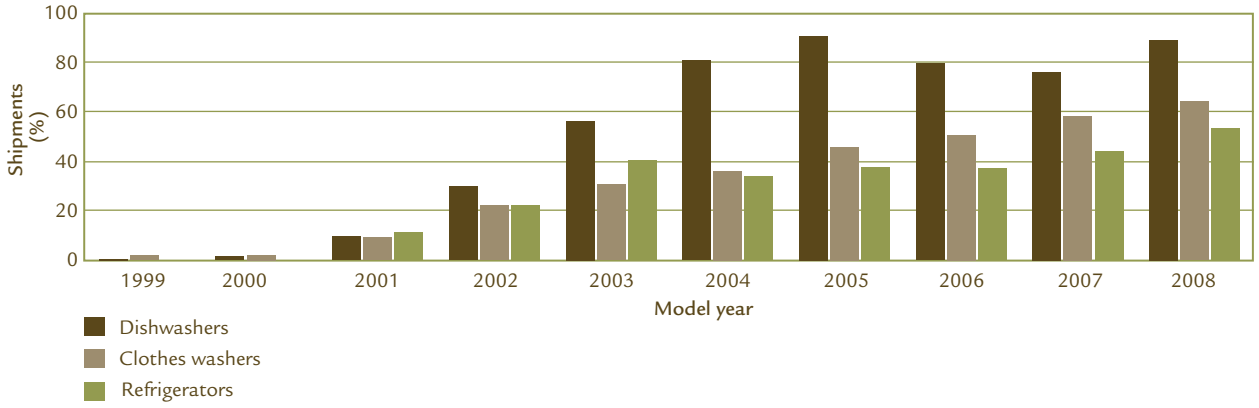
ENERGY STAR specifications and levels are periodically updated as product saturation is reached, to encourage industry to strive for more efficient products and thus maintain the relevance and credibility of the brand.

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.

FIGURE 2-4

Distribution of ENERGY STAR qualified shipments of appliances, 1999 to 2008



Source: *Energy Consumption of Major Appliances Shipped in Canada. Trends for 1990–2008.*

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 developed 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:

- 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

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

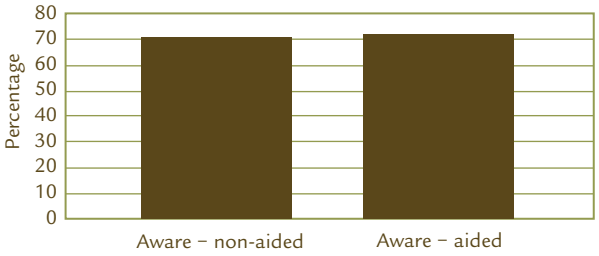
standards and to ensure that other regulatory requirements, such as labelling, are met.

Program components include the following:

- regulations under the *Energy Efficiency Act* (the 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

FIGURE 2-5

ENERGY STAR Awareness Levels in Canada, 2010



Source: Tracking Study: Awareness of ENERGY STAR/EnerGuide Symbols 2010, Ipsos Reid.

Key 2009–2010 Achievements

- Amended the *Energy Efficiency Act* in September 2009, allowing for energy efficiency standards to be set for products that affect energy consumption, including windows and doors, as well as thermostats and other energy-system control devices. The amendment also clarified the authority to prescribe standards for classes of products that may be based on common energy-using characteristics. For example, a standard for all products that consume electricity in standby mode (when the product is turned off) could be prescribed by using the powers clarified in the amended Act.
- Since 2008, seven new product standards and four more stringent standards have been implemented.
- In fiscal year 2009–2010, ENERGY STAR criteria were developed for five new products, and eight existing criteria were revised. Two hundred and sixty-five companies joined the ENERGY STAR Initiative in Canada for a total of 1135 participants.
- 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 eight products.
- Delivered five specialized workshops on the use of the ENERGY STAR calculator to the procurement and institutional community.

For more information:

oee.nrcan.gc.ca/residential/energystar-energuide-r2000.cfm?attr=0

regulations.nrcan.gc.ca

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 manages 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.

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:

oee.nrcan.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 $745 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

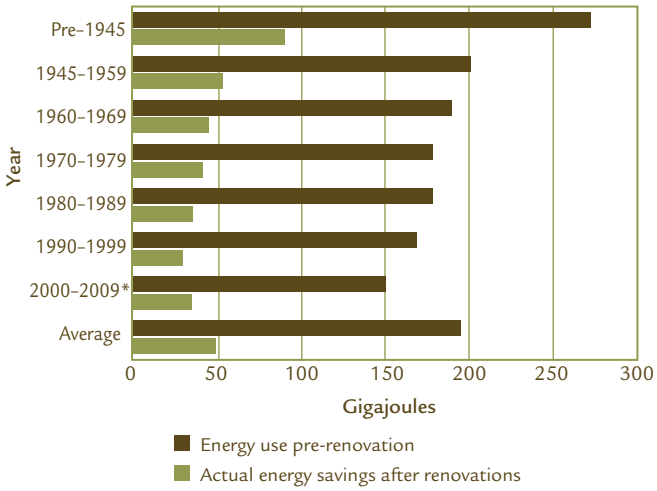
assigns a new energy-rating label. After the required improvements have been made, the property owner is entitled to a grant.

In fiscal year 2009–2010, an additional $285 million was allocated to the ecoENERGY Retrofit – Homes program in response to unprecedented demand, bringing the total budget for this element to $745 million over four years. On March 31, 2010, the program ceased accepting bookings for pre-retrofit evaluations, but continued to process grant applications from homeowners who had these evaluations and remained eligible. This demonstrated prudent program management and ensured that all eligible homeowners who previously entered the program had the opportunity to apply for a grant.

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

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).

Key 2009–2010 Achievements

- As of March 31, 2010, the ecoENERGY Retrofit – Homes program received more than 290 000 grant applications and performed nearly 610 000 pre-retrofit evaluations. The program has provided more than $350 million to more than 275 000 grant recipients. Participants reduced their annual energy consumption by about 22 percent and greenhouse gas (GHG) emissions by approximately 3 tonnes per house per year.
- Over the same time period, more than 73 000 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 25 percent of program participants).
- All regions of Canada, except one territory, have full or partial matching programs from which homeowners can get seamless access to both federal and provincial/territorial government support for home retrofits.
- Since program inception, a reduction of approximately 0.90 megatonnes (Mt) of 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 four 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 – Small and Medium Organizations was originally a five-year program. However, demand was less than expected, and on April 30, 2010, the Government of Canada announced that the program would end in March 2011. Until then, projects continue to be approved, and no existing agreements are affected. Applications continue to be processed on a first-come, first-served basis until March 31, 2011, or until all funds are allocated.

ecoENERGY Retrofit provides 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 2009–2010 Achievements

- As of March 31, 2010, 848 contribution agreements had been signed in the buildings and industry sectors (494 buildings projects and 354 industry projects). These agreements are for projects worth $161 million, yielding annual energy cost savings of $29 million.
- More than 1900 buildings and industry sector participants took part in webinars and information sessions.
- Since program inception, the program has approved projects that will save approximately 0.156 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.

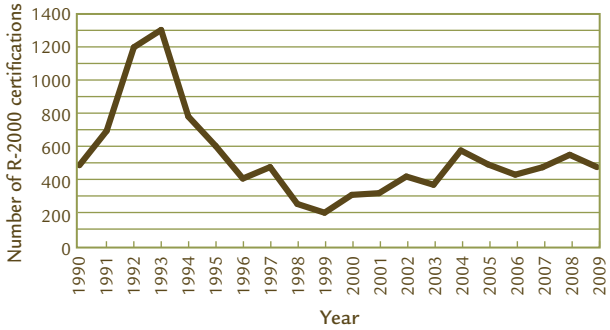
Description

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, including building design simulation for new buildings and the Dollars to $ense Energy Management workshops for existing buildings, so designers, builders, owners and operators can learn about and use best practices and new technologies to improve the energy efficiency of new and existing buildings
- updating building energy ratings and promoting labelling systems for housing, including the EnerGuide Rating System (ERS), 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)

FIGURE 3-2

Number of R-2000 Housing Certifications, 1990 to 2009



Source: NRCan national housing database and internal data.

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

- supporting the National Research Council financially in upgrading the *National Energy Code for Buildings*, last published in 1997
- 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
- establishing and maintaining partnerships to reduce energy use and improve energy efficiency information

Key 2009–2010 Achievements

- By March 31, 2010, more than 4000 building owners, managers, operators, designers and builders had received energy management training, while almost 400 commercial buildings received energy labels as part of a pilot energy management labelling and benchmarking program.
- Issued more than 540 000 housing labels for new and existing houses.
- More than 1700 building professionals took part in technical support workshops, and more than 4700 housing professionals, builders and energy advisors were trained.
- As of the end of the 2009–2010 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. Eleven provinces and territories participate in the Building Energy Codes Collaborative.
- More than 75 percent of new homes are constructed in provinces that have announced the intent to increase the minimum ERS level of new homes to ERS80 by 2012. This represents a 30 percent decrease in energy consumption when comparing with homes built according to the requirements of the 2006 building code.
- Since program inception, an estimated 1.07 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 over four years to accelerate energy-saving investments and exchange best-practices information within Canada's industrial sector. The program helps industry become more energy efficient by providing tools, training and cost-shared studies to enable industry to identify opportunities, calculate payback and overcome technical, management and financial barriers to energy efficiency project implementation.

The Canadian Industry Program for Energy Conservation (CIPEC) is an industry-government partnership delivered through the ecoENERGY for Industry program. The CIPEC network encompasses more than 50 associations and 25 industrial sectors, covering 98 percent of industrial energy use in Canada. Registered CIPEC Leader companies voluntarily commit to energy efficiency improvements as well as to reducing GHG emissions. Innovative companies at the leading edge receive recognition though the national CIPEC Leadership Awards.

Key program elements 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
- the ecoENERGY Assessment Incentive for Industry, which offers a cost-shared solution 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. Typically, opportunities for annual energy savings of 10 percent to 25 percent are identified.
- the CIPEC Leaders network, which demonstrates industry sector commitment to reducing energy use, provides members with opportunities for networking, recognition and sharing of best-practices, as well as eligibility for financial incentives
- tools, publications and benchmarking studies that create awareness of energy-saving opportunities and promote actions to achieve those savings

Key 2009–2010 Achievements

- More than 3100 industrial energy managers have attended the Dollars to $ense Energy Management workshops since program inception, with 1060 trained in 2009–2010. Customized workshops are held on-site to facilitate access in remote locations.
- Welcomed 320 new members to the CIPEC Leaders network, which now has 2100 members, and held 35 network meetings.
- Organized and hosted the Energy 2009 Industrial Energy Efficiency Conference and awards gala, which attracted 400 participants from industry, utilities and academia.
- Since program inception, the ecoENERGY for Industry program helped Canadian industry avoid approximately 1.11 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 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

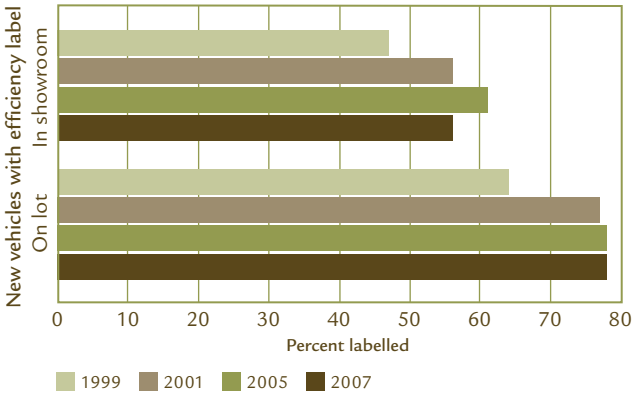
ecoENERGY for Personal Vehicles also facilitates work with the vehicle industry to implement and monitor the voluntary memorandum of understanding (MOU) between the Government of Canada and the auto industry to reduce automobile GHG emissions.

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 3-3)

FIGURE 3-3

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.

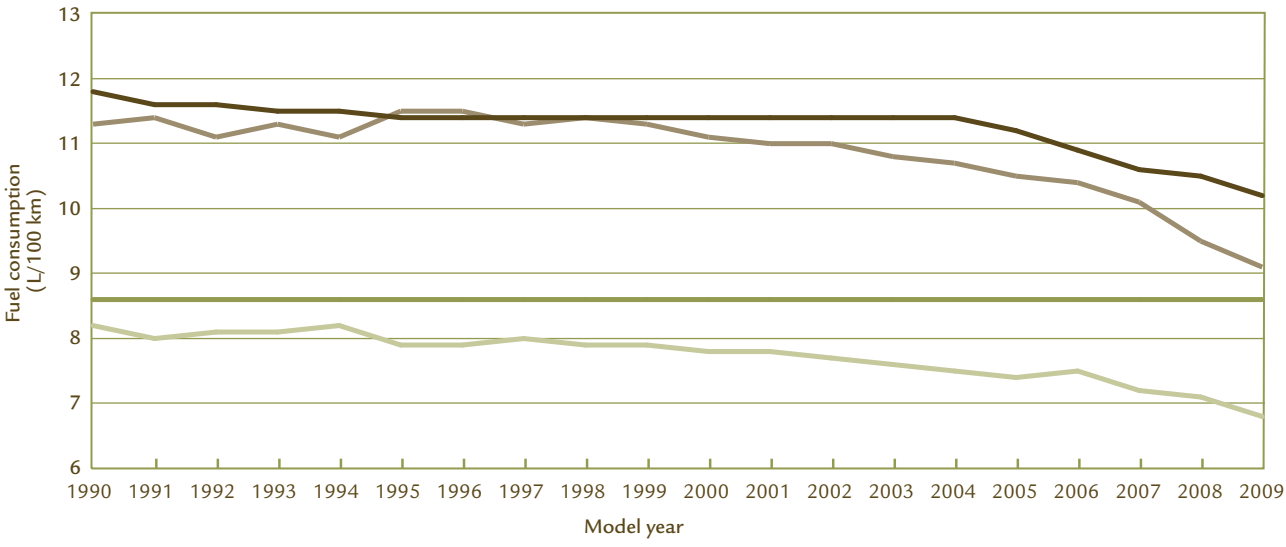
- the 2005 MOU between the Government of Canada and the Canadian auto industry – a framework for automakers to produce more fuel-efficient and lower-GHG-emission vehicles by 2010 (see Figure 3-4)
- the annual ecoENERGY for Vehicles Awards, which recognize and identify, for consumers, the most fuel-efficient 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

Key 2009–2010 Achievements

- In fiscal year 2009–2010, more than 350 000 new drivers were trained using materials from the Auto$mart fuel-efficient driving curriculum. A fuel savings of 5 percent to 25 percent is possible when drivers adopt fuel-efficient driving techniques.
- Distributed more than 300 000 copies of the *2009 Fuel Consumption Guide*, including 117 000 copies to 3400 new car dealerships and 600 to Canadian Automobile Association offices.

FIGURE 3-4

Company Average Fuel Consumption (CAFC) Versus Canadian Voluntary Standards, 1990 to 2009*



*2009 data are estimates.
Source: www.tc.gc.ca/eng/programs/environment-fcp-cafctargets-385.htm

- All provinces and most territories have incorporated fuel efficiency into driver education handbooks.
- Nearly 21 million Canadians have been reached through targeted campaigns on fuel-saving practices related to idling and tire inflation since the program was launched in 2007. In 2009–2010, the "Be Tire Smart" campaign reached 9 million people about the environmental and fuel economy benefits of proper tire inflation and regular maintenance.
- To date, the estimated GHG emission reductions associated with idle reduction and tire maintenance campaigns and with new driver training are 0.1 Mt.

For more information:

vehicles.nrcan.gc.ca

ecoENERGY FOR FLEETS

Objective

To achieve reductions in fuel use and related costs 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:

- 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
- funding for fuel-efficient technology demonstrations, which help overcome knowledge barriers, encouraging uptake of fuel-saving technologies by fleets

Key 2009–2010 Achievements

- In fiscal year 2009–2010, nearly 14 000 commercial drivers participated in SmartDriver training workshops and more than 360 participants took part in Fuel Management 101 workshops to promote greater uptake of transportation energy efficiency practices.
- Completed two idling awareness campaigns.
- Since program inception, a reduction of approximately 0.31 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 provides an operating incentive to facilities that produce renewable

alternatives to gasoline, such as ethanol, and renewable alternatives to diesel, such as biodiesel, based on production volumes. The program will invest up to $1.48 billion over nine years, starting April 1, 2008, in support of biofuel production in Canada.

This program is expected to increase domestic production and develop a competitive domestic renewable fuel industry. The expected program volume is 2.5 billion litres (L) of domestic production by March 2012, with a target of 2 billion L of renewable alternatives to gasoline and 500 million L of renewable alternatives to diesel fuel.

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 legislation.

Key changes to the program were announced in December 2009: a realignment of the nine-year funding allocation, a new payment regime and a new decision-making methodology.

ecoENERGY for Biofuels is a key component of Canada's renewable fuel 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 2009–2010 Achievements

- As of March 31, 2010, 21 contribution agreements had been signed with companies.
- These agreements represent a total commitment of $966.2 million and a domestic production of 1.6 billion L of biofuels (1.4 billion L of ethanol and 0.189 billion L of biodiesel).

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.

FBI services include project facilitation, such as energy management technical advice, program policy advice and procurement services, to assist organizations in making energy efficiency improvements. The FBI uses a financing technique known as energy performance contracting, in which the cost of the job is paid for from the savings stream.

Other levels of government, institutions and private sector firms have drawn on the FBI's experience for help in designing their own energy efficiency programs using energy performance contracting. Since its inception in 1991, the FBI has 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 2009–2010 Achievements

- Since 2007–2008, the FBI has facilitated five new contracts with federal agencies: Canadian Forces Base Gander, Canadian Forces Base Gagetown, Foreign Affairs and International Trade Canada, Fisheries and Oceans Canada, and Public Works and Government Services Canada.

- In fiscal year 2009–2010, the FBI helped facilitate three potential projects. Two of them reached the request for proposal tendering and evaluation stage, and the third was close to procurement.

For more information:

oee.nrcan.gc.ca/fbi

NATIONAL RENEWABLE DIESEL DEMONSTRATION INITIATIVE

Objective

Initiated in December 2008, the National Renewable Diesel Demonstration Initiative (NRDDI) aims to address remaining 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 by 2012, upon successful demonstration of renewable diesel fuel use under the range of Canadian conditions. More recently, the government has announced its intention to accomplish this by 2011, subject to technical feasibility.

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 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 have been provided to approved projects that demonstrate aspects of renewable diesel use and/or distribution in Canada.

Key 2009–2010 Achievements

- Seventeen stakeholder organizations were consulted.
- Five contribution agreements and three MOUs were signed to deliver projects in forestry, construction, rail, electricity generation (gensets), home heating and agricultural applications to address stakeholder questions about cold weather operability, long-term storage, materials compatibility and sediment formation.
- Two projects were completed.
- A study that assessed infrastructure readiness for the proposed regulation was completed.

For more information:

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

CHAPTER 4

Clean Energy Science and Technology

INTRODUCTION

Natural Resources Canada (NRCan) invests in the research, development and demonstration (R,D&D) of new and emerging clean 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), the ecoENERGY Technology Initiative and the Clean Energy Fund. These programs allocated more than $120.5 million in the 2009–2010 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 the 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 2009–2010 key achievements of the OERD, CanmetENERGY and other partners in energy S&T.

For more information:

nrcan.gc.ca/eneene/science/resres-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 its economy and the environment.

Description

PERD supports R&D activities within nine portfolios, comprising oil sands and offshore regulatory issues, sustainable bioenergy, the reduction of air impacts, the improvement of efficiency in electricity, the integration of alternative and renewable energy into the grid, and the improvement of efficiencies in end-use, with a focus on transportation, buildings and industry. Efficiencies are sought in energy production, distribution and end use. Examples of funded projects appear throughout 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 2009–2010 fiscal year was approximately $54.9 million. Of that amount, $17.4 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 $37.5 million was 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 of Canada's actions toward clean air and greenhouse gas (GHG) emissions reductions. It is a $230-million investment in clean energy S & T. 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 2009–2010 fiscal year was nearly $45.6 million.

CLEAN ENERGY FUND

Objective

To fund the demonstration of technologies, including large-scale carbon capture and storage projects, and renewable energy and clean energy systems demonstrations to reduce GHG emissions reductions and increase the percentage of electricity produced from clean sources.

Description

The $795-million Clean Energy Fund, a component of Canada's Economic Action Plan announced in 2009, provides funding for the demonstration of promising technologies to support the Government of Canada's commitments to reducing GHG emissions. Approximately 20 percent of the Clean Energy Fund has been committed to or earmarked for renewable and clean energy system projects and research related to marine energy, smart grid, wind, energy storage, bioenergy, geothermal energy in the North, and community energy systems.

The Clean Energy Fund expenditures for the 2009–2010 fiscal year were approximately $30 million. Of that, $6 million was allocated to energy demonstration projects, which will contribute directly and indirectly to improved energy efficiency and the integration of renewable energy sources in Canada.

Key 2009–2010 Achievements

- Nineteen demonstration projects in renewable energy and clean energy technologies were announced in 2009–2010. These projects for renewable and clean energy systems will demonstrate marine energy, smart grid, wind, energy storage, bioenergy, geothermal energy in the North, and community energy systems.

For more information:

nrcan.gc.ca/eneene/science/renren-eng.php

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 the integration of energy efficiency and renewable energy 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 innovative technologies, particularly integrated systems, 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, thermal storage systems and micro co-generation systems through, for example, 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 (PV) 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 control and operation systems, and the commissioning/recommissioning of buildings.

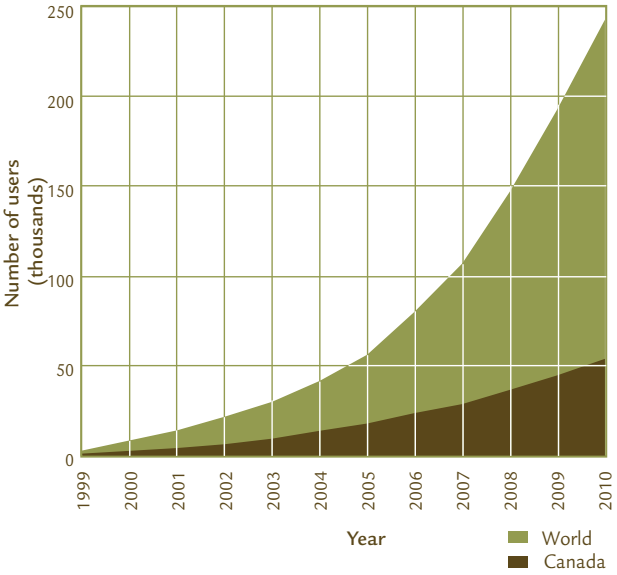
CanmetENERGY's partnerships with industry help to build advanced residential and commercial buildings that incorporate a wide array of innovative technologies and consume significantly less energy than their conventional counterparts. Under cost-sharing arrangements to accelerate the development and 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 2009–2010 Achievements

- CanmetENERGY increased the number of users of the RETScreen®[8] Clean Energy Project Analysis Software to more than 242 000 people in 222 countries, adding an average of 1000 new users every week (see Figure 4-1). More than 250 colleges and universities worldwide are now using RETScreen for education. As well, RETScreen was selected for several external awards, including the Summit Award for Leadership in Green Procurement (recipient), the Leadership Award at the Euromoney and Ernst & Young Global Renewable Energy Awards (finalist), and the Technology and Innovation Application Award at the GLOBE Awards for Environmental Excellence (finalist).

FIGURE 4-1

RETScreen Software: Cumulative Growth of User Base



Source: NRCan/RETScreen Customer Database.

- The DABO™ software developed by CanmetENERGY helped reduce building energy consumption at the Palais des congrès de Montréal by 10 percent in 2008–2009 and 13 percent in 2009–2010. DABO is a fault detection and diagnosis, performance analysis and documented history creation software application. This continuous building optimization program adds intelligence and memory to the building automation system. IFCS was selected as the commercial partner for licensing DABO and distributing it in Canada, Europe and China. Several projects to introduce DABO commercially are under development.

- North America's first solar seasonal storage community is meeting 80 percent of space heating needs with solar energy in its third year of operation. This milestone at the Drake Landing Solar Community in Okotoks, Alberta, is the highest performance level achieved anywhere in the world. This significant achievement gives confidence that the overall goal of more than 90 percent of heating needs being met by solar energy by year five is achievable.

- The Local Energy Efficiency Partnership™ (LEEP) is a process that enables builders to determine which new energy-efficient and renewable technologies best fit their production homes. CanmetENERGY and EnerQuality are expanding the pilot project of the LEEP process in four Ontario cities. The project will produce 40 demonstration homes within two years. CanmetENERGY is further developing the technology information for the LEEP processes so that each is tailored to the interests of the particular region.

- CanmetENERGY is examining the system performance of an innovative cold climate air-source heat pump. The project will monitor the long-term operation of the ACADIA™ pump from Hallowell International under a variety of climatic conditions. In particular, the project will track its performance at lower outdoor ambient temperatures than those currently considered practical for conventional pumps. The results of this work will help revise the heat pump performance standard.

[8] RETScreen is a registered trademark of Her Majesty the Queen in Right of Canada as represented by the Minister of Natural Resources.

- CanmetENERGY and its partners – Smart Growth on the Ground and the City of Prince George, British Columbia – completed extensive testing of an energy mapping methodology that will allow communities across Canada to assess their GHG reduction capacity. The technique developed included input from municipal, utility, provincial and federal databases to characterize the energy consumption patterns of the city.

- CanmetENERGY and its partners – Concordia University, the Canadian Solar Buildings Research Network, and Day4 Energy Inc. and Conserval Engineering, Inc. from the Canadian solar industry – designed and installed a combined solar power and heat generation system on a new building at Concordia's headquarters in Montréal. Day4 Energy supplies PV panels, and Conserval Engineering supplies the SolarWall®. The integrated 24.5-kilowatt-peak (kWp) PV panels and the 76 kWp of heat by fresh air solar-heating with the SolarWall cover approximately the top two floors of the building's south-facing façade. This demonstration in a commercial building showcases innovative means by which buildings of the future could produce energy for their own use, thereby reducing their demand on the electricity grid.

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 carbon dioxide (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, and 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 2009–2010 Achievements

- CanmetENERGY collaborated with the Xeni Gwet'in First Nation in the design and demonstration of solar PV "mini-grid" systems in a remote community in British Columbia. This project evaluated the benefits of three key improvements: installing PV systems on six houses (totalling 27 kilowatts [kW]), replacing a 90-kW generator with a 30-kW unit and installing a switch to control commercial and institutional electricity loads. The annual savings in diesel fuel was 26 000 litres compared with the reference year – a reduction of 25 percent in fuel and 73 tonnes (t) of GHG emissions.
- A nickel mining and processing company is carrying out an in-plant trial of an energy efficiency and emissions control strategy, jointly developed with CanmetENERGY. The new process is expected to reduce electricity needs by 14 percent (from 43 megawatts [MW] to 37 MW) and reduce petroleum coke consumption by 25 percent (from 4 t per hour (t/hr) to 3 t/hr). As a result, the direct and indirect reduction of CO_2 emissions is expected to be 120 kilotonnes (kt) per year. In addition, the new process is expected to reduce sulphur dioxide emissions by 20 kt per year, which makes a $300-million scrubbing treatment unnecessary.
- Oxyfuel fluidized bed combustion (FBC) units were developed at CanmetENERGY to examine oxyfuel firing in FBC systems. The bench-scale units are the first and the pilot-scale units the largest units built to date that demonstrate oxyfuel FBC technology with flue gas recycling. This technology can produce a pure CO_2 stream for capture and storage while burning a wide range of carbon-based fuels. Foster Wheeler Canada Ltd. is using the pilot-scale unit for fuel evaluation as a prelude to the company building a 300-MW electrical commercial scale demonstration unit.
- CanmetENERGY is developing a technology for hot scrubbing CO_2 for carbon capture and storage to replace amine scrubbing, thus reducing the energy penalty of CO_2 removal from power plants. CanmetENERGY is the first to demonstrate the technology experimentally. It also has developed several new methods of improving sorbent performance for CO_2 removal and a novel sorbent using a unique and inexpensive pelletization

technology that has shown the best performance so far reported in the literature.

- CanmetENERGY is leading the development of marine energy standards as Chair of Technical Committee (TC) 114. This committee was established by the International Electrotechnical Commission (IEC) and was mandated to produce global standards for these technologies. CanmetENERGY is leading the development of a technical specification that will provide uniform terminology for this sector. The standards developed through the IEC serve as a basis for national standardization. Active participation by members from CanmetENERGY in IEC TC 114 allows Canada to be at the forefront of standards development for this industry.

- CanmetENERGY, in co-operation with Core Energy Technologies, Inc. and Ontario's electrical and gas equipment approval agencies, installed a Stirling engine micro-cogeneration unit in an Ottawa area home, as a showcase and pilot testing opportunity. The unit is fuelled by natural gas and provides space heating and domestic hot water production while generating 1 kW of grid-tied electrical power. This technology is being adapted to also provide backup power for critical electrical loads during emergency power outages. CanmetENERGY has created new electrical testing capacity for the integration and evaluation of such systems under closely controlled laboratory conditions, which will lead to a better understanding of how to optimize micro-cogeneration products for the Canadian marketplace.

- CanmetENERGY cooperated with the Canadian Standards Association (CSA) in the adoption and publication of two PV module performance standards: CAN/CSA-C61215:08 is a design qualification standard for crystalline silicon PV modules and CAN/CSA-C61646:10 is the equivalent for thin film PV modules. Thin film technologies, a second generation of PV modules, are gaining a larger share of the PV market. Adopting these two international standards provides a technical basis for the design certification of PV modules sold in Canada and ensures the availability of high-quality PV modules for the Canadian market. CanmetENERGY chairs the Canadian national committee to the IEC for solar PV energy with an objective of ensuring harmonization of standards requirements at a global level.

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 2009–2010 Achievements

- CanmetENERGY signed a three-year agreement with the Agence de l'efficacité énergétique to provide technical support for three demonstration projects in the food and beverage sector. The projects will demonstrate the benefits of integrating the refrigeration systems with the thermal energy system of the facilities and will foster the implementation of systems that use natural refrigerants instead of synthetic refrigerants. Additionally, the agreement requires that CanmetENERGY provide recommendations for an incentive program that targets the retrofit or installation of refrigeration systems in Quebec food-processing plants.
- In collaboration with the Agence de l'efficacité énergétique in Quebec, CanmetENERGY delivered the first Canadian advanced training session on heat integration of industrial processes to engineering firms, consultants, utilities and industries. Participants also had the opportunity to familiarize themselves with the newly developed process integration software that identifies and evaluates the impact of heat recovery projects in small and medium-sized enterprises and in large industries. These activities are part of a multiyear capacity building program to improve energy efficiency in Quebec.
- CanmetENERGY signed a four-year research agreement with Institut de recherche d'Hydro-Québec to develop a systematic approach to identify and recover energy from waste heat in industry. The main objective of this project is to develop a decision-making tool for the selection of waste heat recovery and upgrading solutions. The agreement also includes the development of advanced technologies such as heat pump and power production cycles, as well as a full-scale demonstration project at an industrial site. The recovery of energy from waste heat represents one of the greatest opportunities for reducing energy use and GHG emissions in industry.

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 Contaminant (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 2009–2010 Achievements

- CanmetENERGY is leading the research in developing monitoring technologies and protocols to quantify total particulate matter (PM) and the black carbon fraction from upstream oil and gas industry flares. PM, in particular the black carbon fraction of the total PM, is believed to be a highly potent source of GHG emissions. Early results from this research have been recognized internationally by the World Bank Global Gas Flaring Reduction partnership, the International Methane to Markets Partnership and the Arctic Council.
- CanmetENERGY worked with Syncrude Canada Ltd. to demonstrate a new dry stackable tailings technology known as rim ditching. Preliminary results from this large pilot test (80 000 cubic metres) are very promising. This method would be another way of managing oil sands fine tailings by decreasing the amount of water that is trapped in the pore space of fine tailings. After this water is removed, it can be recycled back to the process, thereby reducing the volume of fresh water required from the Athabasca River.
- CanmetENERGY identified silica-organic compounds in process water and their role in causing problems in recycling process water for in situ operations. This work was related to a major project for a steam-assisted gravity drainage operation that was investigating issues with its process water. Because in situ production is becoming the more prominent process, it is essential to understand the chemistry associated with recycling process water to reduce the demand on water resources.
- NRCan's Horizontal Task Team on Water completed its report on building a competitive advantage through sustainable water use, a freshwater strategy for the Department. This report outlines NRCan's recommended policy for issues about water that need to be addressed. This report gives NRCan guidance to focus research and policy development on water issues.
- CanmetENERGY and United States' national laboratories analysed the chemistry of diesel fuels and fuel blends. Fuel chemistry was assessed to determine its compatibility with advanced engines designed to produce no nitrogen oxide and PM emissions with maximum efficiency. CanmetENERGY worked with the Fuels for Advanced Combustion Engines working group within the Coordinating Research Council to examine fuels and combustion interactions.

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. Department of Energy, the International Energy Agency (IEA) 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. R&D 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 R&D of on-board energy-storage and power systems, such as batteries and fuel cells. As the Government of Canada's lead, CanmetENERGY plays a significant role in coordinating and reviewing technical input from many private and public partners for the Canadian Electric Vehicle Technology Roadmap (evTRM).

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 R&D for testing advanced fuels and fuel usage, as well as engine performance and components.

This area of R&D 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 2009–2010 Achievements

Research and Development

- CanmetENERGY partnered with the Canadian electric vehicle industry to produce an evTRM, published in January 2010. The evTRM identified strategic initiatives needed to support the implementation of electric vehicles on Canadian roads. An interdepartmental working group on electric mobility was formed to focus Government of Canada R&D efforts.

- Humidification is an important and delicate function of fuel cell performance. In fiscal year 2009–2010, CanmetENERGY supported research at dPoint Technologies Inc. to develop a fuel cell humidifier that uses a proton exchange membrane. This new membrane reduces the cost of humidifiers for 5-kW fuel cells from $2,500 to $60. More than 65 fuel cell companies in 15 countries are using this new low-cost humidifier.

- CanmetENERGY's hydrogen and fuel cell laboratory in Ottawa, Ontario, processed and characterized new materials for fuel cells and new nanomaterials for hydrogen storage. The two-year-old laboratory provides research expertise to external partners and access to unique facilities to meet joint technical targets. Canadian partners include Vale, the University of Waterloo, the University of Calgary and the NSERC Hydrogen Canada (H2CAN) Strategic Research Network supported by the Natural Sciences and Engineering Research Council of Canada (NSERC).

- In 2009, CanmetENERGY began coordinating a project on the life-cycle analysis of alternative fuels and technologies for urban transit buses, in conjunction with the IEA and Environment Canada. The project examines the environmental performance and ownership costs of various technology options. The resulting data will help transit authorities make decisions about alternative fuel and technology purchases and use.

Demonstrations

- In 2010, the five Ford Focus fuel cell vehicles of the Vancouver Fuel Cell Vehicle Program in British Columbia completed five years of operation and the fleet exceeded 350 000 kilometres (km). One of the vehicles exceeded 95 000 km, and none of the vehicles have had major component failures.

- The Canadian airport hydrogen project, the largest multiapplication hydrogen and fuel cell demonstration project in Canada, was launched in 2009. The project is located at the Pierre Elliot Trudeau International Airport in Montréal, Quebec, and at the Vancouver International Airport in Richmond, British Columbia. It will demonstrate and field test hydrogen technologies, including portable, mobile and stationary applications, as well as hydrogen fuelling infrastructure.

- In 2009, CanmetENERGY maintained involvement in demonstration projects under the National Renewable Diesel Demonstration Initiative (NRDDI). The NRDDI supports the mandate proposed by the Government of Canada of a 2 percent annual average renewable diesel content in the Canadian diesel pool by 2012. These projects covered the use of various biodiesel blends in on-road heavy-duty trucks, off-road equipment in forestry and construction, marine engines and rail agricultural equipment, as well as in stationary furnaces and electricity generators.

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, IEA 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 2009–2010 Achievements

- There is no mature foundation of standard practices for using biomass fuels for power generation. With funding from NRCan, Ontario Power Generation carried out an extensive review of global utility industry experience and global standards regarding process safety and industrial hygiene. The review investigated issues about the safe storage and handling of biomass, identified process safety and industrial hygiene risks and recommended mitigating actions and safety requirements.
- CanmetENERGY developed a pyrolysis project under the U.S.-Canada Clean Energy Dialogue, which reflects the strong interest of both countries in this technology area. The overall objective of this collaboration is to improve the potential for using the biomass pyrolysis pathway to generate biofuels for transport and stationary uses and for biorefinery applications.
- In an NRCan-supported project, Nexterra Systems Corp. completed the construction and commissioning of a first-of-its-kind project in the Kruger Products tissue mill in New Westminster,

British Columbia. This demonstration project was the critical step in commercializing the direct-fired gasification technology application for boilers and is expected to be replicated by leaders in the North American forest industry.

- Nexterra Systems Corp. received the Sustainability Champion Award from the Vancouver Organizing Committee for the 2010 Olympic and Paralympic Winter Games. The award was for Nexterra's leadership and contribution in making sustainability an integral part of the 2010 Olympics through strategic advice and support for the carbon offset program. Nexterra has acknowledged that it could not have achieved these successes without the support of NRCan and others over the years.
- CanmetENERGY led the collaboration among industry, government and academic stakeholders required to provide accurate, highly technical information to develop an ASTM International standard for pyrolysis oil. This will be the first worldwide standard for pyrolysis oil.
- CanmetENERGY supported the revision of the new CSA standard B415.1-10, Performance testing of solid-fuel-burning heating appliances. Improvements to the new version include stricter emission rates, the inclusion of appliances not covered previously (central heating furnaces and hydronic boilers) and the incorporation of alternative efficiency measurements.
- PlanET Biogas Solutions of St. Catharines, Ontario, designed, engineered and optimized two full-scale anerobic digestion systems to test the digestion of various agriculture and agri-food residues.
- In collaboration with the Wood Pellet Association of Canada, CanmetENERGY provided funding and technical expertise to develop *The Pellet Handbook*. The aim of this IEA-led activity is to contribute to pellet use within the energy sector. Canada has unique experience and expertise in pellet production, handling, storage and transportation.

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 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: Agriculture and Agri-Food Canada, Environment Canada, Industry Canada, National Research Council Canada and NRCan. CBIN coordinates and manages two federal government bio-based R&D initiatives:

- the PERD Bio-Based Energy Systems and Technologies program ($3.0 million in 2009–2010)
- the ecoENERGY Technology Initiative Bio-Based Energy Systems ($2.1 million in 2009–2010)

Key 2009–2010 Achievements

- A standard was developed for residential wood heating appliances: CSA B415.1-10, Performance testing of solid-fuel-burning heating appliances. The test results of the four wood-heating appliances were incorporated into recommendations for the standard. The standard is now available. The revised standard is a significant step toward regulations for residential wood-heating appliances.
- The development of an ASTM International standard for pyrolysis oil (ASTM D7544-09) was a significant development. Previously, there were no worldwide standards for pyrolysis oil. Significant co-operation was required among industry, government and academic stakeholders. This specification covers a pyrolysis liquid biofuel produced from biomass that is intended for use in industrial burners equipped to handle these types of fuels.
- A pilot anaerobic digestion (AD) mobile unit was operated for six months at La Pinière Wastewater Treatment Plant in Laval, Quebec, to treat municipal wastewater excess sludge. This pilot demonstrated the applicability of AD to municipal biosolids, the validation of AD at the pilot scale and the development of a high-impact partnership with a municipal government. The demonstration proved the valorization of organic waste into renewable energy, with potential for reduction of GHGs. The research estimated that the insertion of AD in the current chain of sludge treatment at La Pinière could potentially reduce more than 10 t of organic solids per day, generate 5250 normal cubic metres of gas per day (Nm^3/d) or 3150 normal cubic metres of methane per day (Nm^3CH_4/d) of biogas and reduce GHG emissions by 4000 t CO_2 equivalent per year.
- A new third-generation bio-baler developed in 2009 harvested willow in plantations at a rate of 30 to 40 bales an hour – a significant improvement over the first generation bio-baler. This new harvest rate corresponds to a range of 14 to 18 t of fresh crop per hectare (ha) (7 to 9 t dry matter/ha). The machine is robust and may soon compete economically with modified self-propelled forage harvesters, which are the only commercial machines used to harvest willow from plantations in the form of wood chips.

For more information:

www.cbin.gc.ca

CHAPTER 5

Renewable Energy

RENEWABLE ENERGY USE

In 2008, renewable sources accounted for more than 62 percent 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	58.0	–
1991	61 116	58.0	3.0
1992	62 895	58.0	2.9
1993	63 114	56.0	0.3
1994	63 175	56.0	0.1
1995	66 542	57.0	5.3
1996	67 101	59.0	0.8
1997	68 202	61.0	1.6
1998	68 340	62.0	0.2
1999	68 614	61.8	0.4
2000	69 031	62.0	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
2008	78 371	62.4	1.9

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

TABLE 5-2

Renewable Energy Technologies Used in Canada

Electricity – Commercial	**Mechanical power**
Hydroelectric dams	Wind water pumps
Tidal barrages	**Thermal energy**
In-stream current devices	Biomass (e.g. roundwood, pellets, wood chips)
Biomass (e.g. wood waste)	Ground-source heat pumps (i.e. earth energy)
Biogas (e.g. methane from landfill sites)	Solar air-heating systems
Wind turbines	Solar hot water systems
Photovoltaic 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 60.4 percent of the electricity generated in 2008. Canada's hydro supply is dominated by large-scale projects that were developed by electric utilities. Of the 74 436 megawatts (MW) of installed hydro capacity, 3452 MW come from small hydro sites (capacity less than 50 MW), representing 2.7 percent of Canada's total installed electricity capacity. Significant potential remains for additional large and small run-of-river 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 4.3 percent of Canada's total energy supply comes from bioenergy, second only to hydro power (which generates 11.8 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 and forestry industries are Canada's major producers and users of bioenergy. In 2008, 607 MW of biomass generating capacity came from spent pulping liquor used in the pulp and paper industry. This amount represents approximately 40 percent of the total biomass generating capacity, while 50 percent of the capacity (765 MW) came from wood refuse used in the forestry industry.

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 2008, the biomass installed capacity was 1516 MW, of which 9.5 percent was from landfill gas plants (109 MW) and municipal solid waste plants (35 MW). Approximately 200 million litres (L) 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.

Geothermal energy can be used as a heat source or sink for heating or cooling applications, such as ground-source heat pumps (GSHPs). GSHPs are electrical systems that use the relatively constant temperature of the ground to provide heating, cooling and hot water for homes and commercial buildings.

For this reason, a GSHP 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.

As of December 31, 2009, in Canada there were approximately 46 000 installed GSHPs with 555 megawatts of thermal energy (MW_{th}) of installed capacity producing an estimated

760 gigawatt-hours equivalent annually. In 2008, 15 000 GSHP units were installed in Canada. This compares with 9100 units installed in 2007 and 4217 units installed in 2006.

Wind Energy

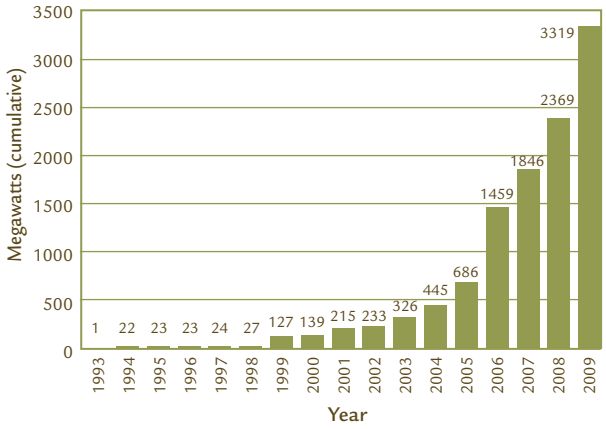
Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada's land mass and coastal waters combine to provide a wind resource with potential estimated at more than 100 000 MW.

As of December 31, 2009, 3319 MW of wind power had been installed in Canada. This makes Canada the 13th country that has reached the 1000-MW milestone and the country with the 12th-largest installed wind energy capacity.

The best year in terms of wind power installations was 2009, with 950 MW of new wind power generating capacity installed across the country, representing a 40 percent increase from the 2008 level (2369 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.

FIGURE 5-1

Canadian Wind Power Cumulative Capacity, 1993 to 2009



Source: Canadian Wind Energy Association.

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.

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 2008 was 720 000 square metres (m^2), or approximately 500 MW_{th}. The domestic market increase has averaged 13 percent annually since 1998. In 2008, the solar thermal collector market in Canada was 139 159 m^2, more than twice the installations in 2007 (60 900 m^2), with revenues up 44 percent from the 2007 level. 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 power installed capacity reached 94.57 MW in 2009, compared with 32.72 MW in 2008. The grid-connected market accounts for 87 percent of the market in 2009, compared with only 33 percent in 2008. This significant growth was spurred primarily by two programs from the Government of Ontario: a renewable energy standard offer program launched in 2006 and the new feed-in tariff program launched in 2009. Out of the approximately 82 MW of grid-connected installed capacity in 2009, small, residential and building integrated solar PV systems represented 11 percent,

while three large ground-mounted utility-scale solar PV farms alone represented 76 percent.

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.

PULP AND PAPER GREEN TRANSFORMATION PROGRAM

Objective

The Pulp and Paper Green Transformation Program (PPGTP) was created to fund green capital projects at Canadian pulp and paper mills, leading to improved environmental and commercial sustainability of the sector.

Description

The $1-billion PPGTP was launched in June 2009. It supports innovation and environmentally friendly investments in Canada's pulp and paper industry in such areas as energy efficiency and renewable energy production. In October 2009, credits were allocated to 24 companies, based on black liquor production ($0.16/L) at 38 pulp and paper mills. Companies have until March 31, 2012, to invest their credits at any of their Canadian pulp and paper mills in approved green capital projects that lead to measurable environmental benefits.

Key 2009–2010 Achievements

- Signed 10 contribution agreements with seven companies for close to $200 million, with approximately $49 million provided for 2009–2010.
- These agreements support the creation of approximately 60 MW of renewable electrical capacity.

For more information:

www.cfs.nrcan.gc.ca/subsite/pulp-paper-green-transformation

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 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 2009–2010 Achievements

- As of March 31, 2010, 100 contribution agreements had been signed with proponents, representing about $1.4 billion in federal funding over 10 years and 4400 MW of renewable power capacity.
- After all 100 projects are commissioned, the expected greenhouse gas (GHG) emission reductions from full-year operations are expected to be about 6 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 the large-scale deployment of solar water-heating units in the residential sector
- industry capacity-development – providing financial contributions to develop technology standards and certification processes for solar thermal technologies, human resources skills and tools and to provide public information for renewable thermal energy technologies

Key 2009–2010 Achievements

- Installed 297 solar thermal systems in the industrial, commercial and institutional sectors.
- Signed contribution agreements with 11 partners (utilities, developers and buyers' groups) to run pilot projects that will test large-scale methods to deploy solar-heated water in the residential sector. Under the pilot projects, up to 2000 solar water-heating systems will be installed in Canadian homes by 2011.
- 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.
- Signed nine contribution agreements with companies for the certification of packaged solar domestic water-heating systems.
- The estimated GHG reductions from systems installed under the program during 2007–2008, 2008–2009 and 2009–2010 are 3.3, 5.1 and 8.0 kilotonnes (kt), respectively. The cumulative annual GHG reductions from the program from these installations are 16.4 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 included in the "Key Achievements" sections of 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. Their main objectives are to facilitate access to data on energy use in the industry, transportation and building sectors; monitor the quality of data; develop expert knowledge; and investigate methods of improving data collection and analysis. Since their establishment, these centres are also sponsored by various entities, including other federal departments, provincial government agencies, industry associations and energy supply utilities.

There are two national consultative bodies in the area of energy efficiency: the Steering Committee on Energy Efficiency (SCEE), 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 other Canadian communities can replicate.

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, 2010, the GMF had approved more than $450 million for more than 800 sustainable community plans, feasibility studies, field tests and capital projects with the potential to leverage almost $3 billion of economic activity in approximately 400 Canadian communities. Actual environmental benefits include the reduction of an estimated 103 994 tonnes of carbon dioxide annually from 28 completed capital projects.

More details can be found in the *Green Municipal Fund Annual Report 2009–2010* at **fmv.fcm.ca/About_Us/Annual_Reports/**.

STEERING COMMITTEE ON ENERGY EFFICIENCY

In 2004, federal, provincial and territorial energy ministers established the SCEE and tasked it with establishing a coordinated, complementary agenda for energy efficiency in the built environment, industry and transportation sectors. The SCEE held four face-to-face meetings in the 2009–2010 fiscal year – in Winnipeg, Montréal, Ottawa and Toronto – with members representing the federal, provincial and territorial governments.

There are three working groups under the auspices of the SCEE. In 2007, the SCEE and its working 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 SCEE working groups are continually 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.

At the September 1, 2009, meeting of the Council of Energy Ministers, the efforts of these working groups culminated in the announcement of a series of tools for collaborative energy efficiency actions, namely:

- *On the Road to a Fuel-efficient Truck: A Guide for Purchasing Aerodynamics for Heavy-Duty Tractors and Trailers* – to provide truck owners and operators with the information to select, install, maintain and drive with aerodynamic devices that can be installed on heavy-duty trucks to reduce fuel use and greenhouse gas (GHG) emissions, as well as how to calculate expected fuel savings and return on investments
- *The Energy Management Information Systems (EMIS) Audit and Implementation Plan Manual and Tool* – to assist industrial facilities in better measuring and tracking energy use to help promote investing in energy efficiency through the proper use of an EMIS audit, preparing business cases and implementing systems to achieve long-term reductions in energy consumption per unit of production
- *Recommissioning Guide for Building Owners and Managers* – to provide education for sector clients and training for service providers on how existing building recommissioning can facilitate the optimal energy performance envisioned by updated building codes
- *Integrated Community Energy Solutions: A Roadmap for Action* – to provide a broad strategy to capitalize on synergies available at the community level to achieve improvements in energy performance and cuts to GHG emissions, as well as a menu of tools to complement existing sectoral energy efficiency strategies
- Formed in 2003, the Built Environment Working Group (formerly the Demand Side Management Working Group) has members representing NRCan, industry and all provinces and territories. Its subcommittees perform 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
  - energy efficiency financing in the commercial/institutional sector
  - a positioning paper on energy efficiency
- The SCEE 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 2009–2010 fiscal year, TWGEE members collaborated to launch *On the Road to a Fuel-efficient Truck: A Guide for Purchasing Aerodynamics for Heavy-Duty Tractors and Trailers*, referenced above. Additionally, TWGEE members developed a best practices guide for developing idle-reduction programs, which was distributed to federal and provincial government partners, strengthening the cooperation, collaboration and alignment among jurisdictions on this issue. The TWGEE also undertook research studies that will be used to engage industry stakeholders on the issue of fuel-efficient tires and involve them in developing a framework that could be used in Canada to promote fuel-efficient tires to heavy-duty truck tire purchasers.

- 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.

  The working group launched Canada's involvement in developing the ISO[9] 50001 standard for Energy Management Systems Standard. In the 2009–2010 fiscal year, significant progress was made in addressing the scope, language and definition of the standard, energy performance indicators and the energy planning process. The standard is expected to be available in the 2011–2012 fiscal year. In support of the standard, three pilot workshops were undertaken with respect to the energy management information systems. These efforts have facilitated the development of a new EMIS Dollars to $ense Energy Management workshop to be launched in 2011–2012.

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 twice during the 2009–2010 fiscal year.

FEDERAL-PROVINCIAL AND FEDERAL-TERRITORIAL CO-OPERATION

Interest continues to grow in energy efficiency as a means of maximizing the services obtained from Canada's existing energy supply capacity. In addition to general co-operation on energy efficiency, provincial and territorial governments helped to deliver or employ 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.

[9] International Organization for Standardization.

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 territory, were able to 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® qualified products. The ENERGY STAR Initiative in Canada 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 and the Province of Ontario have recently incorporated a component on fuel efficiency into their driver education curricula. Also, many provinces display the OEE's publications in their licensing bureaus.
- Similarly, for commercial drivers, four memoranda of understanding with provinces and territories were put in place in 2009–2010, with five more under negotiation. Under these agreements, the province or territory will begin to incorporate knowledge of fuel-efficient driving techniques as a requirement in commercial driver licensing for novice drivers. OEE's ecoENERGY for Fleets program will provide the educational and informational materials that are needed by the provinces, territories and driver educators to respond to this new requirement. This will ensure that new licensees in these jurisdictions are exposed to information on fuel-efficient driving practices as part of the licensing process and further encourage the uptake of program materials by driver education schools.
- 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 GHG emissions from personal vehicles by improving the buying, driving and maintenance practices of Canadians.

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 Manitoba Hydro Power Smart program is widely recognized for its effective, user-friendly tools for homeowners, businesses and industry to boost energy efficiency and save significantly on energy costs.

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

The 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 work of three agencies: Efficiency NB, Conserve Nova Scotia and Prince Edward Island's Office of Energy Efficiency.

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

The provinces have been promoting the use of renewable energy for electricity generation. They provide numerous incentives, including voluntary renewable energy targets, legislated renewable portfolio standards and the procurement of renewable energy through requests for proposals, standard offers and feed-in tariff programs.

The Building Energy Codes Collaborative

The Building Energy Codes Collaborative (BECC) is a federal-provincial-territorial committee supported by the Council of Energy Ministers, the SCEE 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 BECC are as follows:

- provide a forum for provinces, territories and the Government of Canada 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 NECB

NRCan and BECC prepared a business plan for updating the 1997 NECB 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 Canada (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 NECB 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
- continued processing of payments by the OEE's Buildings Division 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. Though the two programs are closed, payments, which can be made only when the client verifies that work has been completed, are still being processed.

- signing a three-year collaboration agreement with CanmetENERGY and the Agence de l'efficacité énergétique to help refrigerated facilities (ice and curling rinks, supermarkets, warehouses) in Quebec reduce their energy consumption and GHG emissions through the Programme d'optimisation en réfrigération (OPTER). This program is based on the CoolSolution approach developed by CanmetENERGY. CanmetENERGY provides technical support and training for consultants and decision-makers.

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 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.

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 supports up to 40 percent of eligible project costs.

In 2009, SDTC approved funding for the detailed engineering phase of a large demonstration-scale cellulosic ethanol facility project. Based on the results, SDTC will decide whether to fund the construction phase of the project. SDTC is also assessing other projects for funding.

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 Energy Management 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.

NRCan works with Efficiency NB to facilitate the access for owners of small and medium-sized buildings to the ecoEnergy Retrofit – Small and Medium Organizations program.

Atlantic Energy Gateway

The Atlantic Energy Gateway (AEG) is a $4-million joint initiative of NRCan and the Atlantic Canada Opportunities Agency for facilitating co-operation among Atlantic provinces for the development of the region's clean energy resources.

In 2009, an AEG advisory committee of federal, provincial and utility members was formed. The committee oversees research and analysis that will provide insight into the challenges and opportunities involved in maximizing the benefits of developing clean energy in the Atlantic region.

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 ISO 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 mid 2011.

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 national 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 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 SLT analyses policies to promote conservation and the efficient use of energy, as well as 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, including the *Energy Policies of IEA Countries – Canada – 2009 Review*, which was released in April 2010. 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. In 2009–2010, the IEA released a report card to the Group of Eight (G8) that recognized Canada as one of the top four IEA member countries that has fully or

partially implemented the IEA's recommendations on energy efficiency.

Canada's international energy research and development (R&D) objectives are mainly advanced through the IEA's working parties, implementing agreements, and experts groups that are under the Committee for Energy Research and Technology. Canada participates in 31 of the IEA's 40 implementing agreements on R&D collaboration programs. NRCan contributed $889,000 to IEA implementing agreements in 2009–2010. One such agreement is the IEA Implementing Agreement for a Co-operating Programme on Efficient Electrical End-Use Equipment (4E). This agreement brings together energy efficiency policy-makers from Asia, Europe and North America to encourage the use of more efficient appliances (e.g. solid state lighting, electric motor systems and standby power). Co-operation through implementing agreements has helped to accelerate technology development and set the stage for technology deployment in Canada, generating benefits that far outweigh the direct costs of collaboration.

Canada also co-operates with research centres in IEA member countries on several R&D and technology agreements and programs outside the IEA. NRCan, together with Foreign Affairs and International Trade Canada, 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.

CanmetENERGY was named the operating agent of the new IEA Annex 54, "Integration of Micro-generation and other Energy Related Technologies in Buildings." The research program will focus on improved models of poly-generation and/or hybrid type micro-generation systems. The purpose is to better assess the application of these systems, to identify the impact on energy use and GHG emissions and to investigate the competitiveness of these micro-generation systems in relation to other technologies. Participants are from 14 countries in Europe, Asia, Japan and North America and represent 24 research organizations, academia and private companies.

Group of Eight

At the 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." Working groups were formed around the process' four pillars, one of which was energy, with a special focus on energy efficiency. The Energy Working Group explored the common ground available for building international support for new ideas and approaches for increasing energy efficiency. It 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 served as co-chair with India. The Working Group held its final meeting in April 2009 and submitted its report to the Heiligendamm Dialogue Process Steering Committee. The Steering Committee summarized the reports of the four working groups and submitted its report and conclusions to the 2009 G8 Summit in Italy.

International Partnership for Energy Efficiency Cooperation

NRCan participated in the development of an agreement establishing the International Partnership for Energy Efficiency Cooperation (IPEEC). This agreement was formally signed by Canada and 11 other countries during the G8 Energy Ministers Meeting in May 2009. The partnership supports the on-going energy efficiency work of the participating countries and relevant international organizations. The IPEEC Executive Committee met in 2009 and 2010, and the Policy Committee first met 2010. A key component of the IPEEC framework is task groups that pursue projects that interest most, but not all, IPEEC

member countries. Canada contributed to the Sustainable Buildings Network Task Group and the Super-Efficient Equipment and Appliance Deployment Task Group.

Methane to Markets

CanmetENERGY represents Canada, in collaboration with the Environment Canada Climate Change International Branch, at the international Methane to Markets Partnership Steering Committee and co-chairs the Methane to Markets Oil and Gas Subcommittee with Mexico and Russia. CanmetENERGY-Devon R&D projects were showcased at the international Methane to Markets Partnership Expo in Delhi, India, on March 2–5, 2010. These domestic and international projects manage energy and emissions at oil and natural gas production and processing operations.

United Nations

RETScreen® International is managed under the leadership of NRCan's CanmetENERGY. The RETScreen Clean Energy Project Analysis software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of renewable energy and energy-efficient technologies. RETScreen is managed through cost- and task-shared collaborative ventures with other governments and multilateral organizations and with technical support from more than 350 experts representing industry, government and academia.

Key partners are the NASA Langley Research Center, the Renewable Energy and Energy Efficiency Partnership and the Energy Branch of the United Nations Environment Programme.

Asia-Pacific Economic Cooperation (APEC)

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.

Asia-Pacific Partnership

The OEE participates through the Asia-Pacific Partnership (APP) on Clean Development and Climate on a task force on standby power data to internationally coordinate its efforts to reduce standby power consumption.

CanmetENERGY participates in the APP on three task forces: the Buildings and Appliances Task Force (BATF), the Renewable Energy and Distributed Power Generation Task Force (REDGTF) and the Cleaner Fossil Energy Task Force (CFETF). The Electricity Resources Branch of NRCan is the federal lead of the Power Generation and Distribution Task Force in 2010.

CanmetENERGY-Devon administered a project to develop corporate's guidelines for energy and emissions management at the China National Petroleum Corporation's upstream oil and natural gas facilities. This work was in collaboration with the Environment Canada Climate Change International Branch, APP funding and the U.S. Environmental Protection Agency (EPA). Also, a joint workshop for the APP CFETF and the international Methane to Markets Partnership's Oil and Gas Subcommittee was co-hosted at Lake Louise, Alberta, by CanmetENERGY-Devon, Environment Canada and the EPA.

Within the BATF and REDGTF, CanmetENERGY proposed the Net Zero Energy Homes initiative. Under this initiative, Canadian delegates have initiated a collaborative dialogue with BATF

and REDGTF partners to establish a formal international partnership that will map the path to achieving net zero energy homes.

Through a series of workshops and design charettes, Canada offered 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 has ensured synergies. The workshops prominently featured Canadian industries, case studies and research, development and demonstration, potentially leading to commercial and technology transfer opportunities for Canadian firms.

As of May 2010, the APP had endorsed 175 projects and 22 flagship projects. Flagship projects comprise a portfolio of projects and activities that collectively exemplify the vision and objectives of the APP. Canada is involved in 30 APP projects.

U.S.-Canada Clean Energy Dialogue

The U.S.-Canada Clean Energy Dialogue (CED) was launched by Prime Minister Harper and President Obama in February 2009. It is a strategy for aligning regulatory standards and enhancing collaboration on the development of clean energy technologies to reduce GHG emissions. There are three working groups under the CED, and NRCan is involved in two of them: the Electric Grid Working Group and the Clean Energy Research and Development Working Group. Both focus areas are detailed in the CED Action Plan, which was presented to the Prime Minister and President in September 2009.

The Electricity Grid Working Group is focused on bilateral co-operation facilitating the long-term transition to a modernized electricity system based on clean and renewable generation. This facilitation includes identifying options for increasing Canada-U.S. trade in clean electricity, including the role that energy storage technologies might play in accommodating increased penetration of renewable sources. The facilitation also includes sharing best practices and engaging provinces, territories, industry and stakeholders in increasing the application of communications technologies, sensors and computer software to the electrical system – a concept known as the smart grid.

Human resources challenges are a particular problem in the electricity sector because of significant infrastructure renewal and modernization requirements. To foster dialogue on workforce issues, the Working Group brought together leading experts from industry and academia to identify required skills and share best practices. An outcomes report and recommendations were issued in summer 2010.

Energy storage technologies may hold the key for accommodating high proportions of intermittent renewable energy sources on the electric grid. However, these technologies face several technological, economic and regulatory barriers. To further understanding of these barriers, the Working Group commissioned a scoping paper that was presented in conjunction with a CED conference focused on increasing Canada-U.S. trade in clean electricity in May 2010.

R&D drives technological discovery and innovation, which are key ingredients in developing the low-carbon energy system of the future. The Clean Energy R&D working group aims to facilitate greater cross-border R&D collaboration by connecting Canadian and U.S. experts and institutions in priority areas for the Clean Energy Dialogue, including future-generation biofuels, clean engines/vehicles, and energy efficiency (homes and buildings). Strengthening collaboration in these areas through joint research, development and deployment will help reduce GHG emissions while strengthening both countries' economies and creating new jobs.

The ENERGY STAR program is an on-going collaborative activity under the Clean Energy R&D Working Group. Expanding collaboration in the program will increase the availability and

number of energy-efficient products and appliances and facilitate the harmonization of the North American equipment market.

NRCan's Buildings Division is working with the EPA to develop a Canadian version of the U.S. ENERGY STAR building benchmarking program. The "Measure it, Manage it" Building Energy Benchmarking System tool will allow benchmarking of energy use of building types in both countries. This tool will help building operators and owners and energy utilities track, benchmark and manage energy consumption to reduce GHG emissions from commercial and institutional buildings.

United States

In addition to collaboration through the Clean Energy Dialogue, NRCan's OEE signed an MOU with the EPA in September 2005 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 the reporting of initiatives. They are working together to harmonize program efforts in Canada and the United States.

In 2009, CanmetENERGY, working with the Standards Council of Canada, formed a National Smart Grid Technology and Standards Task Force to provide Canadian input into smart grid standardization activities being led by the U.S. National Institute of Standards and Technology. This process is engaging key stakeholders and regulators in Canada and has enhanced Canada-U.S. collaboration on smart grid interoperability issues.

North America

CanmetENERGY has established partnerships among Canada, the United States and Mexico under the Security and Prosperity Partnership (SPP) of North America to support marine energy research and low-head hydropower demonstrations. CanmetENERGY and other Canadian partners in the SPP program are collaborating with the United States to optimize the rotor design, electricity production and interconnection for the next generation of Verdant Power's *Free Flow* Kinetic Hydropower System, for use in tidal currents and in-stream river applications. Through the same program, CanmetENERGY has created collaborative support for the demonstration of an innovative very low-head hydropower technology in Canada to evaluate the impacts on fish behaviour and the adaptation of the technology for cold climates.

NRCan also continues to work with the United States and Mexico through the Energy Efficiency Experts Group (EEEG) to promote the SPP agenda of harmonizing energy efficiency standards and co-operating on energy efficiency labelling programs. The EEEG is one of nine expert groups of the North American Energy Working Group.

APPENDIX 1

NRCan's Efficiency and Alternative Energy Initiatives and Expenditures, 2009-2010

	(millions of dollars)
Energy Efficiency and Alternative Transportation Fuels[1]	**$530.4**
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	

[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, refer to the text box on page 66.

	(millions of dollars)
Energy Efficiency – Energy Science and Technology[2]	**$81.9**
Clean Energy Systems for Buildings and Communities	
Clean Electric Power Generation	
Clean Energy Systems for Industry	
Environmentally Sustainable Oil and Gas	
Clean Transportation Energy	
Sustainable Bioenegy	
Canadian Biomass Innovation Network	
Alternative Energy – Renewable Energy Sources	**$148.3**
ecoENERGY for Renewable Heat	
ecoENERGY for Renewable Power	
Pulp and Paper Green Transformation Program	
Wind Power Production Incentive[3]	
Initiative to Purchase Electricity From Emerging Renewable Energy Sources[4]	
Total	**$760.6**

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

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

[4] The Initiative to Purchase Electricity From Emerging Renewable Sources is fully committed, but incentives will be paid out 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 adjustments to the original Statistics Canada data were required and are documented in Appendix A of NRCan's *Energy Use Data Handbook, 1990 to 2007*. 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, 2007

Sector	Industrial	Transportation	Residential	Commercial/ Institutional	Agriculture	Total
Energy use (PJ)	3 471.60	2 595.20	1 447.20	1 141.60	215.00	8 870.50
Percentage	39.1	29.3	16.3	12.9	2.4	100.0

FIGURE 1-2: GHG Emissions From Secondary Energy Use by Sector, 2007

Sector	Transportation	Industrial	Residential	Commerical/ Institutional	Agriculture	Total
GHG emissions (Mt)	179.4	168.5	74.3	64.5	14.9	501.6
Percentage	36.0	34.0	15.0	13.0	3.0	100.0

FIGURE 1-3: Energy Intensity and the Energy Efficiency Effect, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy intensity index	1.00	1.00	1.00	1.00	0.99	0.98	1.00	0.96	0.91	0.89	0.88	0.84	0.85	0.86	0.85	0.82	0.77	0.81
Index of energy efficiency effect	1.00	0.98	0.97	0.96	0.96	0.92	0.93	0.91	0.89	0.87	0.87	0.85	0.85	0.86	0.85	0.81	0.80	0.84

FIGURE 1-4: Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated secondary energy use without energy efficiency improvements	1.00	1.00	1.03	1.05	1.10	1.15	1.18	1.20	1.20	1.25	1.29	1.28	1.32	1.35	1.38	1.40	1.39	1.44
Actual energy use	1.00	0.98	1.00	1.02	1.05	1.07	1.11	1.11	1.09	1.13	1.17	1.14	1.18	1.22	1.24	1.23	1.19	1.28

FIGURE 1-5: Canadian Households by Type of Dwelling, 2007

Dwelling type	Number of households (thousands)	Percentage
Single detached homes	7 322	56
Single attached homes	1 375	11
Apartments	4 039	31
Mobile homes	249	2
Total	**12 985**	**100**

FIGURE 1-6: Residential Energy Use by End Use, 2007

Activity	Energy use (PJ)	Percentage
Space heating	908.1	63
Water heating	257.9	18
Appliances	192.4	13
Lighting	60.8	4
Space cooling	27.9	2
Total	**1447.2**	**100**

FIGURE 1-7: Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Number of households	1.00	1.03	1.05	1.07	1.08	1.10	1.12	1.13	1.14	1.16	1.18	1.20	1.21	1.23	1.25	1.27	1.29	1.31
Average floor space by household	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.03	1.03	1.03	1.02	1.02	1.03	1.04	1.06	1.08	1.09
Energy intensity (GJ)/ household)	1.00	0.96	0.97	0.98	0.98	0.95	1.01	0.96	0.86	0.89	0.92	0.87	0.89	0.91	0.88	0.86	0.81	0.86

FIGURE 1-8: Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.22	1.21	1.13	1.17	1.24	1.21	1.28	1.31	1.33	1.36	1.33	1.42
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.05	1.13	1.08	0.99	1.03	1.08	1.04	1.08	1.12	1.10	1.09	1.04	1.13

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 located in Ottawa, Ontario

FIGURE 1-10: Average Energy Consumption of New Electric Appliances, 1990 and 2007 Models

Appliance	1990 model (kWh/yr)	2007 model (kWh/yr)
Clothes washers	97	23
Clothes dryers	1103	912
Dishwashers	227	57
Refrigerators	956	483
Electric ranges	772	524
Freezers	714	384

FIGURE 1-11: Commercial/ Institutional Energy Use by Activity Type,* 2007

Activity types	Energy use (PJ)	Percent
Offices**	397.37	35
Retail trade	191.14	17
Educational services	153.91	14
Health care and social assistance	111.21	10
Accommodation and food services	87.7	8
Wholesale trade	66.08	6
Transportation and warehousing	45.1	4
Arts, entertainment and recreation	34.88	3
Information and cultural industries	25.91	2
Other services	19.85	2
Total	**1133.15**	**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, 2007

Purpose	Energy use (PJ)	Percent
Space heating	572.5	50
Auxiliary equipment	189.7	17
Lighting	110.3	10
Water heating	94.7	8
Auxiliary motors	90.4	8
Space cooling	75.5	7
Street lighting	8.4	1
Total	**1141.5**	**100**

FIGURE 1-13: Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
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	1.27	1.34	1.36	1.37	1.43	1.40	1.48
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	1.34	1.26	1.32

FIGURE 1-14: Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2007

Subsector	Energy Use (PJ)	Industrial Energy Use (%)
Mining	867.0	25.0
Other manufacturing**	721.0	20.8
Pulp and paper	668.7	19.3
Petroleum refining	362.4	10.4
Smelting and refining	271.6	7.8
Iron and steel	224.0	6.5
Chemicals	204.8	5.9
Cement	69.7	2.0
Construction	62.4	1.8
Forestry	19.6	0.6
Total	**3471.6**	**100.0**

* 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.

FIGURE 1-15: Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2007

Industry	Energy cost of total production cost (%)
Transportation equipment and manufacturing	0.7
Petroleum refining	1.5
Chemicals	5.0
Iron and steel	11.4
Pulp and paper	10.5
Aluminum	9.9
Cement	22.9

FIGURE 1-16: Industrial Energy Use, Actual nd without Energy Efficiency Improvement, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated energy use without energy efficiency improvements	1.00	1.00	1.02	1.04	1.10	1.14	1.15	1.17	1.20	1.25	1.29	1.27	1.32	1.33	1.35	1.36	1.32	1.35
Actual energy use	1.00	0.99	0.99	1.00	1.05	1.08	1.10	1.10	1.09	1.12	1.15	1.11	1.17	1.20	1.22	1.20	1.16	1.28

FIGURE 1-17: Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2007

Index (1990=1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated energy use without energy efficiency improvements	1.00	1.01	1.02	1.01	1.09	1.12	1.13	1.15	1.17	1.23	1.28	1.26	1.31	1.32	1.34	1.34	1.30	1.33
Actual energy use	1.00	0.99	0.98	0.96	1.02	1.04	1.05	1.05	1.04	1.06	1.09	1.04	1.09	1.09	1.12	1.07	1.02	1.09

FIGURE 1-18: Transportation Energy Use by Mode, 2007

	Energy use (PJ)	Percentage
Car	664.7	
Passenger light trucks	438.1	
Motocycles	4.0	
School buses	12.4	
Urban transit	30.3	
Inter-city buses	6.4	
Passenger air	253.9	
Passenger rail	2.6	
Passenger total	**1412.4**	**54.4**
Freight light trucks	176.2	
Medium trucks	156.2	
Heavy trucks	548.4	
Freight air	5.8	
Freight rail	83.9	
Marine	109.0	
Freight total	**1079.5**	**41.6**
Off-road total	**102.1**	**3.9**
Total transportation energy use	**2594.0**	**100.0**

FIGURE 1-19: Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2007 (percentage)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Passenger car	74.7	75.2	72.7	69.7	67.2	65.0	62.8	59.7	59.1	60.9	63.0	63.4	62.7	62.1	61.6	61.6	61.1	59.5
Passenger light truck	25.3	24.8	27.3	30.3	32.8	35.0	37.2	40.3	40.9	39.1	37.0	36.6	37.3	37.9	38.4	38.4	38.9	40.5

FIGURE 1-20: Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

Index (1990=1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
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	1.51	1.53	1.55	1.59
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	1.38

FIGURE 1-21: Average Activity per Truck, 1990 to 2007 (tonne kilometres/truck)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total medium- and heavy-duty truck vehicle activity	105 779	98 642	103 508	117 665	133 777	142 851	141 271	164 079	162 940	175 178	178 398	198 907	197 518	202 313	241 247	243 756	238 925	236 663

FIGURE 1-22: Trucking Energy Intensity, 1990 to 2007 (megajoules/tonne kilometre)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total medium-and heavy-duty trucks energy intensity	3.74	3.81	3.81	3.64	3.44	3.50	3.42	3.33	3.18	3.02	3.05	2.85	2.82	2.93	2.62	2.65	2.71	2.81

FIGURE 2-1: Volume of Monthly Import Documents

Month	Paper	Electronic	Total
Apr. 09	17	103 991	104 008
May 09	30	112 666	112 696
Jun. 09	46	121 992	122 038
July 09	99	126 970	127 069
Aug. 09	1	128 215	128 216
Sept. 09	218	129 675	129 893
Oct. 09	146	140 222	140 368
Nov. 09	32	124 412	124 444
Dec. 09	..	124 766	124 766
Jan. 10	11	117 320	117 331
Feb. 10	88	122 166	122 254
Mar. 10	71	140 060	140 131
Total	759	1 492 455	1 493 214

FIGURE 2-4 Distribution of ENERGY STAR® Qualified Shipments of Appliances, 1999–2008

Appliance	1999 (%)	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)	2008 (%)
Dishwashers	0.6	1.6	9.7	29.8	56.5	81.0	90.8	79.7	76.2	89.3
Clothes washers	1.9	2.2	9.2	22.1	30.6	36.2	45.9	50.8	58.4	64.4
Refrigerators	..	..	11.4	22.3	40.7	34.2	37.6	37.3	44.3	53.4

FIGURE 2-5: ENERGY STAR® Awareness Levels in Canada, 2010

	Percentage
Aware – non-aided	71
Aware – aided	72

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)	271	200	187	174	174	163	149	193
Actual energy savings after renovations (GJ)	85	52	44	40	35	29	31	47

* 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 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number of R-2000 certifications	495	699	1196	1299	784	610	416	484	265	213	319	329	428	379	583	500	439	483	557	484

FIGURE 3-3: New Vehicle Fuel Efficiency Labelling

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

FIGURE 3-4: Company Average Fuel Consumption (CAFC) versus Canadian Voluntary Standards, 1990 to 2009*

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	11.3	8.6	8.2
1991	11.6	11.4	8.6	8.0
1992	11.6	11.1	8.6	8.1
1993	11.5	11.3	8.6	8.1
1994	11.5	11.1	8.6	8.2
1995	11.4	11.5	8.6	7.9
1996	11.4	11.5	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	10.7	8.6	7.5
2005	11.2	10.5	8.6	7.4
2006	10.9	10.4	8.6	7.5
2007	10.6	10.1	8.6	7.2
2008	10.5	9.5	8.6	7.1
2009	10.2	9.1	8.6	6.8

* 2009 data are estimates.

FIGURE 4-1: RETScreen Software: Cumulative Growth of User Base

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Canada	1 421	2 966	4 527	6 650	9 754	14 125	18 178	24 005	28 990	36 891	44 987	54 152
World	1 688	5 782	9 838	15 292	20 499	27 752	38 270	56 432	78 215	110 264	148 046	188 623

FIGURE 5-1: Canadian Wind Power Capacity, 1993 to 2009

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Wind power capacity (MW)	1	22	23	23	24	27	127	139	215	233	326	445	686	1459	1846	2369	3319

Natural Resources Canada's Office of Energy Efficiency

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

Canada