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Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act*
For the Fiscal Year 2010–2011

Canada

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Minister's Foreword

I am pleased to introduce the *2010–2011 Report to Parliament on Improving Energy Performance in Canada*. Canada has one of the world's largest resource endowments of both traditional and emerging sources of energy. It is increasingly looked to as a secure and dependable supplier of a wide range of energy products.

Our Government is committed to taking concrete action to reduce greenhouse gas emissions and help protect the environment by investing in clean energy technologies that demonstrate the greatest potential for progress.

Building on initiatives started in 2006, the Next Phase of Canada's Economic Action Plan renewed support for energy efficiency activities. The $195-million ecoENERGY Efficiency Program is helping to improve energy efficiency, reduce greenhouse gas emissions, improve air quality and save money for Canadians and Canadian businesses.

In Budget 2011, we also renewed the popular ecoENERGY Retrofit – Homes program to enable as many as 250,000 more Canadians to increase the energy efficiency of their homes. Participants, on average, reduced their annual energy consumption by about 21 percent and greenhouse gas emissions by approximately three tonnes per household per year.

On the international stage, we are continuing to work with the United States, through the Clean Energy Dialogue, to enhance joint collaboration on the development of clean energy science and technologies to reduce greenhouse gases and combat climate change.

This fall, we signed an agreement with the U.S. Environmental Protection Agency to create a common platform for measuring and assessing the energy performance of commercial buildings in both countries.

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We will also continue to implement measures to sharpen Canada's competitiveness, productivity and capacity for innovation using clean energy technologies including renewables, carbon capture and storage, and the use of forest and agricultural by-products to generate energy. Our investments not only create innovation and jobs — they also build a better economy.

We all have an important role to play in building a clean energy future for Canadians.

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

Executive Summary

Canadians spent approximately $189 billion in 2008 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 2008, the latest year for which figures are available, secondary energy use increased by 26 percent.
- In 2008, secondary use accounted for 70 percent of primary energy use and produced 66 percent (487.8 megatonnes [Mt]) of Canada's total greenhouse gas (GHG) emissions. This last figure includes emissions produced by utilities in meeting the demand for electricity.
- Energy efficiency has improved 18 percent since 1990. These improvements reduced energy use by approximately 1 205.9 petajoules, decreased GHG emissions by 67.3 Mt and saved Canadians $26.9 billion in 2008.

The industrial sector consumed the most energy, accounting for 37 percent of total secondary energy use in 2008. Transportation was second (30 percent), followed by residential (17 percent), commercial/institutional (14 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, development and demonstration; 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 2008 are estimated to have reduced GHG emissions by 67.3 Mt and saved Canadians $26.9 billion in 2008.

Between 1990 and 2008, the residential sector recorded a 31 percent improvement in energy efficiency. The figures for the transportation (21 percent), industrial (12 percent) and commercial/institutional (12 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, changing 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 16.9 percent of its primary energy supply coming from renewable energy sources in 2009.

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 programs and lists their key achievements for the 2010–2011 fiscal year. Program entries for market transformation programs also include quantitative performance indicators in graph or table format. A list of NRCan's efficiency and alternative energy initiatives and expenditures appears in Appendix 1.

Introduction

NATURAL RESOURCES CANADA'S EFFICIENCY AND ALTERNATIVE ENERGY PROGRAMS

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

Gains in energy efficiency have substantial benefits for society, the economy and the environment. Energy efficiency can add to the global security of energy supplies by reducing the need for energy. It saves consumers and businesses money by decreasing their energy bills without disruptions to their daily routine, and it can increase access to energy services by reducing their effective cost. 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 2010–2011 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
- the CanmetENERGY Minerals and Metals Sector, which delivers 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 environmental improvements in pulp and paper mills and the commercialization of innovative technologies across the forest sector

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

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 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 to 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. In 2010–2011, NRCan offered financial incentives for renewable power and heat, ethanol and biodiesel 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

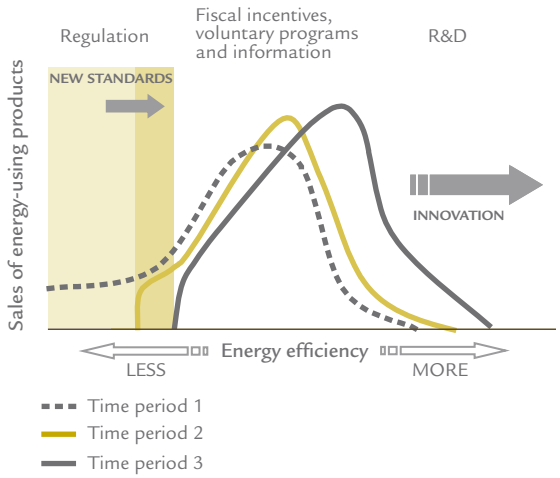


Figure Int-1 shows how these policy instruments work together to increase energy efficiency, that is, how they help to reduce the amount of energy required to complete a task or obtain a certain level of service. Energy performance regulations eliminate less efficient products from the market. Fiscal 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, measuring Canadians' energy use and monitoring the adoption of new technologies in the marketplace.

In 2010–2011, an analysis of energy use inside and outside the dwelling was undertaken for reference year 2007. This analysis, which examines the penetration rates and energy use characteristics of indoor equipment, such as home electronics and fireplaces, and outdoor equipment, such as lawn mowers and snow blowers, is a complement to the Survey of Household Energy Use. Data on other sectors of the economy continue to be collected, analysed and published by the Office of Energy Efficiency.

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 eighteenth 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/institutional, 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 2010–2011 achievements. Chapter 4 explains clean 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 $189 billion in 2008 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 13 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. In 2008, the amount of primary energy consumed was estimated at 12 510.5 petajoules[3] (PJ).

DID YOU KNOW?

One petajoule is approximately equal to the energy used by almost 9 000 households in one year (excluding transportation use).

Secondary energy use accounted for almost 70 percent of primary energy use in 2008, or 8 720.2 PJ. It was responsible for 66 percent (487.8 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 2008, secondary energy use increased by 26 percent, the Canadian population grew 20 percent, and the GDP increased 62 percent. Thus energy use grew less rapidly than the economy but more rapidly than the population.

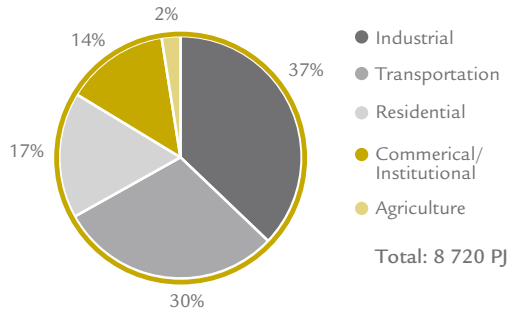
As demonstrated in Figure 1-1, the industrial sector was the largest energy user, accounting for 37 percent of total secondary energy use in 2008. The transportation sector was the second largest energy user at 30 percent, followed by the residential sector at 17 percent, the commercial/institutional sector at 14 percent and the agricultural sector at 2 percent.

[2] Data in this chapter are presented for 1990–2008. Readers are encouraged to consult the Office of Energy Efficiency Web site to view data updates as they become available.

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

FIGURE 1-1

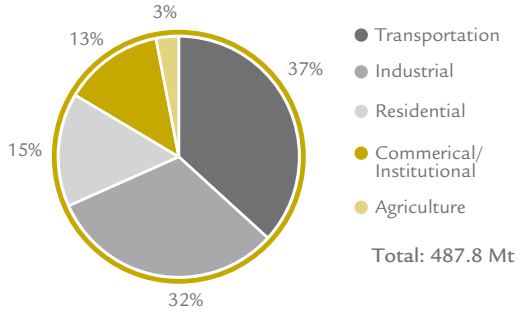
Secondary Energy Use by Sector, 2008



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

FIGURE 1-2

GHG Emissions From Secondary Energy Use by Sector, 2008



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.

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.

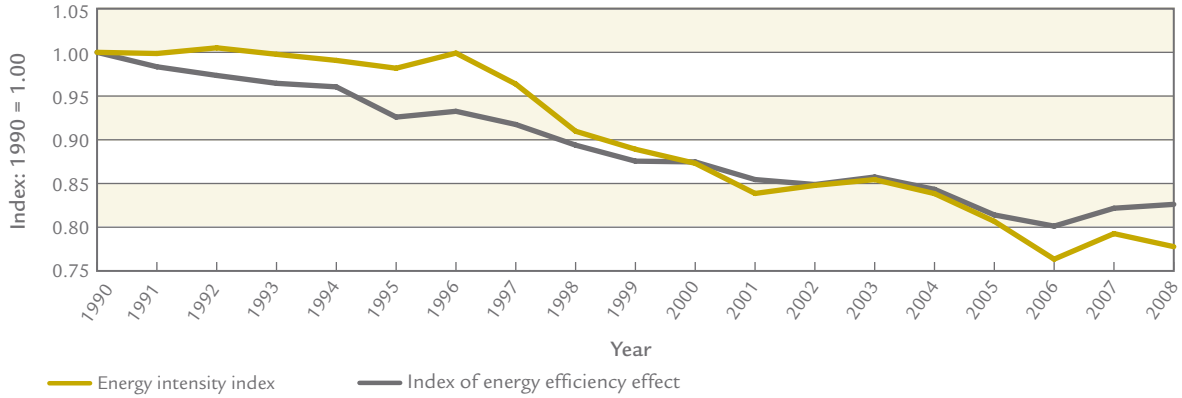
To properly gauge changes in energy efficiency over time, differences in economic structure and weather need to be normalized or factored out of the intensity calculation. Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) applies an internationally recognized factorization analysis 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 2008. 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.

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

FIGURE 1-3

Energy Intensity and the Energy Efficiency Effect, 1990 to 2008



Source: Natural Resources Canada, Residential, Commercial/Institutional, Transportation, Industrial End-Use Models, Ottawa, 2010.

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.

TABLE 1-1

Explanation of Changes in Secondary Energy Use, 1990 to 2008

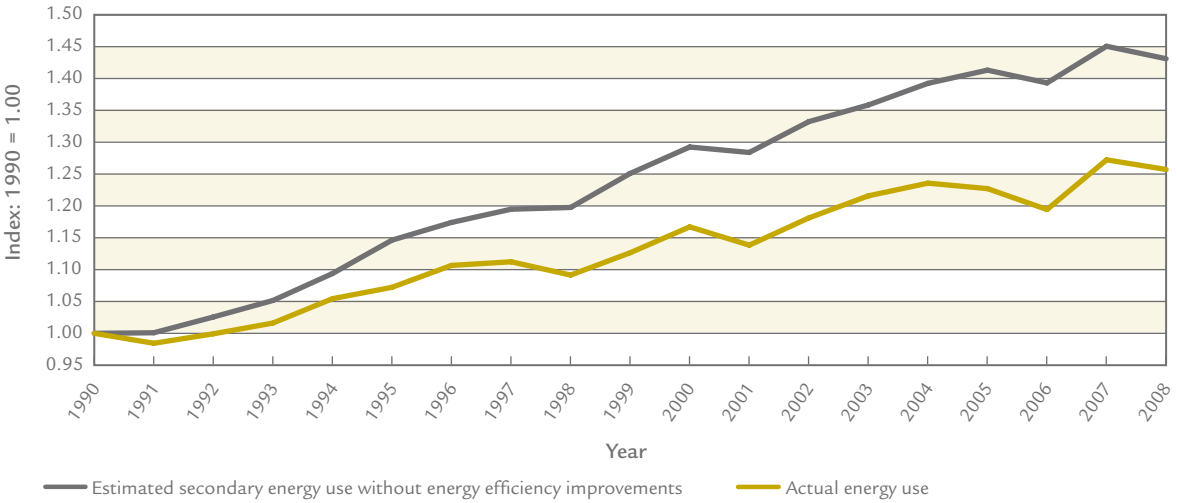
	Sectors					
	Residential	Commercial/ Institutional	Industrial	Transportation	Total*	Change (%)
1990 energy use (PJ)	1 282.2	867.0	2 710.0	1 877.9	6 936.2	
2008 energy use (PJ)	1 465.3	1 205.9	3 237.8	2 594.1	8 720.2	
Change in energy use (PJ)	183.1	338.9	527.8	716.2	1 784.0	25.7
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0						
Explanatory factor (change due to)						
Activity	465.7	322.5	1 331.4	823.7	2 943.3	42.4
Weather	25.0	9.3	n/a	n/a	34.3	0.5
Structure	10.5	-1.0	-471.1	219.6	-242.1	-3.5
Service level	73.5	111.5	n/a	n/a	185.0	2.7
Energy efficiency	-391.6	-103.6	-332.5	-378.2	-1 205.9	-17.4
Other factors		0.2		51.2	69.4	1.0
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0 *Total also includes energy use for agriculture.						

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

Between 1990 and 2008, secondary energy use in Canada increased from 6 936.2 PJ to 8 720.2 PJ. Without improvements in energy efficiency, increases attributable to activity, weather, structure and service level would have led to an energy increase of

FIGURE 1-4

Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



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

43 percent. However, as a result of an 18 percent (1 205.9 PJ) improvement in energy efficiency,[4] actual secondary energy use increased by only 26 percent. This improvement in energy efficiency is estimated to have reduced GHG emissions by 67.3 Mt and decreased energy expenditures by $26.9 billion in 2008. The change in energy use between 1990 and 2008, actual and without energy efficiency improvements, is shown in Figure 1-4.

TRENDS IN RENEWABLE ENERGY

Canada is a leader in the production of renewable energy, with over 16.9 percent of its primary energy supply coming from renewable energy sources in 2009. 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 2009, 61.7 percent of Canada's electricity generation was provided by large and small hydroelectric plants, which generated 366 terawatt hours (TWh) of electricity, down 2 percent from 374 TWh in 2008. Small hydro plants (less than 50 megawatts [MW]), with installed generating capacity of 3 372 MW, provided about 2.3 percent of the total electricity generation in Canada.

DID YOU KNOW?

Canada is a global leader in the generation of clean and renewable energy. We are the world's second largest producer of hydroelectricity, and more than three quarters of the electricity we generate produces no GHG emissions. Canada is also positioned first and ninth in the world for the installed capacity of solar air heating collectors and wind energy respectively.

In 2009, non-hydro renewable sources accounted for an estimated 2.7 percent of Canada's electricity generation. In terms of annual additions to the installed capacity, wind energy is the fastest-growing source of electricity in Canada, with an increase in capacity from 139 MW in 2000 to 3 319 MW in 2009. As of March 31, 2011, wind energy capacity was 4 825 MW, and its growth is expected to continue at a significant pace.

With 1 671 MW of installed capacity in 2009, biomass (waste and virgin biomass and landfill gas) remains one of the main non-hydro renewable energy sources in Canada.

Solar photovoltaic (PV) energy also experienced high rates of capacity growth – about 38 percent average growth rate annually between 1992 and 2010 – although it started from a very low baseline. So far, 2010 has been the best year for solar PV, with an estimated installed capacity of 290 MW, representing an increase of 196 MW from the previous year.

The Canadian active solar thermal installed capacity in 2010 was 1 025 600 square metres (m^2), which is approximately 712 megawatts thermal (MW_{th}). The domestic market increase has averaged 13 percent annually since 1998. In 2010, the solar thermal collector market in Canada was approximately 179 360 m^2, which was 38 percent more installations than in 2009 (130 000 m^2).

British Columbia and Nova Scotia 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.

In 2009, 15 643 ground-source heat pump (GSHP) units were installed in Canada. This compares

[4] Based on the OEE Index.

with 14 879 units installed in 2008 and 9 284 units installed in 2007. As of December 31, 2009, there were approximately 83 000 GSHPs representing about 1 000 MW_{th} of installed capacity and producing an estimated 1 370 gigawatt-hours equivalent annually.

As described in Chapter 5, in 2010–2011, NRCan carried out three initiatives – ecoENERGY for Renewable Power, ecoENERGY for Renewable Heat and the Pulp and Paper Green Transformation Program – to increase the use and production of renewable energy in Canada. In addition, the Investments in Forest Industry Transformation program supports projects promoting innovative technologies in the forest sector; alternative energy systems could thus qualify for funding through this program.

TRENDS IN RESIDENTIAL SECTOR

Energy Use and Greenhouse Gas Emissions

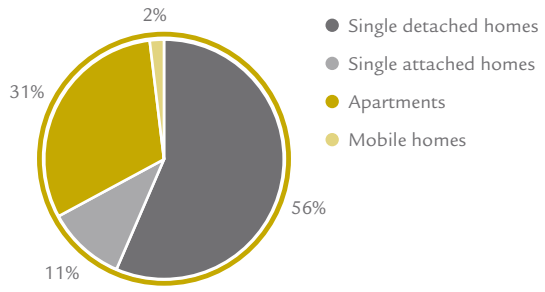
The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling; water heating; and the operation of appliances, electronic equipment and lights. In 2008, this sector accounted for 17 percent (1 465.3 PJ) of secondary energy use and 15 percent (74.2 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). In 2010–2011, the OEE's ecoENERGY Retrofit – Homes and ecoENERGY for Buildings and Houses programs aimed to improve the energy efficiency of single detached and attached houses.

Between 1990 and 2008, residential energy use increased by 14 percent, or 183.1 PJ. Because homeowners gradually switched to cleaner energy sources (less GHG-intensive fuels), the associated GHG emissions grew only 8 percent during the same period.

FIGURE 1-5

Canadian Households by Type of Dwelling, 2008

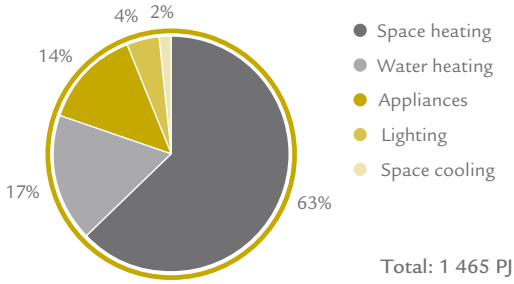


Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Energy intensity (gigajoules/household) decreased 14 percent despite the average household operating more appliances, becoming larger and increasing its use of space cooling. Space and water heating constituted 80 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, 2008



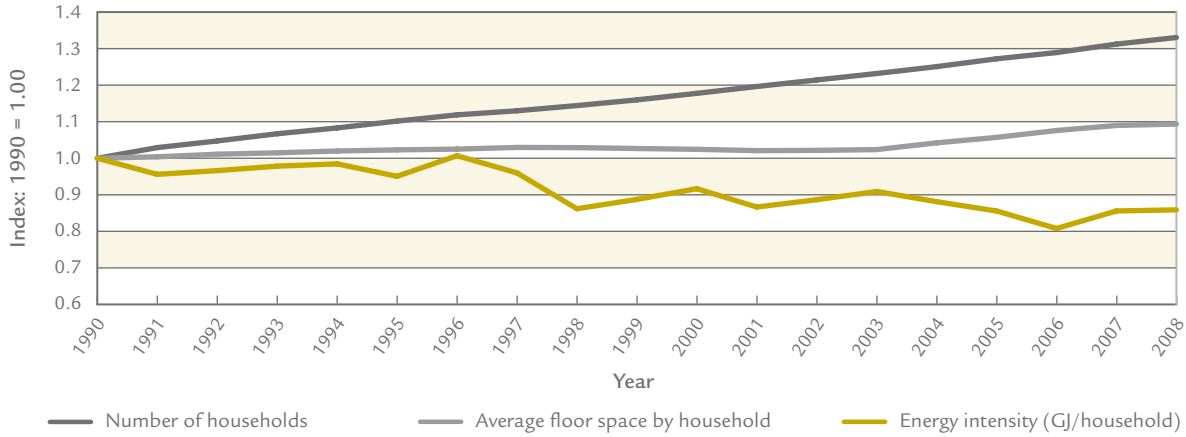
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Five main factors influenced residential energy use between 1990 and 2008 – 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 (465.7 PJ). Growth in activity was driven by a 45 percent increase in floor area

FIGURE 1-7

Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2008



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

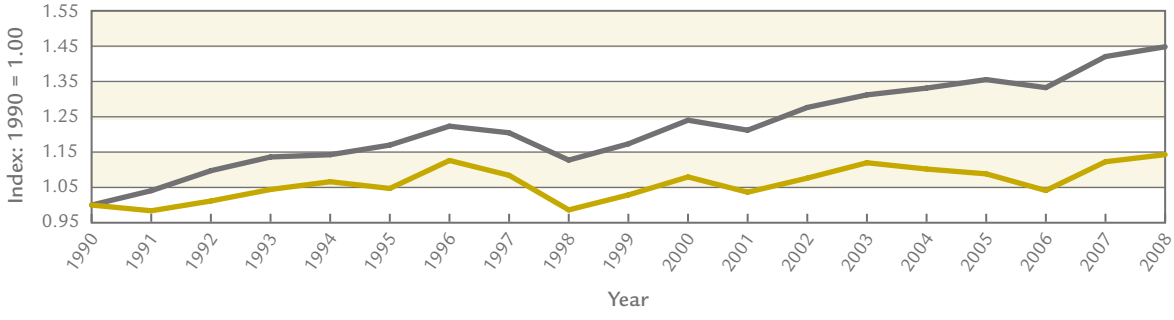
and by a rise of 33 percent in the number of households.

- Weather – In 2008, the winter was colder and the summer was warmer than in 1990. The net result was an overall increase in energy demand of 25.0 PJ.
- Structure – The increase in the relative share of single family houses resulted in the sector using an additional 10.5 PJ of energy.
- Service level – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 73.5 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 391.6 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 1-8

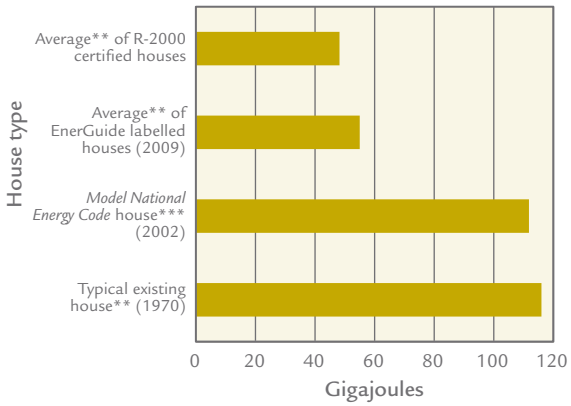
Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2010.

FIGURE 1-9

Annual Heating* Consumption for Houses Constructed to Different Standards

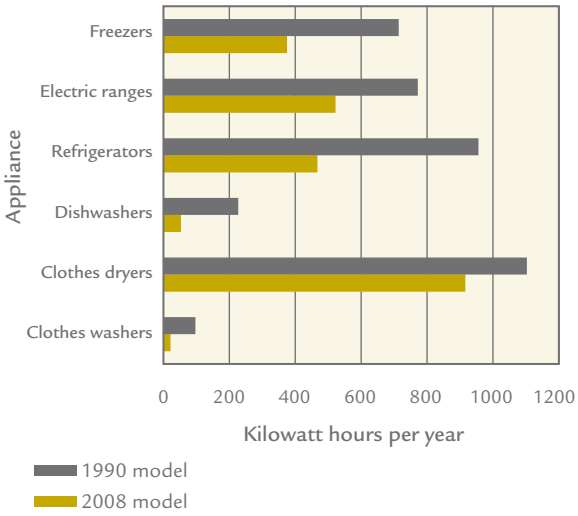


*DHW and space heating
**National average
***198 m^2, two-storey, single detached house heated with natural gas located in Ottawa, Ontario

Source: NRCan national housing database and internal data.

FIGURE 1-10

Average Energy Consumption of New Electric Appliances, 1990 and 2008 Models



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2010.

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 2008 than in 1990 and Canadians operated more appliances in 2008 than they did in 1990.

DID YOU KNOW?

Energy use for powering all household minor appliances more than doubled between 1990 and 2008. This 44.3-PJ increase was equivalent to the energy required to provide lighting to all Canadian homes in the mid-1980s.

Energy Efficiency

The change in residential energy use between 1990 and 2008 and the estimated energy savings due to energy efficiency measures are shown in Figure 1-8.

Overall, energy efficiency upgrades – including improvements to the thermal envelope (insulations, windows, etc.) and more energy-efficient appliances, furnaces and lighting – resulted in significant monetary savings for each Canadian household. The 31 percent improvement in energy efficiency between 1990 and 2008 translated into $8.2 billion in energy savings in 2008.

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 2008 models.

In 2010–2011, NRCan carried 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

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. This sector uses energy mainly for space and water heating, operation of auxiliary equipment, space cooling and lighting, as well as operating auxiliary equipment (such as computers) and motors.

In 2008, the commercial/institutional sector accounted for 14 percent of secondary energy use and 13 percent of GHG emissions in Canada. Between 1990 and 2008, commercial/institutional energy use (including street lighting) increased by 39 percent, from 867 PJ to 1 205.9 PJ. GHG emissions from the sector rose by 38 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 2008, offices accounted for 35 percent of the sector's energy demand. Retail trade (17 percent) and educational services (13 percent) were the next largest users.

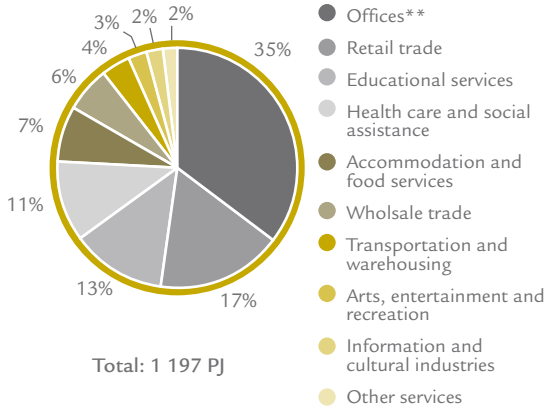
Energy is used for seven purposes in commercial/institutional activities. As illustrated in Figure 1-12, in 2008, the largest of these was space heating, which accounted for 48 percent of the energy use in the sector. Two other end uses have shown large increases in energy requirements: auxiliary equipment, resulting from increasing computerization of work spaces; and space cooling, resulting from the higher cooling rate of commercial/institutional buildings.

Five main factors influenced commercial/institutional energy use between 1990 and 2008 – activity, weather, structure, service level and energy efficiency effect:

- Activity – A 37 percent increase in floor space led to a 38 percent (322.5 PJ) growth in energy use and an increase of 17.5 Mt in GHG emissions.
- 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 – In 2008, the winter was colder and the summer was warmer than in 1990. The net result was a 9.3-PJ increase in energy demand in the commercial/institutional sector, mainly for space conditioning, which had the effect of increasing GHG emissions by 0.5 Mt.
- Service level – An increase in space cooling and in the service level of auxiliary equipment, which is the penetration rate of office equipment (e.g. computers, fax machines and photocopiers), led to a 111.5-PJ increase in energy use and a 6.0-Mt increase in GHG emissions.

FIGURE 1-11

Commercial/Institutional Energy Use by Activity Type,* 2008



*Excludes street lighting

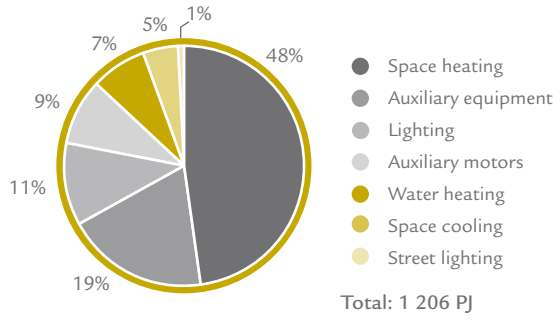
** "Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

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

- Energy efficiency – Improvements in the energy efficiency of the commercial/institutional sector saved 103.6 PJ of energy and 5.6 Mt of related emissions.

FIGURE 1-12

Commercial/Institutional Energy Use by Purpose, 2008



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

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 51 percent. However, actual energy use increased by only 39 percent between 1990 and 2008, resulting in energy savings of $2.4 billion in 2008.

Between 1990 and 2008, the estimated energy efficiency improvements resulted in energy savings of 103.6 PJ for this sector (see Figure 1-13).

In 2010–2011, NRCan carried 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

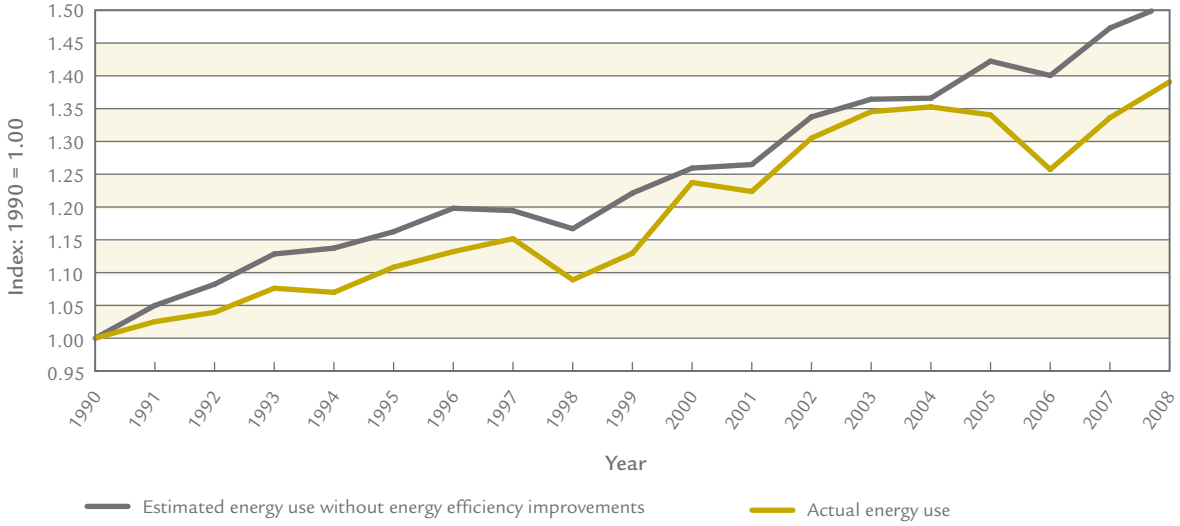
TRENDS IN INDUSTRIAL SECTOR

Energy Use and Greenhouse Gas Emissions

The industrial sector includes all manufacturing, mining (including oil and gas extraction), forestry and construction activities. However, it excludes

FIGURE 1-13

Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



Source: Natural Resources Canada, Commercial/Institutional End-Use Model, Ottawa, 2010.

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 2008 accounted for 37 percent (3 237.8 PJ) of secondary energy use and 32 percent (154.0 Mt) of GHG emissions (including electricity-related emissions). Between 1990 and 2008, actual industrial energy use increased by 19 percent, from 2 710.0 PJ to 3 237.8 PJ. The associated end-use GHGs increased 13 percent, from 136.0 Mt to 154.0 Mt.

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 25.5 percent of total industrial energy demand in 2008 (see Figure 1-14).

In most industries, energy purchases accounted for only a small portion of total expenditures. However, for some relatively energy-intensive industries – cement, aluminum, pulp and paper, and iron and steel – this share was 9.9 percent or higher (see Figure 1-15). For cement, in particular, the share was 22.9 percent.

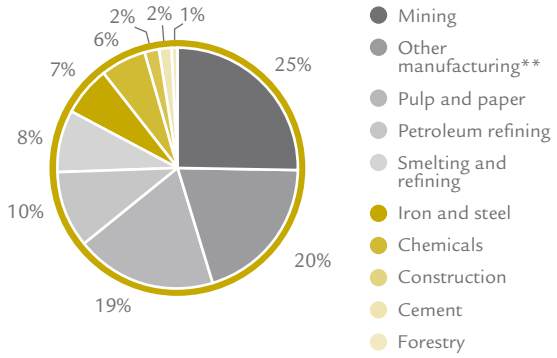
Between 1990 and 2008, industrial GHG emissions, including electricity-related emissions, increased by 13 percent. Excluding electricity-related emissions, industrial GHG emissions increased by 12 percent. Most of this increase in direct GHG emissions occurred in the upstream oil and gas industry. The pulp and paper industry, however, achieved a 42 percent decrease in GHG emissions.

Three main factors influenced industrial energy use between 1990 and 2008 – activity, structure and energy efficiency effect:

- Activity – The mix of GDP, gross output and production units (activity measures) increased the energy use by 49 percent, or 1 331.4 PJ.

FIGURE 1-14

Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2008



*The subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.

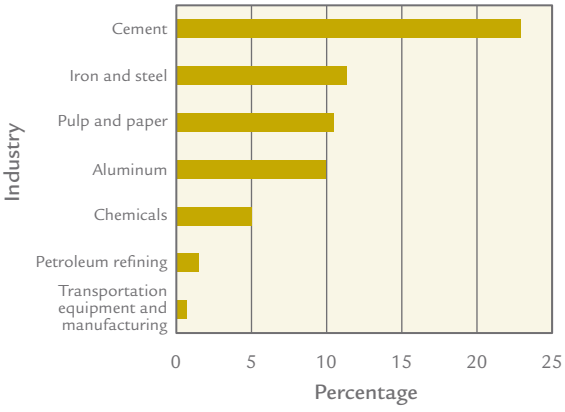
** "Other manufacturing" comprises more than 20 manufacturing industries.

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

- Structure – The structural changes in the industrial sector, specifically a relative decrease in the activity share of energy-intensive industries, helped the sector to reduce its energy use by 471.1 PJ.
- Energy efficiency – Improvements in the energy efficiency of the industrial sector avoided 332.5 PJ of energy use.

FIGURE 1-15

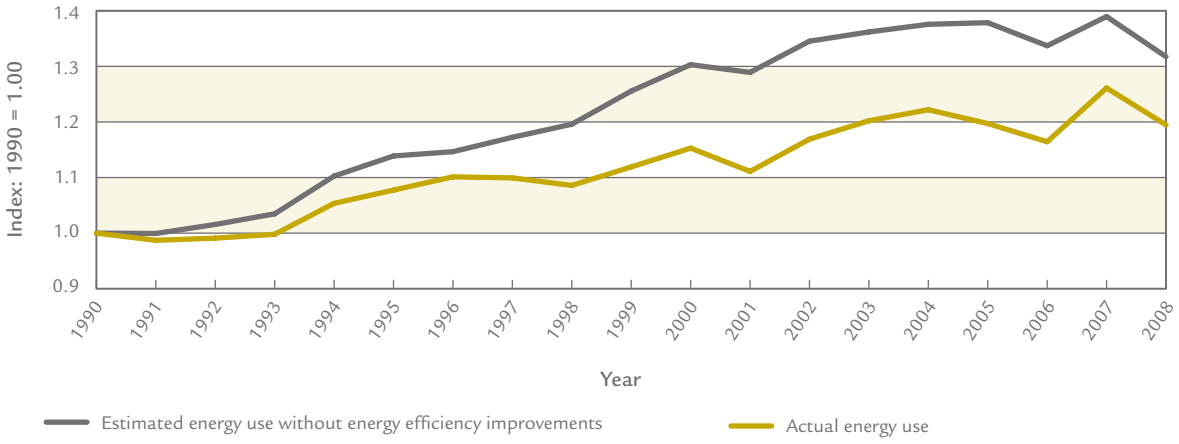
Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2008



Source: Statistics Canada, CANSIM Table 301-0006.

FIGURE 1-16

Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2010.

Energy Efficiency

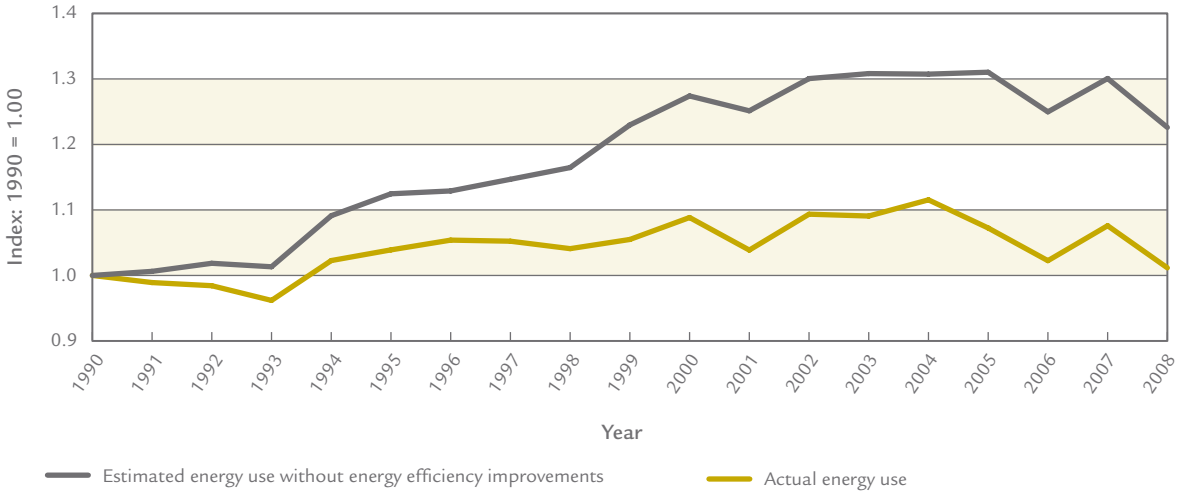
The change in energy use between 1990 and 2008 and the estimated energy savings attributed to energy efficiency are shown in Figure 1-16.

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

Since 1990, energy efficiency in the industrial sector has improved 12 percent. In 2008 alone, Canadian industry saved $4.3 billion in energy costs and 332.5 PJ of energy, or 15.8 Mt of GHG emissions. The improvement in energy efficiency was largely the result of improvements in energy intensity. The energy savings due to the energy efficiency improvements made by some industries were offset by increases in consumption by the upstream mining, fertilizer and forestry subsectors.

FIGURE 1-17

Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2008



Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2010.

From 1990 to 2008, 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 21 percent, which represents 535.8 PJ of savings (see Figure 1-17).

In 2010–2011, NRCan carried 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

TRENDS IN TRANSPORTATION

Energy Use and Greenhouse Gas Emissions

In 2008, transportation was second to the industrial sector in terms of secondary energy use, accounting for 30 percent (2 594.1 PJ) of Canada's total secondary energy use and the largest portion of Canadian end-use GHG emissions at 37 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 2008, 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.

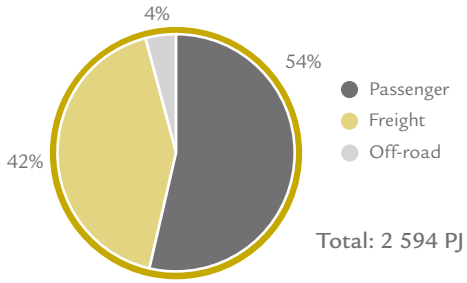
The passenger subsector has three modes: road, rail and air. The freight subsector, as defined by NRCan, is composed of road, rail, air and marine modes. All of NRCan's transportation energy use programs focus on the energy used in road transportation. Between 1990 and 2008, total transportation energy use increased by 38 percent, from 1 877.9 PJ to 2 594.1 PJ, and the associated GHG emissions rose 36 percent, to 179.4 Mt. Within the transportation sector, passenger transportation energy use increased by 18 percent (212.4 PJ), while freight transportation energy use increased by 71 percent (454.5 PJ).

Three main factors influenced passenger transportation energy use between 1990 and 2008 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. passenger-kilometres [Pkm] travelled) increased energy use by 39 percent, or 445 PJ, with a corresponding 30.2-Mt increase in GHG emissions. Light truck and air transportation led the growth in Pkm (and therefore, activity effect), with respective increases of 157 percent and 96 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 27.7-PJ increase in energy

FIGURE 1-18

Transportation Energy Use by Mode, 2008



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

consumption and a 1.9-Mt increase in GHG emissions.

- Energy efficiency – Improvements in the energy efficiency of passenger transportation saved 262.2 PJ of energy and 17.8 Mt of energy-related GHG emissions. The light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation represented 73 percent of these energy savings.

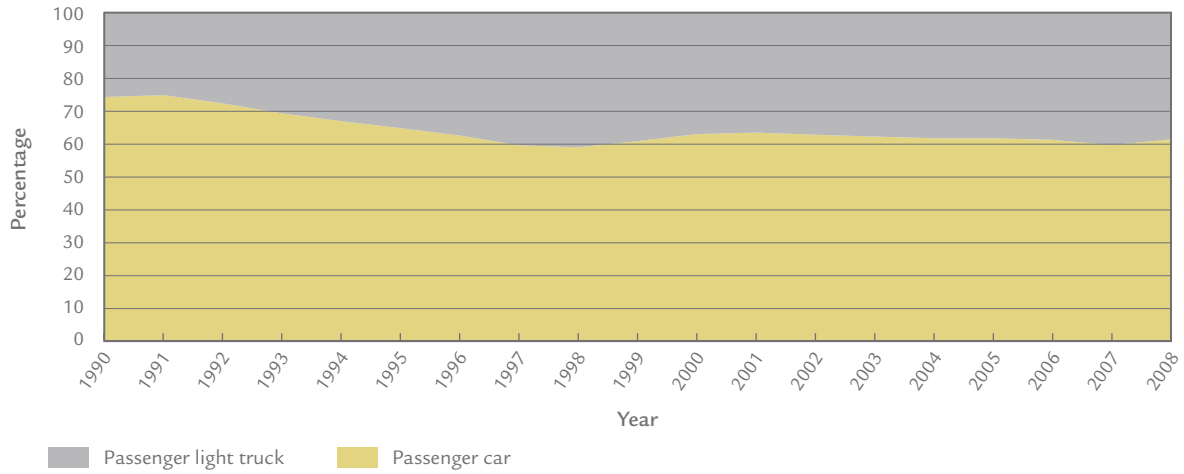
Three main factors influenced freight transportation energy use between 1990 and 2008 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. tonne-kilometres moved) increased energy use 59 percent, or 378.7 PJ, and caused a corresponding 26.8-Mt increase in GHG emissions. This increase in the number of tonne-kilometres was mainly due to an increase of 185 percent in heavy-trucks activity and an increase of 53 percent in medium-trucks activity.
- Structure – Changes to the mix of transportation modes – or the relative share of tonne-kilometres travelled by air, marine, rail and road – are used to measure changes in structure. Therefore, for example, an overall change in the structure would result in a decrease (increase) in energy use if a relative share of a more (or less) efficient transportation mode increases relative to other modes. Over the period, the shift between modes was the increase in the share of freight moved by heavy trucks relative to other modes. The overall effect on the structure was positive, given the increase in Canada-U.S. trade and the just-in-time delivery demanded by clients, thus contributing to a more intensive use of truck transportation. Therefore, the analyses show an increase of 191.9 PJ in energy use and an increase of 13.6 Mt in GHG emissions due to the structure effect.
- Energy efficiency – Improvements in the energy efficiency of freight transportation saved 116.1 PJ of energy and 8.2 Mt of GHG emissions. Improvements in freight trucks (light, medium and heavy trucks) were a large contributor, representing 51 percent of the savings.

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

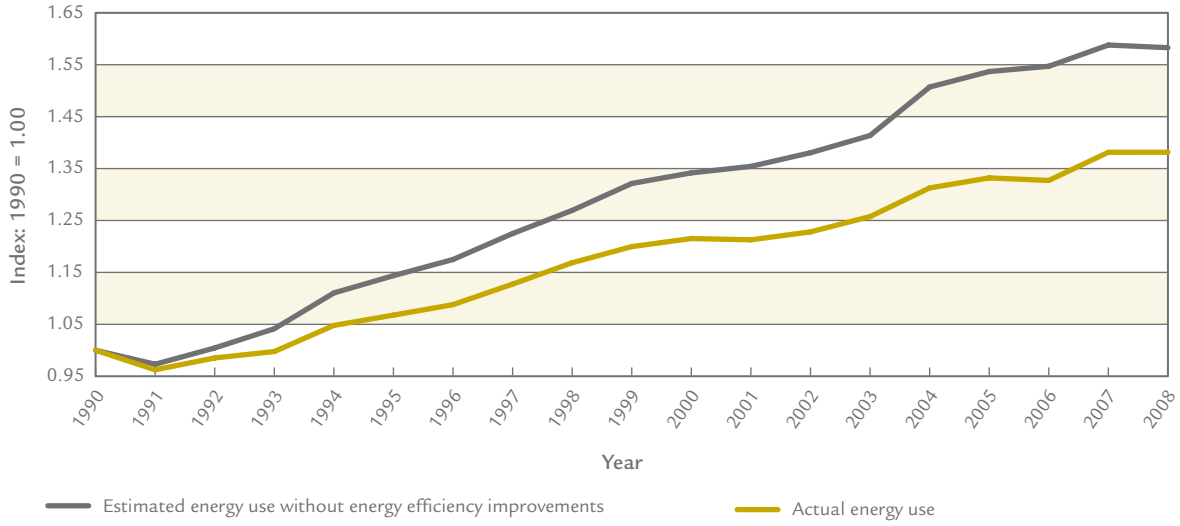
Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2008



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

FIGURE 1-20

Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



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

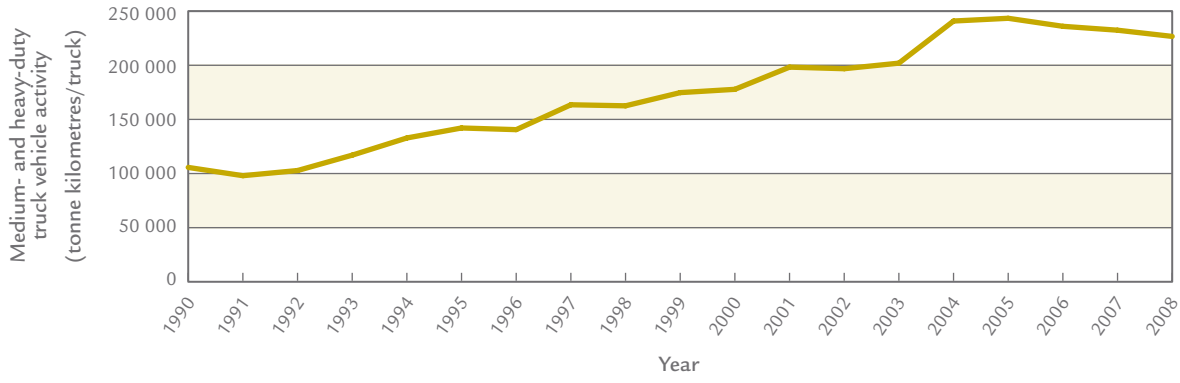
Energy Efficiency

Without improvements in energy efficiency, increases attributable to activity and structure would have led to an increase in transportation energy use of 58 percent. However, between 1990 and 2008, actual energy use increased by 38 percent. During this period, energy efficiency in the transportation sector improved by 21 percent, leading to a savings of $12 billion, or 378.2 PJ of energy. This change in energy use between 1990 and 2008 and the estimated energy savings due to energy efficiency improvements are shown in Figure 1-20.

Figures 1-21 and 1-22 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2008. 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

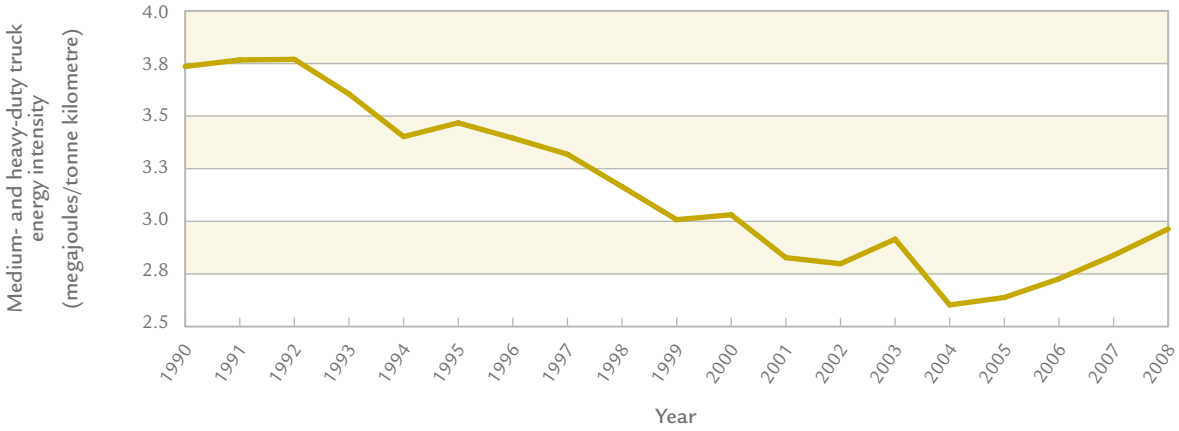
Average Activity per Truck, 1990 to 2008



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

FIGURE 1-22

Trucking Energy Intensity, 1990 to 2008



Source: Natural Resources Canada, Transportation End-Use Model, Ottawa, 2010.

In 2010–2011, NRCan carried 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 transportation 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 2010, biofuel production capacity increased from 228 million litres to 1.69 billion litres: 1.49 billion litres of ethanol and almost 200 million litres of biodiesel. In 2010, approximately 1.38 billion litres of ethanol was produced, and ethanol use represented 4.29 percent

of gasoline sales (an increase of 0.68 percent from 2009).

Environment Canada announced that the *Renewable Fuels Regulations* – requiring gasoline producers and importers to have an annual average renewable fuel content of at least 5 percent based on the volume of gasoline produced and imported – came into force on December 15, 2010. The Regulations included provisions requiring an average of 2 percent renewable content in diesel fuel and heating oil, subject to technical feasibility. Technical feasibility was demonstrated, and the 2 percent regulation and the coming-into-force date for the requirement is July 1, 2011.

In 2010–2011, NRCan carried out initiatives to increase the use and production of renewable and alternative fuels under the following programs:

- ecoENERGY for Biofuels
- Sustainable Development Technology Canada's NextGen Biofuels Fund™

Natural Gas Use in the Canadian Transportation Sector: Deployment Roadmap

Facilitated by NRCan, the *Natural Gas Use in Transportation Deployment Roadmap* brought together stakeholders representing government, industry, end-users, academia and environmental organizations to identify the optimal use of natural gas across the medium- and heavy-duty portions of the transportation sector.

The Roadmap work culminated in a comprehensive report that includes 10 recommendations stemming from business modelling, consultation with end-users and an investigation of research and development needs. These recommendations cover four key areas: de-risking investment and early adoption, addressing information gaps, increasing capacity to sustain markets, and ensuring ongoing competitiveness. The final report is available online at oee.nrcan.gc.ca/transportation/alternative-fuels/resources/pdf/roadmap.pdf.

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 a 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 six 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 U.S.-Canada Clean Energy Dialogue and the Clean Energy Ministerial. Both of these efforts contribute to regional co-operation on energy efficiency issues.

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.

In 2009, an amendment to the *Energy Efficiency Act* broadened the scope of the Report to Parliament by the Minister of Natural Resources, as follows:

- Once every three years, "the Minister shall demonstrate the extent to which the energy efficiency standards prescribed under this Act are as stringent as comparable standards established by a province, the United Mexican States, the United States of America or a state of the United States of America."
- Within four years, the Minister shall "…demonstrate the extent to which energy efficiency standards have been prescribed under this Act for all energy-using products whose use has a significant impact on energy consumption in Canada."

A 2011 internal analysis addressed the first requirement by evaluating the minimum energy performance standards (MEPS) for Canada's 40 federally regulated products in effect as of March 31, 2011, and comparable standards in 21 jurisdictions (in the provinces, in Mexico and at federal and state levels in the United States). The analysis determined the differences in the level of stringency among these jurisdictions. (The second reporting requirement by the Act will be provided in the 2011–2012 Report to Parliament.)

Of the 21 jurisdictions reviewed, only 9 have regulations that are comparable with those in Canada (see Table 2-1). These jurisdictions are Mexico, United States, California, British Columbia, Quebec, New Brunswick, Nova Scotia, Manitoba and Ontario. The other 12[5] jurisdictions were U.S. states. While there has been significant standards-making in American states, Canada is closely aligned with U.S. federal standards, which pre-empt state standards. Consequently, the stringency comparison was made on a national basis except where states have standards and the U.S. Government does not.

[5] Arizona, Connecticut, Maryland, Nevada, New Hampshire, New York, New Jersey, Oregon, Rhode Island, Washington, Massachusetts, Vermont

TABLE 2-1

Comparison of the Stringency of Canada's Standards (as of March 31, 2011)

	United States	Mexico*	B.C.	Ont.	Que.	Man.	N.S.	N.B.	Calif.**	Total
Canada's standards are equivalent	27	7	10	23	6	0	22	19	2	116
Canada's standards are more stringent	4	1	17	9	14	0	10	14	1	70
Canada's standards are less stringent	4	2	3	1	0	2	1	1	1	15
Total standards available for comparison	35	10	30	33	20	2	33	34	4	201
Standards not comparable with Canada's standards	5	29	10	7	20	38	7	6	2	124
Percentage of Canadian standards at least as stringent as comparable standards***										93%

* Column sums to 39 instead of 40 due to difference in energy measurement of residential gas water heaters.
** Column does not sum to 40 due to products being covered under federal standards.
*** Calculated by summing over all jurisdictions the total number of standards for which Canada's MEPS are equivalent or more stringent (rows 1 and 2 of the table) and dividing by the total number of standards summed over all jurisdictions (rows 1, 2 and 3 of the table).

Approximately 93 percent of the standards prescribed under the Act are at least as stringent as comparable standards established by a province, Mexico, the United States and California. For example, Canada has standards that are equivalent in stringency to 116 standards in the United States, including California; Mexico; and six Canadian provinces. Of the remaining 7 percent prescribed under the Act, Canada has proposed equivalent or more stringent standards for more than half of the products. For further information, contact equipment@nrcan-rncan.gc.ca.

COMPLIANCE AND ENFORCEMENT

The Regulations outline a number of responsibilities for dealers who import to Canada, or ship from one Canadian province to another for the purpose of sale or lease, 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 certification body that verified the energy performance of the product and the size category, as described in Schedule IV of the Regulations.

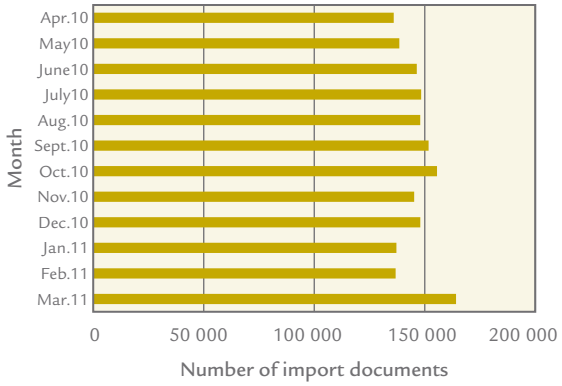
The Regulations require that when importing a regulated product into Canada, dealers provide specific product information on customs documents for all shipments (i.e. type of product, brand name, model number, address of dealer and purpose of import). A customs document contains less information than 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 1.75 million records (records from April 1, 2010, to March 31, 2011) relating to the importation of regulated energy-using products to Canada in 2010–2011.

Figure 2-1 illustrates the volume of import documents received, in paper form and electronically, per month during the 2010–2011 fiscal year.

FIGURE 2-1

Volume of Monthly Import Documents



Source: OEE Equipment Database.

More than 2.4 million new or revised model numbers were submitted to NRCan for entry into NRCan's equipment database (records from April 1, 2010, to March 31, 2011) 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 11 amendments have resulted in a reduction of 26.03 megatonnes (Mt) in aggregate annual GHG emissions (see Table 2-2).

During 2010–2011, NRCan conducted the analysis and consultation necessary to implement the remaining standards identified in the Clean Air Regulatory Agenda (CARA). Standards contained in Amendment 11 were pre-published in June 2010. Analysis to support a revision to the implementation dates for standards for light bulbs was also completed and pre-published in April 2011.

In total, the final 2020 CARA-projected energy efficiency impacts of the published and soon-to-be pre-published amendments (amendments 10–13) plus market transformation programs (including the proposed light-bulb delays and the removal of room air conditioning and portable air conditioning) are savings of 111.56 PJ of energy and 11.75 Mt of GHG emissions.

LABELLING AND PROMOTION

Since 1978, the EnerGuide label (see Figure 2-2) has given Canadians the 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

TABLE 2-2

Estimated Impact of *Energy Efficiency Regulations*, 2010 and 2020 (Aggregate Annual Savings)

Product (amendment number in brackets)	Energy savings (PJ)		GHG 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	0.25	0.67
Ballast/room A/C, PAR lamps (6)	3.96	9.44	0.60	1.20
Clothes washers, domestic hot water, exit signs, chillers (8)	16.12	42.59	1.28	3.60
A/C, commercial refrigeration (9)	1.64	5.51	0.16	0.55
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 dehumidifiers, residential gas furnaces (10)	6.09	88.10	0.40	9.67
Residential boilers, dry-type transformers, commercial three-phase induction motors, external power supplies, large air conditioners and heat pumps, room air conditioners, standby power, commercial reach-in refrigerators, digital television adaptors, residential general service incandescent reflector lamps, industrial three-phase induction motors, commercial general service incandescent reflector lamps (11)	0.55	7.50	0.07	0.96
Total	**184.77**	**336.53**	**26.03**	**44.76**

are published annually. They are distributed to consumers, retailers and appliance salespeople. In fulfilling requests for information, electric utilities and provincial governments also distribute the directories. Online directories for all appliances and heating and cooling equipment are published on the Web site of the Office of Energy Efficiency (OEE) and updated monthly.

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

Major distributors of these products for sale in Canada report the verified energy performance rating of their products, as tested against the standards in the Regulations. In addition, participants in the voluntary EnerGuide rating program must provide shipment data and aggregate energy efficiency information to track the progress of the program and identify marketplace improvements that can result from labelling.

Given that the equipment products listed above are typically purchased from a brochure or catalogue, a consumer would likely 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. Canada joins other international ENERGY STAR program participants: Australia; New Zealand; Japan; Taiwan; and the European Union, which adopted ENERGY STAR for office equipment. The OEE is the custodian of the program for Canada.

FIGURE 2-2
EnerGuide Label

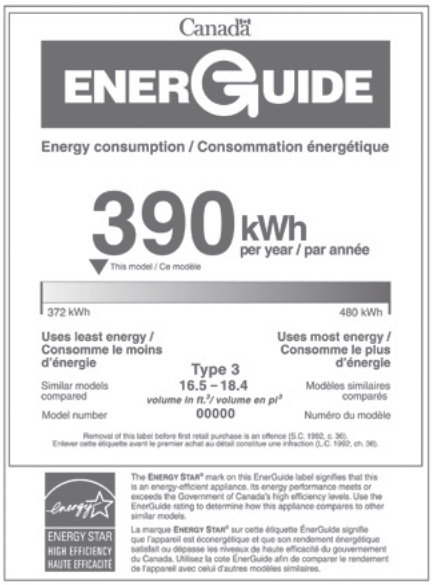


FIGURE 2-3
ENERGY STAR® Symbol

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 equipment
- 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 kitchen products

Canada has 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 and is used by many electrical and gas utilities across Canada. For example, Hydro-Québec, BC Hydro and the Ontario Power Authority had retailer incentive programs for ENERGY STAR qualified televisions. Enbridge Gas and Manitoba Hydro ran incentive programs for ENERGY STAR qualified commercial kitchen equipment.

ENERGY STAR is also the qualifying criterion for sales tax exemptions 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 2009 show an increase in market penetration from almost nil in 1999 to 53 percent for refrigerators, 69 percent for clothes washers and 90 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.

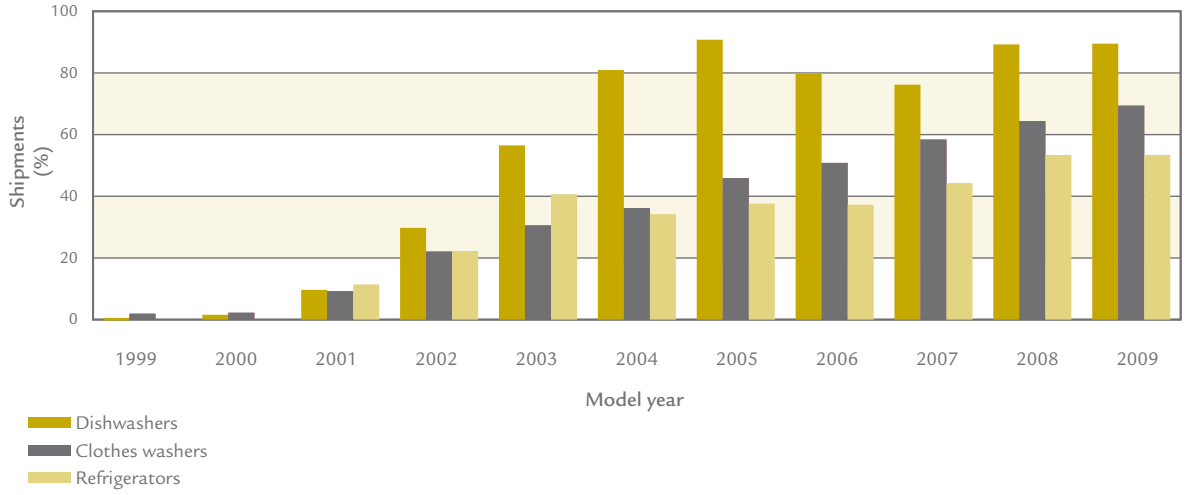
Canada continues to promote ENERGY STAR guidelines in its contacts with the procurement community. It has updated an interactive cost calculator that compares energy cost savings and GHG emissions reductions associated with the purchase of ENERGY STAR qualified products.

Workshops were held across Canada to make governments and institutions aware of the ENERGY STAR criteria and procurement tools. Dalhousie University was the first university in Canada to become an ENERGY STAR participant.

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

FIGURE 2-4

Distribution of ENERGY STAR Qualified Shipments of Appliances, 1999 to 2009



Source: *Energy Consumption of Major Household Appliances Shipped in Canada, Summary Report. Trends for 1990–2009.*

expand the range of product types included in its ENERGY STAR agreement.

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

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

products for sale in Canada. It also carries out initiatives to increase the market share of more efficient products.

ecoENERGY for Equipment also supports labelling programs that encourage the introduction of more efficient technologies. This involves the establishment and promotion of high-efficiency performance criteria, such as ENERGY STAR, and the engagement of stakeholders to promote products that meet these criteria. As products are adopted in the marketplace, the ENERGY STAR or equivalent performance level will become the basis for new, more stringent standards. In addition, ecoENERGY for Equipment maintains a multilayered compliance and enforcement program to ensure that products meet prescribed standards and to ensure that other regulatory requirements, such as labelling, are met.

DID YOU KNOW?

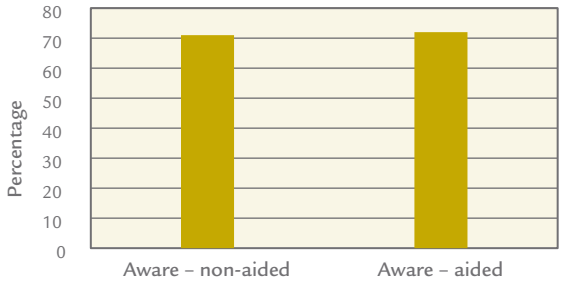
In a typical household, two televisions and associated service-provider hardware consume more electricity than two ENERGY STAR qualified refrigerators. Seventy-one percent of Canadians recognized the ENERGY STAR symbol unaided (see Figure 2-5), and 89 percent recognized the symbol when it was shown to them in an on-line survey.

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 2010–2011 Achievements

- NRCan, in co-operation with the Canadian Electricity Association, utility providers and retailers across Canada, led the ENERGY STAR® Light Fixture campaign to demonstrate easy and practical ways that Canadian families can save energy, save money and help protect the environment. ENERGY STAR qualified fixtures use one quarter of the energy of traditional light fixtures and come in hundreds of styles.
- Carried out the work necessary to publish Amendment 11 to the *Energy Efficiency Regulations*. This amendment increases the stringency and/or scope of existing MEPS for seven currently regulated products and introduces new MEPS and associated reporting and compliance requirements for five products. It is estimated that this amendment will result in 0.97 Mt of annual GHG emission reductions in 2020 and represent $2 billion of net present value over the lifetime of the products shipped by 2020.
- Conducted the analysis and consultation necessary to pre-publish Amendment 13 to the *Energy Efficiency Regulations*. This amendment will increase the stringency and/or scope of existing MEPS for eight currently regulated products and introduce MEPS and/or associated reporting and compliance requirements for seven products. NRCan estimates that this proposed amendment will result in reductions of approximately 1 Mt of GHG emissions in 2020, increasing to

approximately 3 Mt in 2030. The net present value of benefits for all Canadians is estimated to be $762 million over the service life of products shipped by 2030 and $1.4 billion by 2030.

- Ten ENERGY STAR technical specifications were published and implemented, twice the targeted number. Examples include televisions, windows, doors, audio/DVD products and integral light-emitting diode (LED) lamps. In addition, the groundwork has been laid for introducing the Most Efficiency category of ENERGY STAR qualified products.
- Delivered five specialized workshops on the use of the ENERGY STAR calculator and on other ENERGY STAR related guidance 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 managed the ecoENERGY Efficiency Initiative, under the ecoENERGY suite of programs initiated on April 1, 2007. The ecoENERGY Efficiency Initiative included the following programs:

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

In addition, the OEE managed the ecoENERGY for Biofuels program, the National Renewable Diesel Demonstration Initiative and the Federal Buildings 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 had 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

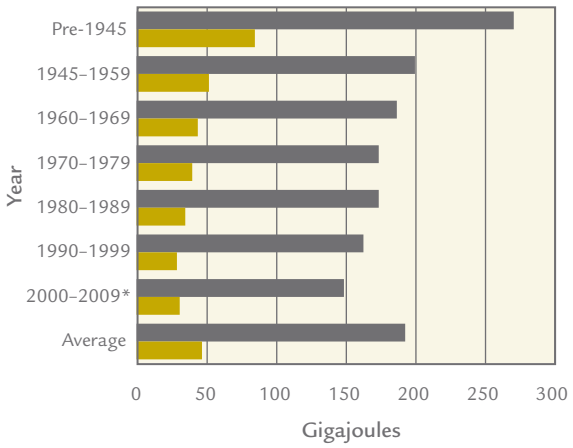
Initiated on April 1, 2007, the four-year, $745-million ecoENERGY Retrofit – Homes program provided federal grants to property owners for improving the energy efficiency of their homes and reducing their home's impact on the environment. Budget 2011 allocated an additional one-year investment of $400 million to the program.

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

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).

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

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

Key 2010–2011 Achievements

- As of March 31, 2011, the ecoENERGY Retrofit – Homes program had received more than 510 000 grant applications from Canadian homeowners (surpassing the four-year program target of 460 000).
- The program has provided more than $700 million to more than 500 000 grant recipients. Participants reduced their annual energy consumption by about 20 percent and greenhouse gas (GHG) emissions by approximately three tonnes per house per year.
- More than 150 000 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 29 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.
- As of March 31, 2011, a reduction of approximately 1.75 megatonnes (Mt) of GHG emissions could 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, a $40-million program over four years, provided financial incentives to implement energy retrofit projects in buildings of less than 20 000 square metres and industrial facilities with fewer than 500 employees.

ecoENERGY Retrofit – Small and Medium Organizations provided 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 could also qualify for funding support from utilities and/or other levels of government. To qualify, eligible organizations submitted 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 2010–2011 Achievements

- As of March 31, 2011, 583 contribution agreements had been signed (244 buildings projects and 239 industry projects), bringing the

number of contribution agreements signed over the life of the program to 1 286 (710 buildings projects and 576 industry projects). In total, the agreements represent $287 million worth of projects, yielding annual energy cost savings of $45 million.

- More than 1 850 buildings and industry sector representatives took part in webinars and information sessions that provided program information.
- Over the course of the program, all of the approved projects will have led to a reduction in GHG emissions by an estimated 0.231 Mt.

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

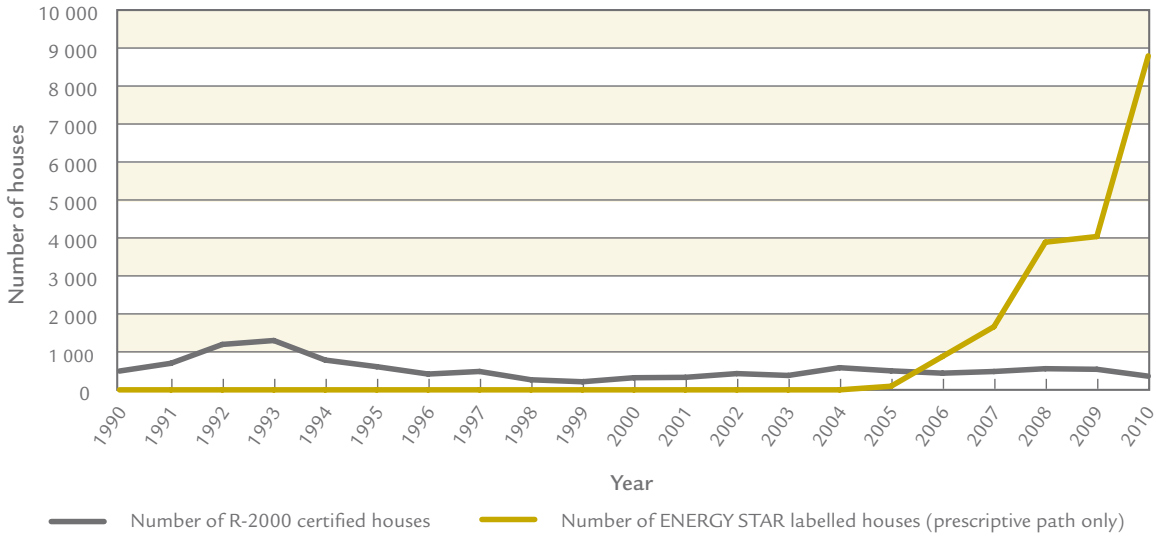
Initiated on April 1, 2007, the four-year, $60-million ecoENERGY for Buildings and Houses program included the following activities for the buildings sector:

- 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 could 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)
- supporting the National Research Council financially to upgrade the *Model National Energy Code for Buildings*, now called the *National Energy Code for Buildings*, which was last published in 1997

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

FIGURE 3-2

Number of R-2000 House Certifications and ENERGY STAR Prescriptive-Labelled Houses, 1990 to 2010



Source: NRCan national housing database and internal data.

- 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 support initiatives aimed at reducing energy use and improving energy efficiency information

Key 2010–2011 Achievements

- By March 31, 2011, more than 1 580 building owners, managers, operators, designers and builders had received energy management training, while more than 350 commercial buildings received energy labels as part of a pilot program on energy management labelling and benchmarking.
- Issued more than 385 000 housing labels for new and existing houses.
- NRCan's EnerGuide Rating System (ERS) has been used in six provinces and territories (British Columbia, Manitoba, Ontario, Northwest Territories, Yukon and Nova Scotia) to develop or implement energy performance requirements in their building codes or municipal bylaws.
- As of the end of the 2010–2011 fiscal year, six provinces (British Columbia, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia) had announced changes to their building codes to achieve the ERS80 level by 2012. All provinces and territories participated in the Building Energy Codes Collaborative.
- In 2010–2011, a new Energy Code for Buildings was developed and approved. This code is 25 percent more stringent than the code published in 1997. It is designed to align with efforts deployed by other countries with similar climates; it exceeds the codes adopted by the U.S. states. The code was published in fall 2011.
- Since program inception, an estimated 1.49 Mt of GHG emissions have been 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 four-year, $18-million ecoENERGY for Industry program accelerated energy-saving investments and exchanged best-practices information within Canada's industrial sector. The program helped 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 included the following:

- the Dollars to $ense Energy Management workshops, which taught industry members how to improve operational efficiency, generate energy savings and reduce GHG emissions

- ecoENERGY assessments for Industry, which offered 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
- the CIPEC Leaders network, which demonstrated industry sector commitment to reducing energy use, provided members with opportunities for networking, recognition and sharing of best practices, as well as eligibility for financial assistance
- tools, publications and benchmarking studies that created awareness of energy-saving opportunities and promoted actions to achieve those savings

DID YOU KNOW?

CIPEC was declared a Champion of Energy Efficiency by the American Council for an Energy-Efficient Economy (ACEEE) in 2009. CIPEC is the first organization outside the United States to win an ACEEE award. One of 56 nominees, CIPEC was recognized for demonstrating exceptional leadership in the development and implementation of energy efficiency initiatives for industry. More than 2 400 industrial facilities in Canada have joined the CIPEC network as CIPEC Leaders.

Key 2010–2011 Achievements

- More than 4 100 industrial energy managers have attended the Dollars to $ense Energy Management workshops since program inception, with almost 1 000 trained in 2010–2011. Customized workshops are held on-site to facilitate access in remote locations.
- Welcomed 208 new companies to the CIPEC Leaders network, which now has 2 400 registered companies. The total number of participant facilities in the program was 4 700 (nearly doubling the four-year program's target of 2 500).
- Almost 1 000 new subscribers received the *Heads Up CIPEC* electronic newsletter in 2010–2011.
- For a 2010–2011 impact analysis, 43 companies that had received financial assistance for a process integration study were interviewed. Collectively they implemented 55 percent of recommended projects, resulting in annual energy savings ranging from 10 percent to 25 percent, i.e. fuel energy savings of 6 600 terajoules/year ($54 million/year) and direct GHG reductions of 311 000 tonnes/year.
- Since program inception, the ecoENERGY for Industry program helped Canadian industry avoid approximately 1.54 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 four-year, $21-million ecoENERGY for Personal Vehicles program provided 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 did so through the following:

- decision-making information and tools, such as the annual *Fuel Consumption Guide*, labels and vehicle awards
- Eco-driver curriculum and training
- fuel-efficient driving and tire inflation campaigns
- collaborative ventures with community groups and industry stakeholders

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

Program components included the following:

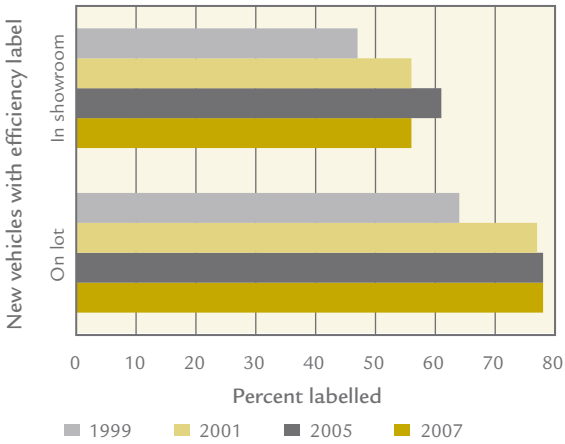
- the EnerGuide labelling system, which placed fuel consumption labels on all new light-duty vehicles sold in Canada (see Figure 3-3)
- the 2005 MOU between the Government of Canada and the Canadian auto industry – a framework for automakers to produce more fuel-efficient and lower-GHG-emission vehicles by 2010 (see Figure 3-4)
- the annual ecoENERGY for Vehicles Awards, which recognized and identified, for consumers, the most fuel-efficient light-duty vehicles in their classes available in Canada
- the Auto$mart driver education series, which taught drivers how to drive safely, save fuel and money, and protect the environment by using fuel-efficient driving techniques
- fuel-efficient driving and tire maintenance campaigns that used educational materials and outreach activities to encourage drivers to embrace fuel-efficient practices

Key 2010–2011 Achievements

- In fiscal year 2010–2011, more than 580 000 new drivers were exposed to the Auto$mart fuel-efficient driving curriculum, bringing the four-year total to more than 1.9 million (exceeding the program target of 500 000). A fuel savings of 5 percent to 25 percent is possible when drivers adopt fuel-efficient driving techniques.
- Since program inception, more than 1 200 000 copies of the *Fuel Consumption Guide* have been distributed. Also, the program collaborated with industry to promote and expand the distribution of fuel efficiency information in electronic formats.
- In 2010–2011, about 3.6 million Canadians were reached by targeted awareness campaigns, such as those for tire maintenance and fuel-efficient driving.
- Since program inception, a reduction of approximately 0.21 Mt of GHG emissions have been attributed to ecoENERGY for Personal Vehicles programming, and a reduction of 3.1 Mt to 3.4 Mt of GHG emissions has been attributed to the MOU with the Canadian auto industry.

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.

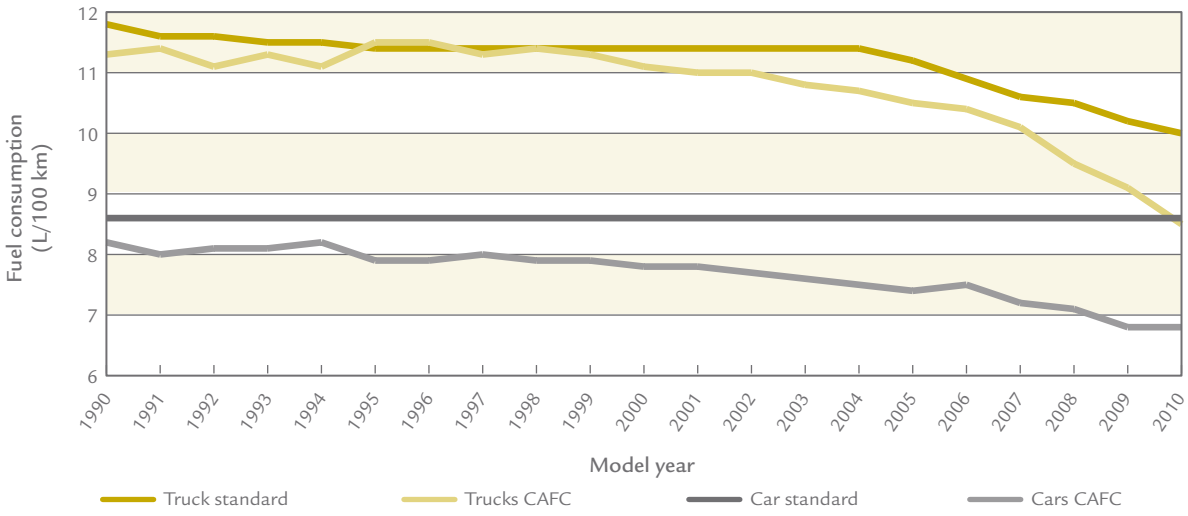
DID YOU KNOW?

The 2010 *Fuel Consumption Guide* provides model-specific fuel consumption information to help Canadian motorists select the most fuel-efficient vehicle to meet their needs. It also provides information to help them drive and maintain their vehicles with fuel efficiency in mind.

For more information:
vehicles.nrcan.gc.ca

FIGURE 3-4

Company Average Fuel Consumption (CAFC) Versus Canadian Voluntary Standards, 1990 to 2010*



*2009 and 2010 data are estimates.

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

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 four-year, $22-million ecoENERGY for Fleets program promoted 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 targeted the commercial/institutional fleet transportation sector and provided information, workshops, technical demonstrations and training programs on fuel-efficient practices for fleet vehicles.

Program components included the following:

- Fuel Management 101 workshops, which assisted fleet managers with the preparation, implementation and monitoring of a fuel management plan
- SmartDriver training programs, which offered 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 helped overcome knowledge barriers, encouraging uptake of fuel-saving technologies by fleets

Key 2010–2011 Achievements

- In fiscal year 2010–2011, more than 8 200 drivers were trained through the SmartDriver program, bringing the four-year total to nearly 23 000.
- More than 270 participants took part in Fuel Management 101 workshops to promote greater uptake of transportation energy efficiency practices, bringing the four-year total to nearly 800.
- Since program inception, a reduction of approximately 0.41 Mt of GHG emissions have been 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 of domestic production by December 2012, with a target of 2 billion litres of renewable alternatives to gasoline and 500 million litres 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 environmental legislation.

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

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

DID YOU KNOW?

Alternative fuels, such as ethanol, biodiesel and natural gas, have a lower carbon content relative to conventional fuels, such as gasoline and diesel. The increased production, awareness and use of alternative fuels can contribute to a reduction in GHGs in the Canadian transportation sector.

Key 2010–2011 Achievements

- As of March 31, 2011, 31 contribution agreements had been signed with companies. At least eight of these facilities are new and began production in 2010–2011.
- These agreements represent a total commitment of $1.133 billion and a domestic production of 2 973 million litres/year of biofuels (1 724 million litres of ethanol and 249 million litres of biodiesel by December 2012 but increasing thereafter to a maximum of 1 877 million litres of ethanol and 269 million litres 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 a non-incented energy efficiency program for Canadian federal organizations (departments, agencies and Crown corporations) to help them undertake energy efficiency improvements.

The program provides tools, training, model documents (contracts, requests for proposals), program policy advice and procurement assistance to help federal organizations develop energy management plans and use energy performance contracting to finance energy efficiency retrofits of facilities.

Other levels of government, institutions and private sector firms have drawn on the FBI program 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, saving $43 million in energy bills and reducing GHG emissions by approximately 285 kilotonnes per year.

DID YOU KNOW?

Using the innovative financing mechanism known as energy performance contracting, the FBI has led to the retrofit of one third of federal floor space without requiring new spending from taxpayers. More than $320 million of private sector funding, using energy performance contracting, helps to improve the energy performance of more than 7 000 buildings across Canada.

The FBI program celebrated 20 years of strong leadership in energy efficiency throughout the federal government in November 2011.

Key 2010–2011 Achievements

- Demonstrated leadership
  - On Oct. 6, 2010, the FBI's leadership was acknowledged when the FBI was identified as a best practice implementation strategy for departments to meet their GHG targets as required in the Federal Sustainable Development Strategy (FSDS) tabled in Parliament.
  - The FBI established the FBI Community of Practice (CoP) as a forum for federal energy managers, to ensure their access to other experts as they collectively discuss issues, strategies and tactics to improve energy efficiency. The CoP meetings have increased awareness of the program and have provided a networking opportunity among federal managers with similar objectives.
  - Increased awareness and exposure of the FBI has led to the FBI partnering with Public Works and Government Services Canada's Office of Greening Government Operations (OGGO) on government-wide awareness initiatives on meeting the FSDS targets. These initiatives are aimed at federal facility and environmental managers. The OGGO is responsible for environmental initiatives in buildings and for green procurement as per the FSDS strategy.
- Established a new financial and technical risk assessment mechanism for the FBI's qualified bidders list (QBL). The QBL pre-qualifies energy service companies based on their technical and financial capacity to undertake FBI projects within the federal fleet of buildings.

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) aimed 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. In 2009, the government announced its intention to accomplish this by 2011, subject to technical feasibility. Technical feasibility was demonstrated, and the 2 percent regulation and the coming-into-force date for the requirement is July 1, 2011.

In consultations, Canadian industry sectors and end-users raised questions related to the proposed large-scale integration of renewable diesel into fuel distribution networks. The NRDDI aimed to address these remaining questions in advance of the proposed regulation coming into force.

Non-repayable contributions were provided to approved projects that demonstrated aspects of renewable diesel use and/or distribution in Canada.

Key 2010–2011 Achievements

- The NRDDI program consulted with 13 industry stakeholders to understand their technical questions about renewable diesel use in Canada. The NRDDI funded seven demonstration projects proposed by stakeholders to address their outstanding technical questions. Each project included a multi-stakeholder technical committee to ensure the project would address the needs of all stakeholders and the results would be presented in a scientifically sound manner. The NRDDI worked closely with Environment Canada and Agriculture and Agri-Food Canada to ensure that the results would also meet their needs. In addition, the NRDDI completed an infrastructure-readiness study to further inform the development and implementation of the proposed regulation.
- The NRDDI final report assessed the technical feasibility of the proposed regulation based on the results of the NRDDI and other relevant projects and studies. NRCan provided the final report to Environment Canada in October 2010, and the report was made public on NRCan's Web site in January 2011. Overall, stakeholders have indicated that their technical concerns have been addressed.

For more information:
oee.nrcan.gc.ca/transportation/alternative-fuels/programs/3330

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 (ecoETI) and the Clean Energy Fund (CEF). These programs allocated more than $239 million in the 2010–2011 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. In 2010–2011, more than 68 percent of the PERD program and activities allocated by the OERD were managed and carried out by NRCan (including CanmetENERGY), as were more than 97 percent of the ecoETI and CEF programs and activities allocated by the OERD. The six departmental priorities listed for CanmetENERGY (*see below*) 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 transportation fuels, renewable energy technologies and cleaner fossil fuels.

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 2010–2011 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 2010–2011 fiscal year was approximately $51.7 million. Of that amount, $16.3 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 $35.4 million was allocated to energy R&D programs managed and performed in NRCan, more than 68 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 ecoETI 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 2010–2011 fiscal year was nearly $72.7 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 and increase the percentage of electricity produced from clean sources.

Description

The $795-million CEF, 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 37 percent of the 2010–2011 CEF was committed to or earmarked for small-scale demonstration projects, including 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 CEF expenditures for the 2010–2011 fiscal year were approximately $115 million. Of that amount, approximately $62 million was allocated to large-scale demonstration projects, and approximately $42 million was allocated to small-scale demonstration projects, which will contribute directly and indirectly to improved energy efficiency and the integration of renewable energy sources in Canada. Approximately $8 million was allocated to R&D.

Key 2010–2011 Achievements

- Thirteen demonstration-project contribution agreements in renewable energy and clean energy

technologies were signed in 2010–2011. These projects will demonstrate marine energy, smart grid, wind, energy storage, bioenergy, geothermal energy in the North, and community energy systems.

- Contribution agreements were signed for two of the three large-scale demonstration projects, bringing the Government of Canada commitment under contract to $150 million.

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

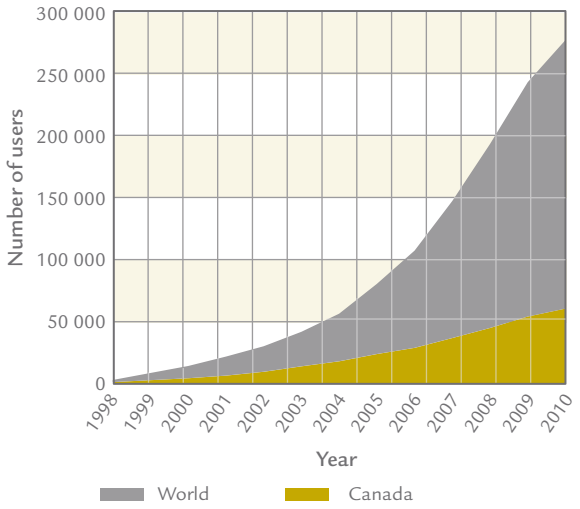
the most environmentally advanced structures on the planet.

Key 2010–2011 Achievements

- CanmetENERGY increased the number of users of the RETScreen®[8] Clean Energy Project Analysis Software to more than 276 000 people in 222 countries, adding an average of 1 000 new users every week (see Figure 4-1). More than 300 colleges and universities worldwide are now using RETScreen for education. As well, RETScreen was selected for several external awards, including the ENERGY GLOBE National Award for Canada, presented at the 2010 World Environment Day hosted in Kigali, Rwanda; the Government Technology Exhibition and Conference (GTEC) Distinction Award Medal (National Category) for International Partnerships; and a Public Service Award of Excellence (Innovation category) for demonstrating leadership and commitment and helping to build Canada's international reputation as a serious player in enabling clean energy worldwide.

FIGURE 4-1

RETScreen Software: Cumulative Growth of User Base



Source: NRCan/RETScreen Customer Database.

- The DABO™ software developed by CanmetENERGY helps to reduce significantly building energy consumption by optimizing the operation of mechanical systems for heating, cooling and ventilation. 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, a Montréal-based company specialized in software editing, is the commercial partner for distributing DABO in Canada, Europe and China. In 2010–2011, IFCS signed DABO licences with Centre universitaire de santé McGill, Banque Nationale du Canada headquarters in Montréal, Université du Québec à Montréal, and Veolia Environnement, a multinational company based in France.
- A field trial of an advanced zoned heating and cooling system, recently completed over three years in 25 homes across Ontario, has demonstrated substantial energy savings and improved homeowner comfort. On the comfort side, the system heated basements more effectively in winter and resulted in cooler and less humid upper levels during hot summer days and nights. On the energy efficiency side, the system demonstrated a 7 percent reduction in annual gas use, a 15 percent reduction in annual electrical use and up to 30 percent summer-peak electrical savings versus baseline high-efficiency non-zoned furnace systems. Results of this work, one of 40 demonstrations, have formed the basis for the Local Energy Efficiency Partnership (LEEP™) presentation series on zoned heating and cooling systems. The Heating, Refrigeration and Air Conditioning Institute is also working with its membership to further advance the technology.

For more information:

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

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

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

DID YOU KNOW?

A major obstacle to solar technology deployment is seasonal availability of the resource. NRCan researchers are introducing new approaches and systems integration to demonstrate the viability of solar thermal energy storage in Canada that can meet up to 90 percent of space heating needs in Canadian homes.

Key 2010–2011 Achievements

- CanmetENERGY provided technical and financial support to the development of the Very Low Head (VLH™) hydro turbine technology, which was successfully demonstrated in France. CanmetENERGY also worked with the Coastal HydroPower Corporation (British Columbia) in conducting a cold-climate adaptation engineering study. Additionally, work was conducted on the development of a cold-climate adaptation package that integrates solutions for Canadian VLH™ site deployments. Now CanmetENERGY is working with Carleton University and Fisheries and Oceans Canada to determine the fish-friendliness of the VLH™ turbine for typical Canadian river systems. Having identified potential demonstration sites and partners in Alberta and Ontario, CanmetENERGY is firming up projects.
- CanmetENERGY is a co-chair of the national Smart Grid Technology and Standards Task Force that aims to identify the current status and future needs of the electric power industry. The task force reports to the Canadian National Committee of the International Electrotechnical Commission and the Standards Council of Canada. CanmetENERGY provides technical expertise to assess the needs in advanced electricity meters and the interoperability of equipment interconnected to the grid. The recommended standards will serve as the basis for a renewed effort to identify key requirements for deploying a modern and resilient electricity transmission and distribution infrastructure in Canada.
- With technical and financial support from CanmetENERGY and Saskatchewan Research Council of Regina, Advanced Engine Technology Ltd. of Ottawa implemented a very successful field trial demonstration of a 6-kWe micro-cogeneration unit at Inland Metal in Regina. Through detailed monitoring and optimization, the unit has operated for more than 4 200 hours, enabling efficiency improvements ranging from 77 percent to 87 percent. This will allow improved units, targeted for installation in Saskatchewan.
- Integrated high-efficiency heating appliances using thermophotovoltaic and thermoelectric generation technologies were developed and prototyped. In these appliances, a portion of fuel combustion heat is converted to electricity while meeting the heating needs for homes. The thermophotovoltaics/thermoelectric power generation is applied to new and existing boilers to generate electricity and produce heat and domestic hot water. The value of the integrated energy systems, provided to the consumer, is in the reliability of the heating system and the reduction of electric power consumption.
- CanmetENERGY, in collaboration with Defence Research and Development Canada (DRDC), Advanced Engine Technology Ltd. and Saskatchewan Research Council, undertook a project to seek innovative integration strategies for sea-water heat pumps driven by on-site cogeneration units. Many northern communities and military installations are challenged by the harsh environment and lack of indigenous energy sources and have few options for a green energy future. Solar and wind resources are seasonal, highly variable and adversely affected by the severe climate. In most cases, every litre of diesel fuel must be delivered by ground, barge or aircraft to such sites. Canadian Forces Station Alert, a community at the northernmost tip of Ellesmere Island, is the site chosen for this work. DRDC is particularly interested in evaluating the long-term sustainable energy options for such communities.

The goal is to dramatically lower the energy-related footprint of the community at Alert.

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 2010–2011 Achievements

- CanmetENERGY signed an agreement with VERI, the research centre of Veolia Environnement to develop and test an ejector-based system prototype to recover waste heat for cooling applications. The ejector system is an innovative thermal compressor developed at CanmetENERGY that aims to improve cooling, heating and refrigeration applications.
- In collaboration with l'Agence de l'efficacité énergétique in Quebec, CanmetENERGY delivered four three-day seminars on process integration and trained 60 professionals and decision-makers from engineering firms, consultants, utilities and industries to better analyse heat recovery projects within industrial facilities. The seminars focused on the use of a site-wide approach that considers process units and utility systems as a whole, to maximize energy savings. Participants had the opportunity to solve case studies using the *Integration* software tool developed by CanmetENERGY. With *Integration*, a powerful tool with unique capabilities, users can identify and evaluate the impact of heat recovery projects and operational improvements in small and medium-sized enterprises and in large industries. These activities are part of a multi-year capacity-building program aimed at improving industrial energy efficiency in Quebec.
- CanmetENERGY worked collaboratively with La Boîte à science, a company specializing in tools and activities designed to raise student awareness of science and technology, in developing a

teacher's kit on energy use and conservation for high-school classrooms. "2025: L'Odyssée de l'énergie" consists of a team game through which pupils discover the principles of heating and cooling and are introduced to the notion of heat recovery. Players are then faced with the task of reducing energy consumption in simplified versions of typical industries, such as paper mills and food-processing plants. The kit was launched at the annual conference of the Association pour l'enseignement de la science et de la technologie au Québec, where it was very well received. To date, 21 schools from all regions of Quebec have reserved the kit, and the Canada Science and Technology Museum in Ottawa has expressed interest in this unique product.

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 2010–2011 Achievements

- CanmetENERGY was selected as the lead of the technical program for a new tailings consortium's field demonstration of two dry stackable tailings technologies. The consortium includes Syncrude Canada Ltd., Shell Canada, Canadian Resources Ltd., and TOTAL E&P Canada. Following the success of the project's technology sharing, an industry-wide collaboration on tailings was formed and announced in 2010. As the lead of the technical program, CanmetENERGY ran a commercial scale demonstration of the centrifuge program in the summer of 2011.
- CanmetENERGY has developed new analytical methods, one of which was published in the scientific literature, to study the movement of naphthenic acids and process chemicals between the process water and solids. These methods use relatively accessible instrumentation that other researchers in this field can use to analyse this important family of oil sand process water contaminants.

- CanmetENERGY has collaborated with Carleton University and the National Research Council to successfully develop and field test a novel camera-based technology known as Sky-LOSA (Line of Sight Attenuation), which enables quantification of soot particle mass emission rates from a distance. This set-up is the first demonstration of a soot emission measurement with Sky-LOSA under field conditions. Additionally, it is the first time the soot emission rate in the unconfined atmospheric plume of a flare has been directly quantified. In collaboration with the World Bank's Global Gas Flaring Reduction (GGFR) partnership and the Global Methane Initiative, this Canadian technology will be field tested in Mexico and China. This initiative is a part of Canada's efforts to assist these jurisdictions in quantifying and reducing emissions associated with oil and natural gas production.
- CanmetENERGY and the U.S. Department of Energy's (DOE's) Vehicle Technologies Program consulted energy companies to solicit input from knowledgeable individuals that could be used to increase the efficiency of government-sponsored fuels and engine research in achieving its intended purpose. A preliminary release noted that all national laboratory research on fuels characterization and CanmetENERGY Devon's work on heavier fuels in particular were significant. Areas identified for continuing research included molecular structure of fuels, combustion kinetics, engine modelling and federal laboratory participation in standards' organizations and energy-vehicle joint research programs. Advice also included the call for more work on life cycle analysis and a recommendation that national laboratories spend more effort on educating the public and politicians on fuels and combustion issues.
- CanmetENERGY is performing research in such areas as the blending and co-processing of biomass- and bitumen-derived feeds. Researchers have developed characterization and analytical methods for co-processing these feeds and products and have developed methods and procedures to address the observed incompatibility of bitumen- and biomass-derived feedstocks. CanmetENERGY has also completed a collaborative bio-gasoline project with Suncor Energy Products Inc. to expand petroleum-cracking technology through the addition of biomass components. CanmetENERGY's research led to the commercialization of bio-gasoline technology and was acknowledged by Suncor management.

DID YOU KNOW?

CanmetENERGY Devon's research results have supported the development of science-based clean air regulation domestically and have been incorporated into international codes of practice for such organizations as the World Bank's GGFR partnership and the international Global Methane Initiative and Asia-Pacific Partnership on Clean Development and Climate.

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

CLEAN TRANSPORTATION ENERGY

Objective

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

Description

CanmetENERGY works with stakeholders in domestic and international hydrogen and transportation industries. These industries include original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial and territorial governments, research organizations, universities, other federal departments, the U.S. DOE, the International Energy Agency (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 in 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.

DID YOU KNOW?

By 2018, there will be at least 500 000 highway-capable plug-in hybrid electric-drive vehicles on Canadian roads, as well as what may be a larger number of hybrid-electric vehicles. All these vehicles will have more Canadian content in parts and manufacture than vehicles on the road in Canada in 2008.

Key 2010–2011 Achievements

Research and Development

- CanmetENERGY partnered with Hydrogenics Corporation of Mississauga, Ontario, to make major improvements in hydrogen production from proton exchange membrane (PEM) water electrolysis technology. These improvements included the continuous operation of the PEM water electrolyzer for 22 000 hours with no failure and no performance loss. The electrolyzer demonstrated an energy efficiency of 75 percent, which exceeds the U.S. DOE target for 2017. Rapid dynamic response and cycling capability was also conducted using a simulated photovoltaic solar plant input, indicating the

technology's viability for renewable energy applications.

- Canadian-based Ballard Power Systems Inc. is a world leader in the development, manufacture, sale and servicing of clean-energy hydrogen fuel cells. In 2010–2011, with support from CanmetENERGY, Ballard improved its understanding of the effect of antioxidant additives in the membrane electrode assembly on fuel-cell durability. These antioxidant additive test results, together with fuel-cell stack shut-down/start-up test data, have been used to develop and refine an empirical stack model that predicts performance degradation. This model enables the setting of improved product warranty targets, leading to improved marketability.
- Solid oxide fuel cells are highly efficient, non-polluting energy devices. However, the high operating temperatures usually required for these fuel cells put severe restrictions on their life and reliability. The Hydrogen and Fuel Cells laboratory at NRCan is investigating new solid oxide fuel cell materials that can operate at reduced temperatures and alleviate these issues. Anode-supported button-type fuel cells were prepared and tested. Results indicate that anode-supported fuel cells could operate at lower temperatures.
- CanmetENERGY partnered with the Canadian Standards Association (CSA) on the development of Technical Information Letters to bridge the gap between the introduction of electric vehicles and the development of codes and standards for their use. Work continues with CSA on developing and harmonizing codes and standards for electric vehicles.
- CanmetENERGY and Electrovaya Inc., a major battery manufacturer in Canada, worked to improve the design and process for manufacturing advanced batteries for electric vehicles. Activities focused on the design and commissioning of a custom furnace for a molten salt process for producing tin-encapsulated carbon nanotube anode material and on a new low-temperature cell using a new electrode design that shows improved low-temperature performance.

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.

NRCan plays a leadership role in the Canadian Biomass Innovation Network (CBIN), 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.

The 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 energy supply and seed the development of Canada's bio-based economy.

CBIN is a horizontal program developed and managed by five departments and one agency: Agriculture and Agri-Food Canada, Environment Canada, Industry Canada, National Research Council Canada, NRCan and the Natural Sciences and Engineering Research Council of Canada. CBIN coordinates and manages three federal government bio-based R&D initiatives, including the following:

- Program of Energy Research and Development – Bio-Based Energy Systems and Technologies Program ($3.0 million in 2010–2011)
- ecoENERGY Technology Initiative – Bio-Based Energy Systems ($1.7 million in 2010–2011)
- Clean Energy Fund R&D Initiative ($0.9 million in 2010–2011)

Key 2010–2011 Achievements

- CanmetENERGY, in collaboration with the Wood Pellet Association of Canada, has made significant contributions to writing and editing *The Pellet Handbook*. This first comprehensive guide in English covers all aspects of pellet production and utilisation. Published in fall 2010, the handbook is the result of collective efforts of the members of the IEA Bioenergy Implementing Agreement.
- CanmetENERGY has acted as a technical advisor to the Cement 2020 project and contributed to Lafarge's biomass-combustion test trials. The Cement 2020 project builds on the Energy Farm project of 2008, whereby various non-food energy crops were planted on land at Lafarge's Bath Cement Plant and on neighbouring lands and then subjected to scientific and practical study for their possible role as fuel for the cement industry. The objective of Cement 2020 is broader: to evaluate the technical, environmental and social implications of replacing fossil fuels in the manufacture of cement. The results of the biomass combustion tests were so encouraging that the plant could completely cut its use of fossil fuels by the end of the decade. In the short- to medium-term, to meet the goal of 30 percent replacement at the Bath plant, Lafarge is looking to source up to 50 000 tonnes of cleaner fuel. Eventually, the experience gained at the Bath plant will be the base for a standard set of guidelines for implementing cleaner, greener fuels by the cement industry worldwide.
- CanmetENERGY is working with a consortium, led by Manitoba Hydro, on the Bioenergy Optimization Program. As one initiative under this technology development program, Ensyn demonstrated, on a commercial scale, the viability and ease with which bio-oil can be fired in various industrial boilers across Manitoba. To facilitate broad testing, a portable fuel-delivery system that addresses the specific requirements of bio-oil handling was designed and built. The test program demonstrated that bio-oil could replace wood waste, waste oil and bunker C fuel oil in a boiler used to produce steam for papermaking. As a result of this successful test program, Tolko Industries Ltd. announced in 2010 that it will install a 400-tonnes/day Ensyn rapid thermal

processing (RTP) unit at its forest operations in High Level, Alberta. This unit could produce 85 million litres of pyrolysis oil per year.

- As a result of CanmetENERGY work, pyrolysis has been identified as one of the priorities under the U.S.-Canada Clean Energy Dialogue. Co-operation in the pyrolysis field was one of three topics at the Canada-U.S. meeting held at the National Renewable Energy Laboratory in Golden, Colorado, in March 2010. As a result of discussions between the two countries, a project was approved to receive $50,000 for collaborative work in pyrolysis. To increase the scope of this collaboration, an additional $58,000 was provided under the Security and Prosperity Partnership of North America. CanmetENERGY has worked with the U.S. DOE Pacific Northwest National Laboratory (PNNL) to develop a work plan to perform comparative tests on some biomass feedstocks that it will prepare and ship to PNNL.
- The Nexterra Systems Corp. gasification system at the New Westminster, British Columbia, Kruger Products installation is the first commercial demonstration of the company's direct-fired gasification system and a first of its kind in the pulp and paper industry. The Kruger installation won the Best New Technology Application award in June 2010, with the British Columbia Technology Industry Association acknowledging the use of technology to enhance overall productivity and business operations. Since the installation of the new gasification system, Kruger has achieved significant energy cost savings, even at current low natural gas prices, and is considering adding a third gasifier to increase boiler capacity. In aggregate, currently installed Nexterra systems could displace more than 2 million British thermal units per year of fossil fuels (equivalent to heating 770 000 North American homes) and reducing GHGs by more than 100 000 tonnes per year (equivalent to taking 25 000 cars off the road). According to Nexterra, "Support from NRCan is one of the key reasons the company has been able to grow into a world leader in bioenergy."
- A new third-generation bio-baler developed in 2009 with NRCan by Agriculture and Agri-Food Canada is being sold commercially under licence by the Anderson Group in Chesterville, Quebec. The Anderson Group sold 21 units between November 5, 2009, and April 22, 2011, generating $1.6 million in revenue. The bio-baler has been nominated by the American Society of Agricultural and Biological Engineers for an AE50 award in 2011 (the bio-baler was identified in the top 5 of the top 50 innovations in agriculture and bio-resource engineering). The machine has been recognized in the British House of Lords as a part of exciting technology used in the United Kingdom for bioenergy.
- NRCan and Agriculture and Agri-Food Canada contributed to the development of the Biomass Inventory and Mapping Analysis Tool (BIMAT). The BIMAT was initiated under the former Technology & Innovation R&D Initiative and received further funding under ecoETI and PERD. The BIMAT, available on the Internet, allows users to calculate the amount of available biomass in a given geographic area of Canada. This information is having application in developing policy and regulations and identifying where to locate bioenergy facilities. Canada is demonstrating global leadership in the development of such tools, as evidenced by the growing demand for developers as invited speakers throughout the world. In 2010–2011, the BIMAT was expanded to include 1) wood residues or dedicated biomass crop to ownership/management responsibility, 2) juvenile hardwood natural forest stands, 3) supply-chain indices for both residues and purpose grown biomass opportunities that allow users to assess economics of biomass supply, and 4) economic and carbon cost model functions for transportation logistics. In 2010, the Web site had more than 2 600 visits and performed more than 600 calculations.

- Established the first two production test sites for fast-growing selected clonal aspen in Alberta, the result of 15–20 years of work by a consortium of forest industry partners. Experience to date shows that aspen managed appropriately can yield higher volumes with higher value fibre attributes than other species used in short-rotation scenarios and is well adapted to the harsh weather conditions of the Prairies.

DID YOU KNOW?

The IEA identifies cost as the principal obstacle to widespread deployment of carbon capture and storage (CCS). NRCan researchers are testing a novel technology to clean and liquefy CO_2 for injection in deep rock formations. This technology uses no chemicals and promises to reduce the cost of CCS.

For more information:

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

cbin.gc.ca

CHAPTER 5 Renewable Energy

RENEWABLE ENERGY USE

In 2009, renewable sources accounted for approximately 64.5 percent of Canadian electricity generation and 61.8 percent of total electricity-generating 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, although the contribution of wind power and solar photovoltaic, the fastest growing sources of electricity in Canada, is becoming increasingly important in the national energy mix (see Table 5-2).

TABLE 5-1

Electricity-Generating 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
2009	80 658	61.8	2.9

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

Hydroelectricity

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

TABLE 5-2

Renewable Energy Technologies Used in Canada

Electricty – 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	**Transportation**
Electricity – In development	Biodiesel
Wave systems	Ethanol from biomass
Tidal systems	

Hydro is the main source of electricity in Canada, accounting for approximately 62 percent of the electricity generated in 2009. Canada's hydro supply is dominated by large-scale projects developed by electric utilities. Of the 76 648 megawatts (MW) of installed hydro capacity, 3 372 MW come from small hydro sites (capacity less than 50 MW), representing 2.6 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 4.5 percent of Canada's total energy supply comes from bioenergy, second only to hydro power (which generates 12.4 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 forest industries are Canada's major producers and users of bioenergy. In 2009, 673 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 51 percent of the capacity (853 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 2009, the biomass installed generating capacity was 1 671 MW, of which 8.7 percent was from landfill gas plants (110 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.

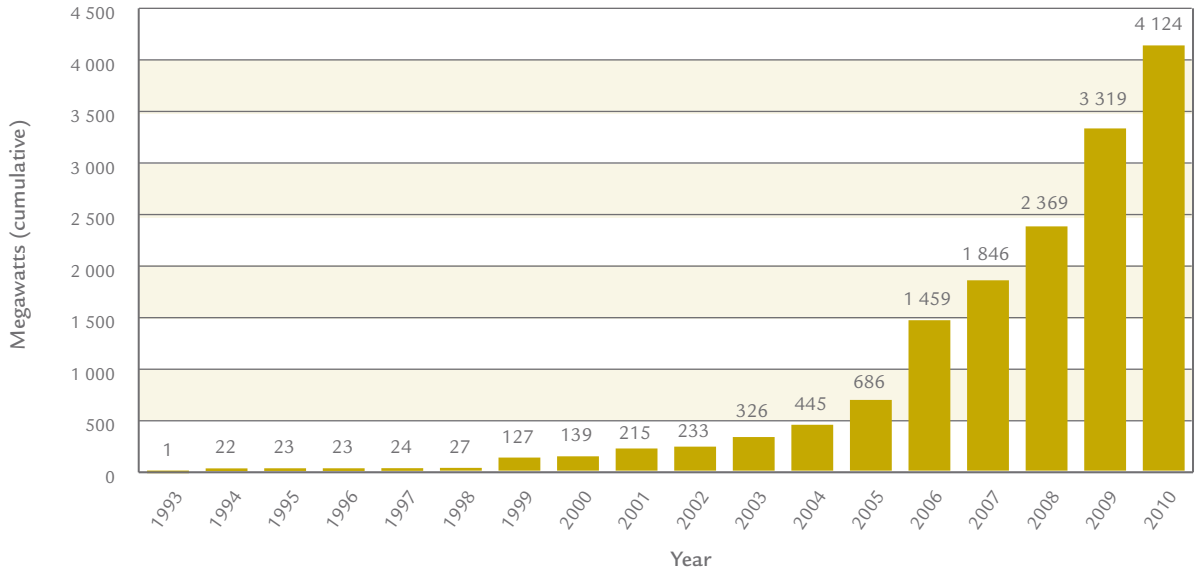
Earth Energy

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.

FIGURE 5-1

Canadian Wind Power Cumulative Capacity, 1993 to 2010



Source: NRCan and the Canadian Wind Energy Association.

For this reason, a GSHP is also 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.

In 2009, 15 643 GSHP units were installed in Canada. This compares with 14 879 units installed in 2008 and 9 284 units installed in 2007. As of December 31, 2009, there were approximately 83 000 GSHPs representing about 1 000 megawatts of thermal energy (MW_{th}) of installed capacity and producing an estimated 1 370 gigawatt-hours equivalent annually.

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, 3 319 MW of wind power had been installed in Canada. This makes Canada the country with the ninth largest installed wind energy capacity. As of March 31, 2011, there were 4 825 MW of wind power in operation in 133 wind farms in all provinces in Canada.

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 (2 369 MW) (see Figure 5-1). Federal and provincial policies continue to spur growth in the Canadian wind industry.

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 2010 was 1 025 600 square metres (m^2), or approximately 712 MW_{th}. The domestic market increase has averaged 13 percent annually since 1998. In 2010, the solar thermal collector market in Canada was 179 360 m^2, 38 percent more than the installations in 2009 (130 000 m^2).

Solar PV energy also experienced high rates of capacity growth – about 38 percent average growth rate annually between 1992 and 2010 – even though it started from a low baseline. So far, 2010 has been the best year for solar PV, with an estimated total installed capacity of 290 MW, representing an increase of 196 MW from the previous year. 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.

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.

British Columbia and Nova Scotia 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.

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 projects resulting in demonstrable environmental benefits at Canadian pulp and paper mills, leading to improved environmental and commercial sustainability of the sector.

DID YOU KNOW?

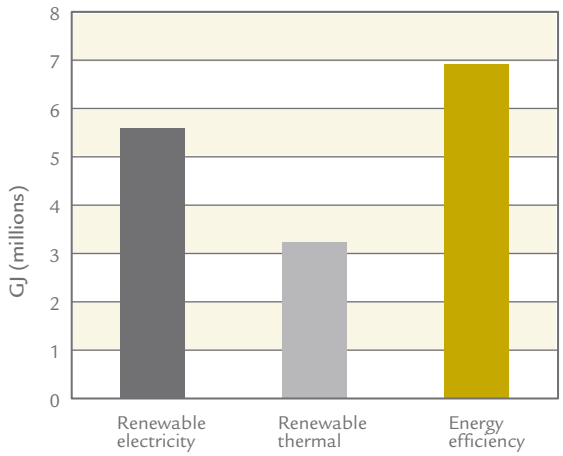
In 2010, the Zellstoff Celgar pulp mill in British Columbia completed the first phase of its green energy project as part of the PPGTP. This phase has allowed Celgar to use the excess steam produced by its industrial processes to generate large amounts of renewable electricity for export to the B.C. grid. Other environmental benefits from the project include a reduction in sulphur dioxide emissions, increased energy efficiency and reduced odour and noise in the community.

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 areas such 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. Renewable energy generation and energy savings from energy efficiency improvements associated with PPGTP projects signed as of March 31, 2011, are shown in Figure 5-2.

FIGURE 5-2

Achievements Resulting From PPGTP Investments



Source: Natural Resources Canada. Pulp and Paper Green Transformation Program. Environmental Benefits Tracking Spreadsheet. 2011.

Key 2010–2011 Achievements

- As of March 31, 2011, contribution agreements had been signed for 75 projects with 22 companies, with funds requested totalling $844 million. Approximately $388 million was expended in 2010–2011 under these agreements.
- As of March 31, 2011, PPGTP projects with signed agreements were expected to support the creation of 185 MW of renewable electrical capacity and save 6.9 million gigajoules of energy per year.
- These projects were also expected to reduce mills' greenhouse gas (GHG) emissions by 336 000 tonnes per year.

DID YOU KNOW?

The expected annual energy savings resulting from signed PPGTP projects are enough to power more than 160 000 homes – the number of homes in Hamilton, Ontario!

For more information:

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

INVESTMENTS IN FOREST INDUSTRY TRANSFORMATION

Objective

The Investments in Forest Industry Transformation (IFIT) program supports Canada's forest sector in becoming more economically viable and environmentally sustainable through targeted investments in innovative technologies.

Description

IFIT is providing $100 million over four years for projects that implement new technologies leading to non-traditional, high-value forest products and renewable energies. By building on the success of previous federal investments in research and development, IFIT ensures that promising breakthrough technologies in the forest sector continue to evolve toward full commercial viability.

Key 2010–2011 Achievements

- Successful program development and launch in summer 2010, followed by a call for proposals that attracted more than 60 applications from companies across Canada representing various forest industry subsectors, company and project sizes, and technology types.

- Signed the first round of contribution agreements worth $6.6 million for projects focusing on waste heat recovery and methanol purification; the latter is the first application in the world of this particular technology.

For more information:
forest-transformation.nrcan.gc.ca

Natural Resources Canada carried 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 4 000 MW of new capacity), such as wind, hydro, biomass, solar PV and ocean energy. The program was launched on April 1, 2007.

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. The program had authority to sign contribution agreements with renewable energy developers until March 31, 2011, but many projects with contribution agreements will continue to receive payments as outlined in contribution agreements and up to March 31, 2021.

Key 2010–2011 Achievements

- As of March 31, 2011, 104 contribution agreements had been signed with proponents, representing about $1.4 billion in federal funding over 14 years and 4 458 MW of renewable power capacity.
- The GHG emission reductions from full-year operations for the 104 projects 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 supported 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 2010–2011 Achievements

- Installed 523 solar thermal systems in the industrial, commercial and institutional sectors.

- Coordinated the federal program with complementary programs in British Columbia, Saskatchewan and Ontario.
- Through contribution agreements with 14 partners (utilities, developers and buyers' groups, tested large-scale methods to deploy solar-heated water in the residential sector. Under these agreements, 575 solar water-heating systems were installed in the fiscal year.
- Completed, through the Association of Canadian Community Colleges, national curricula for solar thermal and PV installers and designers.
- The estimated GHG reductions from systems installed under the program during 2007–2008, 2008–2009, 2009–2010 and 2010–2011 are 3.3, 5.1, 8.2 and 9.5 kilotonnes (kt), respectively. The cumulative annual GHG reductions from the program from these installations are 25 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 have also been 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

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, 2011, the GMF had committed $555.2 million for more than 870 sustainable community plans, feasibility studies, field tests and capital projects with the potential to leverage more than $3 billion of economic activity in approximately 430 Canadian communities. Actual environmental benefits include the reduction of an estimated 175 000 tonnes of carbon dioxide annually from 40 completed capital projects.

More details can be found in the *Green Municipal Fund Annual Report 2010–2011* at sustainablecommunities.fcm.ca/About_Us/Annual_Reports/.

Council of Energy Ministers; and the Office of Energy Efficiency's (OEE's) National Advisory Council on Energy Efficiency (NACEE).

STEERING COMMITTEE ON ENERGY EFFICIENCY

Established in 2004 by the Council of Energy Ministers (which comprises federal, provincial and territorial energy ministers), the SCEE is tasked with establishing a coordinated, complementary agenda for energy efficiency in the built environment, industry and transportation sectors. In fiscal year 2010–2011, the SCEE held a number of teleconference calls, as well as two face-to-face meetings – in Ottawa and Halifax – with members representing the federal, provincial and territorial governments.

The efforts of the SCEE and its working groups facilitated the energy efficiency discussions at the September 17, 2010, meeting of the Council of Energy Ministers (held under the auspices of the Energy and Mines Ministers' Conference). This discussion focused on innovative energy efficiency practices from around the world, specifically examining lessons learned and best practices of note within the context of energy efficiency in Canada. Ministers discussed how they could help enhance existing programs and support emerging technologies for residential and commercial buildings while creating a culture of innovation that will support job growth. Ministers also called for continued collaboration on measures to improve energy efficiency, including the following:

- publishing an updated model energy code for buildings in 2011 and committing to a cycle of further improvement
- collaborating on next-generation home energy-rating systems to support labelling and codes
- strengthening the capacity of the commercial buildings sector to finance energy efficiency projects

These efforts and others are coordinated by the three working groups that operate under the SCEE. Responding to the Ministers' direction, the working groups undertake ongoing actions to develop concrete energy efficiency initiatives consistent with the themes and ideas first expressed in *Moving Forward on Energy Efficiency in Canada: A Foundation for Action*, developed by the Council of Energy Ministers in 2007. These initiatives may be delivered by multiple jurisdictions and in conjunction with key stakeholders.

- Formed in 2003, The Built Environment and Equipment Working Group (BEEWG) has members representing NRCan, industry and all provinces and territories. Its subcommittees perform collaborative tasks related to
  - the *National Energy Code for Buildings*
  - building energy benchmarking
  - the commissioning and recommissioning of buildings
  - energy-efficient equipment
  - integrated community energy solutions
  - lower-income-household energy efficiency options
  - the accelerated penetration of energy-efficient home retrofits
  - energy efficiency financing in the commercial/institutional sector

  The subcommittees undertook work on the following:
  - a national campaign with utilities on ENERGY STAR® qualified lighting fixtures
  - a retailer study on the availability of energy-efficient lighting products, with messaging to their employees and consumers
  - expanding the scope of standby power to include consideration of other consumer electronics issues

- agreement on long-term performance targets for gas water heaters, and further collaboration to validate their performance and identify consumer issues
- a prototype residential electricity audit was piloted in 400 homes in five provinces
- the completion of a major energy-use survey of Canada's commercial and institutional buildings sector that will provide reference case information for developing a buildings' energy benchmarking tool using a Canadian version of the U.S. Environmental Protection Agency's Portfolio Manager, a building benchmarking tool
- the production of tools to aid building owners in achieving new investment opportunities
- an announcement by the Canadian Standards Association of the first national standard on the commissioning of buildings for achieving and documenting the optimal performance of a complete building and its major systems
- encouraging the recommissioning of commercial/institutional buildings

- The mandate of the Transportation Working Group on Energy Efficiency (TWGEE), formed in 2005, is twofold: 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 and provincial energy and transportation departments and ministries. In 2010–2011, the TWGEE developed a heavy-duty-vehicle tire recognition framework that can be used in Canada to promote the purchase of fuel-efficient tires for heavy-duty vehicles. The framework takes into account the winter traction research that was commissioned by the TWGEE.
- The Industry Working Group on Energy Efficiency (IWGEE) was formed in 2006 to promote information exchange among industrial energy end-users and authorities, agencies, utilities and jurisdictions involved in the design, development and delivery of industrial energy efficiency programming in Canada. Since fiscal year 2009–2010, the IWGEE has worked on developing the international ISO 50001 energy management systems standard. The first Canadian energy management systems standard was published in summer 2011. Working with the Canadian Standards Association, NRCan has established four task groups to develop a roadmap to facilitate the early implementation of ISO 50001. IWGEE also initiated the development of a training workshop for energy management information systems.

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 2010–2011 fiscal year.

FEDERAL-PROVINCIAL-TERRITORIAL CO-OPERATION

There is continuing interest in energy efficiency as a powerful 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 has aided all parties in avoiding duplication and ensuring 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. Examples include the following:

- 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.
- Efficiency NB promotes energy efficiency measures across the residential, community and business sectors of New Brunswick, developing and delivering programs and initiatives to achieve this objective.

The provinces have been promoting the use of renewable energy for electricity generation. They provide numerous incentives, including voluntary renewable energy targets, legislated renewable

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.
- NRCan's EnerGuide Rating System has been used in six provinces and territories to develop or implement energy performance requirements in their building codes or municipal bylaws.
- All the provincial and territorial bodies responsible for driver education, with the exception of Nunavut, 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.

portfolio standards and the procurement of renewable energy through requests for proposals, standard offers and feed-in tariff programs.

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 2010–2011, SDTC saw increased interest in the fund, largely attributable to progress on the technology and pre-commercial demonstration projects and the global economic recovery. SDTC is following more than 100 companies, with 20 companies showing high potential for promising technologies.

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 *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 *National Energy Code for Houses*

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). Under this MOU, NRCan contributed up to $4 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 was published in 2011 in an objective-based format. It complements 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 now 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 greenhouse gas (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 has entered into a number of contribution agreements over the past years with the Yukon Energy Solutions Centre in Whitehorse on projects related to energy efficiency. The Centre provides access to technical services and programs for the Yukon population and undertakes outreach and public education activities.

NRCan is committed to promoting energy efficiency and renewable energy with the provinces and territories. Notable collaborations include working with the following:

- 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 and to establish minimum code requirements for energy and water efficiency in new and renovated Part 3 buildings in the province
- the Province of Manitoba, which is 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.
- Efficiency NB to develop a customized version of the *Advanced Buildings Core Performance Guide* produced by the New Buildings Institute, which will assist the New Brunswick design and construction community in applying a step-by-step "prescriptive" program to help achieve predictable energy savings of 30 percent better than those of the NECB
- Efficiency New Brunswick, Conserve Nova Scotia, and the Office of Energy Efficiency of Prince Edward Island, which have agreed to collaborate on a study that will establish a baseline that depicts the current state of the energy performance of new commercial buildings in the Maritimes
- Efficiency NB to facilitate access to the ecoEnergy Retrofit – Small and Medium Organizations program by the owners of small and medium-sized buildings

- the Canadian Standards Association to develop Canada's first edition of the new national standard on commissioning of buildings
- the Ontario Ministry of Municipal Affairs and Housing to investigate next reasonable steps (levels) that Ontario's construction sector could take when complying with the 2011 NECB and to analyse the impacts of potential requirements, including cost, enforcement and industry-capacity impacts
- Productivity Alberta, industry associations and utilities to provide energy management training to companies across Canada through Dollars to $ense workshops
- Climate Change Central, a non-profit corporation in Alberta funded by several stakeholders, including the Government of Alberta, which focuses on information and action on energy efficiency and conservation in the province

Atlantic Energy Gateway

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

In 2010, the AEG Federal-Provincial DM Coordinating Committee approved the AEG work plan, which includes collaborative research studies that will provide insight into the challenges and opportunities involved in maximizing the benefits of developing clean energy in the Atlantic region. Over the remaining course of fiscal year 2010–2011, federal, provincial and utility officials began implementing the work-plan elements.

INTERNATIONAL CO-OPERATION

NRCan co-operates with several international organizations in EAE program areas and supports bilateral EAE co-operation with China, India, Russia, Mexico and the European Union, for example.

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)
- sharing tools and resources with other international partners, such as 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

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 28 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 IEA 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 $979,000 to IEA implementing agreements in 2010–2011. 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.

Canada also participates in the IEA Implementing Agreement for Renewable Energy Technology Deployment (IEA-RETD). Created in 2005, IEA-RETD is a cross-cutting, policy-focused agreement about furthering the deployment of renewables. It undertakes studies to inform policy-makers and other stakeholders on topical issues about the large-scale deployment of renewable energy technologies and organizes international events on related issues. A list of completed and ongoing projects and events is available on the IEA-RETD Web site at www.iea-retd.org.

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 and IPEEC Policy Committee both continued to meet in 2010–2011. A key component of the IPEEC framework is task groups that pursue projects that interest most,

but not all, IPEEC member countries. Canada participates in the Sustainable Buildings Network Task Group, the Global Superior Energy Performance Partnership Task Group and the Super-efficient Equipment and Appliance Deployment Initiative Task Group.

Global Methane Initiative

CanmetENERGY represents Canada, in collaboration with the Environment Canada Climate Change International Branch, at the international Global Methane Initiative Partnership Steering Committee and co-chairs the initiative's 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.

Asia-Pacific Partnership

The OEE participated 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 participated 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 was the federal lead of the Power Generation and Distribution Task Force in 2010.

CanmetENERGY-Devon administered a project to develop 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 Global Methane Initiative 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.

Clean Energy Ministerial

The Clean Energy Ministerial (CEM) process was launched by the United States in July 2010 to further collaborate on and accelerate the world's transition to clean energy technologies. Several CEM initiatives cover three main areas: energy efficiency, clean energy supply and clean energy access. Initiatives are led by various countries and include participation from private sector partners and other organizations, such as the IEA. Canada is active in four CEM initiatives. The Global Superior Energy Performance Partnership (also an IPEEC Task Group) aims to accelerate energy efficiency in commercial and industrial buildings. Through this initiative, NRCan is supporting three pilot projects to advance energy management systems. NRCan is also contributing expertise to support information sharing under the Super-efficient Equipment and Appliance Deployment Initiative (also an IPEEC Task Group); the Carbon Capture, Use and Storage Action Group; and the International Smart Grid Action Network.

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. The objective of the CED is to enhance bilateral collaboration on the development of clean energy technologies to reduce GHG emissions. To date, there are three working groups under the CED, and NRCan is involved in two of them: the Electricity 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. The Electricity Grid Working Group Action Plan was developed pursuant to stakeholder consultation as part of an industry round table that occurred in summer 2009.

All remaining elements of the Electricity Grid Working Group Action Plan were implemented by the end of fiscal year 2010–2011. Three major Canada-U.S. conferences addressing themes identified in the Action Plan were held over the course of the fiscal year – one on labour recruitment and retention strategies for addressing workforce challenges in the electricity sector, one on increasing Canada-U.S. trade in clean electricity as a strategy for reducing continental GHG emissions and one on policy issues associated with the transition to a smarter electric grid. Each of these conferences brought together between 80 and 100 senior representatives from government, industry, environmental non-governmental organizations and academic spheres from both countries. Findings and recommendations from the conferences are documented in publicly available reports on a Web site dedicated to the CED.[9] In addition to these conferences, and to further support the objectives of the Action Plan, the Working Group produced two foundation papers on smart grid and energy storage. It also produced a study examining the impacts on and potential benefits to the Canada-U.S. electricity trade from easing trade-constraining elements of existing Renewable Portfolio Standards.

[9] www.changementsclimatiques.gc.ca/Dialogue/default.asp?lang=En&n=E47AAD1C-1

These activities are providing a foundation for continuing progress on the CED.

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 owners, managers and operators and energy utilities track, benchmark and manage energy consumption to reduce GHG emissions and achieve lower operating costs from commercial and institutional buildings.

United States

In addition to collaboration through the Clean Energy Dialogue, Canada also meets annually with U.S. officials through the Canada-U.S. Energy Consultative Mechanism. This mechanism provides a forum for dialogue on policy issues of interest to both countries.

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 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. Currently, the MOU is being renewed to further their work on harmonizing 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 Natural Resources Canada's Efficiency and Alternative Energy Initiatives and Expenditures, 2010–2011

	(millions of dollars)
Energy Efficiency and Alternative Transportation Fuels [1]	**$587.1**
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	

	(millions of dollars)
Energy Efficiency – Energy Science and Technology [2]	**$85.7**
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 Bioenergy	
Alternative Energy – Renewable Energy Sources	**$527.3**
ecoENERGY for Renewable Heat	
ecoENERGY for Renewable Power [3]	
Pulp and Paper Green Transformation Program	
Investments in Forest Industry Transformation	
Wind Power Production Incentive [4]	
Initiative to Purchase Electricity From Emerging Renewable Energy Sources [5]	
Total	**$1 200.1**

[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 71.

[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 ecoENERGY for Renewable Power program is fully committed, but incentives will be paid out to recipients until 2020–2021.

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

[5] 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 2008*. 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, 2008

Sector	Industrial	Transportation	Residential	Commerical/ Institutional	Agriculture	Total
Energy Use (PJ)	3 237.8	2 594.1	1 465.3	1 205.9	217.2	8 720.2
Percentage	37.1	29.7	16.8	13.8	2.5	100.0

Figure 1-2: GHG Emissions From Secondary Energy Use by Sector, 2008

Sector	Transportation	Industrial	Residential	Commerical/ Institutional	Agriculture	Total
GHG emissions (Mt)	179.4	154.0	74.2	65.3	14.8	487.8
Percentage	37.0	32.0	15.0	13.0	3.0	100.0

Figure 1-3: Energy Intensity and the Energy Efficiency Effect, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Energy intensity index	1.00	1.00	1.01	1.00	0.99	0.98	1.00	0.96	0.91	0.89	0.87	0.84	0.85	0.85	0.84	0.81	0.76	0.79	0.78
Index of energy efficiency effect	1.00	0.98	0.97	0.96	0.96	0.93	0.93	0.92	0.89	0.88	0.87	0.85	0.85	0.86	0.84	0.81	0.80	0.82	0.83

Figure 1-4: Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated secondary energy use without energy efficiency improvements	1.00	1.00	1.03	1.05	1.09	1.15	1.17	1.19	1.20	1.25	1.29	1.28	1.33	1.36	1.39	1.41	1.39	1.45	1.43
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	1.27	1.26

Figure 1-5: Canadian Households by Type of Dwelling, 2008

Dwelling type	Number of households (thousands)	Percentage
Single detached homes	7 437	56
Single attached homes	1 399	11
Apartments	4 076	31
Mobile homes	252	2
Total	**13 164**	**100**

Figure 1-6: Residential Energy Use by End Use, 2008

Activity	Energy use (PJ)	Percentage
Space heating	920.8	63
Water heating	255.9	17
Appliances	203.0	14
Lighting	62.7	4
Space cooling	22.8	2
Total	**1 465.3**	**100**

Figure 1-7: Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
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	1.33
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	1.02	1.02	1.02	1.02	1.04	1.06	1.08	1.09	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	0.86

Figure 1-8: Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.22	1.20	1.13	1.17	1.24	1.21	1.28	1.31	1.33	1.36	1.33	1.42	1.45
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	1.12	1.14

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)	116	21 616	174
Model National Energy Code house*** (2002)	112	1	143.34
Average** of EnerGuide labelled houses (2009)	55	5 048	110
Average** of R-2000 certified houses	48	3 982	102.23

*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 2008 Models

Appliance	1990 model (KWh/yr)	2008 model (KWh/yr)
Clothes washers	97	21
Clothes dryers	1 103	916
Dishwashers	227	53
Refrigerators	956	467
Electric ranges	772	522
Freezers	714	375

Figure 1-11: Commercial/Institutional Energy Use by Activity Type,* 2008

Activity type	Energy use (PJ)	Percentage
Offices**	422.4	35
Retail trade	203.6	17
Educational services	152.5	13
Health care and social assistance	131.1	11
Accommodation and food services	88.2	7
Wholesale trade	73.3	6
Transportation and warehousing	47.2	4
Arts, entertainment and recreation	30.8	3
Information and cultural industries	25.9	2
Other services	21.9	2
Total	**1 196.9**	**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, 2008

Purpose	Energy use (PJ)	Percentage
Space heating	576.9	48
Auxiliary equipment	232.0	19
Lighting	133.1	11
Auxiliary motors	108.5	9
Water heating	90.6	7
Space cooling	55.7	5
Street lighting	9.1	1
Total	**1 205.9**	**100**

Figure 1-13: Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	1.05	1.08	1.13	1.14	1.16	1.20	1.19	1.17	1.22	1.26	1.26	1.34	1.36	1.37	1.42	1.40	1.47	1.51
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	1.34	1.39

Figure 1-14: Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2008

Subsector	Energy use (PJ)	Industrial energy use (%)
Mining	826.7	25.5
Other manufacturing**	640.7	19.8
Pulp and paper	612.4	18.9
Petroleum refining	337.1	10.4
Smelting and refining	268.7	8.3
Iron and steel	212.3	6.6
Chemicals	200.6	6.2
Construction	60.8	1.9
Cement	60.6	1.9
Forestry	18.1	0.6
Total	**3 237.8**	**100.0**

* The 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, 2008

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

Figure 1-16: Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	1.00	1.02	1.03	1.10	1.14	1.15	1.17	1.20	1.26	1.30	1.29	1.35	1.36	1.38	1.38	1.34	1.39	1.32
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	1.26	1.19

Figure 1-17: Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	1.01	1.02	1.01	1.09	1.12	1.13	1.15	1.16	1.23	1.27	1.25	1.30	1.31	1.31	1.31	1.25	1.30	1.23
Actual energy use	1.00	0.99	0.98	0.96	1.02	1.04	1.05	1.05	1.04	1.05	1.09	1.04	1.09	1.09	1.12	1.07	1.02	1.08	1.01

Figure 1-18: Transportation Energy Use by Mode, 2008

	Energy use (PJ)	Percentage
Cars	648.5	
Passenger light trucks	440.1	
Motorcycles	4.1	
School buses	13.6	
Urban transit	31.6	
Inter-city buses	6.6	
Passenger air	249.6	
Passenger rail	2.8	
Passenger total	**1 396.9**	**53.8**
Freight light trucks	177.5	
Medium trucks	152.5	
Heavy trucks	571.3	
Freight air	5.1	
Freight rail	87.7	
Marine	100.4	
Freight total	**1 094.5**	**42.2**
Off-road total	**102.7**	**4.0**
Total transportation energy use	**2 594.1**	**100.0**

Figure 1-19: Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2008 (percentage)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Passenger car	74.2	74.8	72.3	69.3	66.9	64.8	62.5	59.5	58.9	60.8	62.9	63.4	62.7	62.2	61.7	61.7	61.2	59.6	61.4
Passenger light truck	25.8	25.2	27.7	30.7	33.1	35.2	37.5	40.5	41.1	39.2	37.1	36.6	37.3	37.8	38.3	38.3	38.8	40.4	38.6

Figure 1-20: Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	0.97	1.00	1.04	1.11	1.14	1.17	1.22	1.27	1.32	1.34	1.35	1.38	1.41	1.51	1.54	1.55	1.59	1.58
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	1.38

Figure 1-21: Average Activity per Truck, 1990 to 2008 (tonne kilometres/truck)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total medium-and heavy-duty truck vehicle activity	105 640	98 006	102 764	116 979	132 851	142 078	140 535	163 521	162 555	174 741	177 784	198 286	196 825	201 968	240 875	243 414	236 008	232 399	226 670

Figure 1-22: Trucking Energy Intensity, 1990 to 2008 (megajoules/tonne kilometre)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total medium- and heavy-duty trucks energy intensity	3.74	3.77	3.77	3.61	3.40	3.47	3.40	3.32	3.16	3.01	3.03	2.83	2.80	2.92	2.60	2.64	2.73	2.84	2.96

Figure 2-1: Volume of Monthly Import Documents

Month	Paper	Electronic	Total
Apr. 10		135 957	135 957
May 10	6	138 486	138 492
June 10		146 391	146 391
July 10	3	148 370	148 373
Aug. 10	2	147 947	147 949
Sept. 10	1	151 731	151 732
Oct. 10	146	155 399	155 545
Nov. 10	146	145 062	145 208
Dec. 10	159	147 818	147 977
Jan. 11		137 174	137 174
Feb. 11		136 816	136 816
Mar. 11		164 150	164 150
Total	**463**	**1 755 301**	**1 755 764**

Figure 2-4: Distribution of ENERGY STAR Qualified Shipments of Appliances, 1999 to 2009

Appliance	1999 (%)	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)
Dishwashers	0.6	1.6	9.7	29.8	56.5	81.0	90.8	79.7	76.2	89.3	89.5
Clothes washers	1.9	2.2	9.2	22.1	30.6	36.2	45.9	50.8	58.4	64.4	69.4
Refrigerators	..	..	11.4	22.3	40.7	34.2	37.6	37.3	44.3	53.4	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 and ENERGY STAR Prescriptive-Labelled Houses, 1990 to 2010

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of R-2000 certified houses	495	699	1 196	1 299	784	610	416	484	265	213	319	329	428	379	583	500	439	483	557	508	411
Number of ENERGY STAR labelled houses (prescriptive path only)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	878	1 662	3 888	4 037	8 794

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 2010*

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
2010	10.0	8.5	8.6	6.8

*2009 and 2010 data are estimates.

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

Number of users	1998	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	60 553
World Total	3 109	8 748	14 365	21 942	30 253	41 877	56 448	80 437	107 205	147 155	193 033	242 775	276 693

Figure 5-1: Canadian Wind Power Capacity, 1993 to 2010

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Wind power capacity (MW, cumulative)	1	22	23	23	24	27	127	139	215	233	326	445	686	1 459	1 846	2 369	3 319	4 124

Figure 5-2: Achievements Resulting From PPGTP Investments

	PPGTP Achievements (millions of GJ)
Renewable electricity	5.587246
Renewable thermal	3.242063
Energy efficiency	6.92412

Natural Resources Canada's Office of Energy Efficiency

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

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