Natural Resources Canada
Ressources naturelles Canada

# Improving Energy Performance in Canada

## Report to Parliament Under the *Energy Efficiency Act* For the Fiscal Year 2011–2012

Canada

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# Minister's Foreword

I am pleased to introduce the 2011-2012 Report to Parliament on Improving Energy Performance in Canada.

Canada is quickly emerging as a global energy leader. As energy production booms, bringing opportunity, jobs and growth across the country, we must also think about energy use as this equally impacts Canadians and the economy. Energy efficiency presents enormous opportunities for Canada, saving Canadians money, stimulating economic growth and job creation, increasing productivity, competitiveness and exports. It also reduces greenhouse gas emissions, helping Canada to cost-effectively meet its emission reduction target of 17 percent below 2005 levels by 2020.

With this in mind, in September 2011, our Government renewed the ecoENERGY Efficiency program with an investment of $195 million over five years to help improve energy efficiency. Through this initiative, we are developing tools and practices to help Canadians become more energy efficient.

From 2007 to 2012, the ecoENERGY Retrofit–Homes program provided incentives to more than 640 000 homeowners. As a result of this program, these homeowners are now saving over $400 million on their annual energy bills and are lowering their energy consumption by an average of 20 percent. It is estimated that this program triggered more than $8 billion in economic activity and created or protected thousands of jobs during a period of global economic uncertainty. Natural Resources Canada continues to support home investments by providing information and advice through its ecoENERGY Efficiency for Housing initiative.

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In 2011-2012, Natural Resources Canada's Pulp and Paper Green Transformation Program supported 21 projects. As a result, the program has added nearly 200 megawatts of capacity to generate renewable electricity and is enabling mills to save 8.5 million gigajoules of energy annually. This is the equivalent to producing enough renewable thermal energy to continuously heat 70 000 homes.

Internationally, we are continuing to work with the United States, through the Clean Energy Dialogue, to enhance joint collaboration to accelerate the transition to a low-carbon economy, reduce greenhouse gases and combat climate change.

Moving forward, we will continue to implement measures to advance Canada's competitiveness, productivity and capacity for innovation by pursuing new and exciting developments in energy efficiency and technology to create jobs and build Canada's future economy.

The Honourable Joe Oliver, P.C., M.P.
Canada's Natural Resources Minister

# Executive Summary

Gains in energy efficiency and the development of alternative transportation fuels and renewable energy have substantial benefits for society, the economy and the environment. Through its various programs, regulations and initiatives, Natural Resources Canada (NRCan) has been helping industry, individuals and governments across Canada to increase their energy efficiency and develop and deploy renewable and alternative energy sources as ways to reduce greenhouse gas emissions and improve the Canadian economy. Through gains in energy efficiency, Canadians have saved almost $27 billion in 2009 compared to energy use patterns in 1990.

## Types of Energy Use

The two general types of energy use are primary and secondary. Primary use represents Canada's total energy 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 facts in energy use include the following:

- Secondary energy use amounted to about 72 percent of primary energy use in 2009 (8541.6 petajoules [PJ]) and was responsible for 67 percent (463.9 megatonnes [Mt]) of total greenhouse gas emissions in Canada. This last figure includes emissions produced by utilities in meeting the demand for electricity.
- Canadians spent approximately $152 billion on secondary energy use in 2009.
- Due in part to the department's efforts, energy efficiency in Canada improved by 23.5 percent between 1990 and 2009. These efficiencies reduced energy use by approximately 1560 PJ and decreased greenhouse gas emissions by 81.1 Mt in 2009.

The industrial sector consumed the most energy, accounting for 37 percent of total secondary energy use in 2009. Transportation was second (30 percent), followed by residential (17 percent), commercial/institutional (14 percent) and agriculture (2 percent).

## Promoting Energy Efficiency, Alternative Transportation Fuels and Renewable Energy

NRCan uses a broad range of policy instruments, including leadership; information; voluntary initiatives; financial incentives; research, development and demonstration; and regulation, to promote energy efficiency and the use of alternative fuels and renewable energy.

The *Energy Efficiency Act*, which came into force in 1992, gives the Government of Canada the authority to make and enforce regulations concerning minimum energy performance levels, labelling requirements and the collection of data on energy use for energy-using products and products that affect energy use. Thus far, prescribed standards and labelling requirements have been established for more than 40 products in Canada.

Launched in 2011–2012, the ecoENERGY Efficiency program is investing $195 million over five years to make the housing, building and equipment stock more energy-efficient, energy performance more

visible, and industry and vehicle operations more efficient. The program components are

- ecoENERGY Efficiency for Buildings
- ecoENERGY Efficiency for Housing
- ecoENERGY Efficiency for Equipment Standards and Labelling
- ecoENERGY Efficiency for Industry
- ecoENERGY Efficiency for Vehicles

Also in 2011–2012, the ecoENERGY for Alternative Fuels program received funding of $3 million over five years to encourage the use of alternative fuels through education and outreach, as well as through the development of codes and standards for natural gas.

In addition, NRCan invests in the research, development, and demonstration of new and emerging clean energy science and technology that produces economic, social and environmental benefits for Canadians.

The department oversees programs and initiatives that allocated more than $248 million in the 2011–2012 fiscal year to fund research on finding new, long-term, cleaner and more efficient solutions to reduce environmental emissions. With three laboratories across Canada, the department works with various sectors to develop and demonstrate energy-efficient alternative transportation fuel, renewable energy technologies and cleaner fossil fuels.

Canada is a global leader in the production of renewable energy. In 2010, renewable energy sources made up 17.1 percent of the primary energy supply and 62 percent of electricity generation and total electricity-generating capacity.

## National and International Co-operation

NRCan partners with a variety of stakeholders, including provincial and territorial governments, municipal governments, industries, non-governmental organizations, as well as other countries and international organizations, to promote energy efficiency.

Provincial and territorial governments, utilities and non-government organizations use the federal energy efficiency, alternative transportation fuels and renewable energy program tools in their jurisdictions to complement their own energy efficiency programs. For example, 14 regional programs use the department's EnerGuide Rating System to measure home energy use. Seven Canadian jurisdictions also use it in their building code development, implementation or maintenance, and it has been used to develop the energy efficiency requirements for housing in the new National Building Code of Canada.

Municipal governments and agencies participate in the department's energy efficiency, alternative transportation fuels and renewable energy measures as clients and as partners and the department participates in ventures led by municipal organizations, such as the Green Municipal Fund.

Internationally, the department co-operates bilaterally with key partners such as the United States and with international organizations such as the International Energy Agency, the Asia-Pacific Economic Co-operation and the International Partnership for Energy Efficiency Co-operation, which Canada will chair from 2012 to 2014.

## Selected Results

This report provides an overview of the work being done in each sector, highlights NRCan's initiatives and lists their key achievements for the 2011–2012 fiscal year, including the following:

- From 2007 to 2012, the ecoenergy Retrofit–Homes program provided incentives to more than 640 000 homeowners. As a result of this program, these homeowners are now saving over $400 million on their annual energy bills and are lowering their energy consumption by an average of 20 percent. It is estimated that this program triggered more than $8 billion in economic activity and created and protected thousands of jobs over that period.
- The ENERGY STAR® labelling initiative in Canada broadened its scope to include four new product

categories in 2011 and aligned with the United States to pilot an ENERGY STAR "Most Efficient" designation for the highest efficiency products in those categories.

- Projects funded under the Pulp and Paper Green Transformation Program added nearly 200 megawatts of renewable electrical capacity.
- CanmetENERGY's Drake Landing Solar Community project won Energy Globe Foundation's Energy Globe World Award for 2011. This project is the first large-scale, seasonal solar storage system in North America and the Globe World Award is a Canadian first.

A full list of the department's energy efficiency, alternative transportation fuels and renewable energy initiatives and expenditures appears in Appendix 1.

# Introduction

## NATURAL RESOURCES CANADA'S ENERGY EFFICIENCY, ALTERNATIVE TRANSPORTATION FUELS AND RENEWABLE ENERGY PROGRAMS

### Energy Efficiency

Investing in energy efficiency can have substantial benefits for society, the economy and the environment. Energy efficiency saves Canadians and Canadian businesses money by decreasing their energy bills, stimulates the economy by creating local jobs and supports the environment by reducing greenhouse gas emissions, all of which lead to a greater quality of life for all Canadians. In addition, investing in energy efficiency can add to the global security of energy supplies by reducing the need for energy while strengthening Canada's energy security.

Due in part to the efforts of Natural Resources Canada (NRCan), energy efficiency in Canada improved by 23.5 percent between 1990 and 2009. In 2009 alone, the savings from energy efficiency improvements equalled the energy used to power more than 15.1 million homes for an entire year (not including transportation). It was the equivalent of eliminating the emissions produced by 26 million cars and passenger light trucks for a year. Overall, these energy efficiency gains saved Canadians almost $27 billion.[1]

With this in mind, the department partners with a variety of stakeholders such as provincial governments, non-profit organizations and the private sector to promote energy efficiency. The department's energy efficiency initiatives engage Canadian society and all major sectors of the economy in new and innovative approaches to reducing the consumption of energy in the residential, commercial/institutional, industrial and transportation sectors, to improve Canada's environment, its economy and its security.

### Alternative Transportation Fuels

Energy use and greenhouse gas emissions from the transportation sector pose a challenge to the environment. The Government of Canada is committed to diversifying energy use in the transportation sector. It supports producing and using renewable transportation fuels such as ethanol and biodiesel, increasing alternative fuel stakeholder knowledge and developing codes and standards for natural gas. These initiatives can expand our energy mix and contribute to reducing greenhouse gas emissions while at the same time providing new opportunities for the agriculture sector.

### Renewable Energy

Renewable energy is energy obtained from natural resources that can be replenished or renewed within a human lifespan, that is, the resource is a sustainable source of energy. Canada uses several of these types of resources such as moving water, wind, sunlight and plant biomass, which are not at risk of depletion when used for energy production.

Canada is a global leader in the production of renewable energy, particularly in hydroelectricity. As of December 31, 2010, 529 hydroelectric stations were operational across the country, totalling 75 104 megawatts (MW) of installed capacity, which contributed 59 percent of the nation's electricity production. Canada is the third largest hydroelectricity producer in the world, after China

[1] Natural Resources Canada, *Energy Efficiency Trends In Canada 1990–2009*, oee.nrcan.gc.ca/publications/statistics/trends11/pdf/trends.pdf.

and Brazil and the world's second largest net exporter of electricity after Paraguay.[2]

Other renewable energy sources are growing quickly. Wind power and solar photovoltaic are the fastest growing sources of electricity in Canada. As of December 31, 2011, there were 3094 wind turbines operational in 151 wind farms in all provinces and one territory, totalling 5265 MW of installed capacity that generated about 10 terawatt-hours or 1.8 percent of Canada's total electricity generation. In 2011, Canada ranked ninth in the world in terms of total installed wind power capacity and sixth in terms of new installations of wind turbines.

By the end of 2011, the solar photovoltaic industry added 204 MW of installed generating capacity for a total of 495 MW.

Until 2007, when it was surpassed by wind power, biomass was Canada's second renewable energy source for electricity generation, after hydropower, with approximately 1700 MW of installed capacity.

Also, Canada has one of the first large-scale tidal power facilities in the world, the 20-MW Annapolis Tidal Station in Nova Scotia.

### Natural Resources Canada's Energy Efficiency, Alternative Transportation Fuels and Renewable Energy Initiatives

A complete list of NRCan's energy efficiency, alternative transportation fuels and renewable energy initiatives in 2011–2012 is provided in Appendix 1. These initiatives are managed by the following:

- the Office of Energy Efficiency (OEE), which delivers programming to improve energy efficiency and the use of alternative transportation fuels in all sectors of the Canadian economy
- CanmetENERGY, which delivers energy efficiency, alternative transportation fuels and renewable energy research, development and demonstration initiatives
- the Office of Energy Research and Development, which coordinates the department's energy research and development planning and fund allocations
- the Electricity Resources Branch, which develops federal policy in the area of renewable and electrical energy and delivers programs that support the deployment of renewable energy technologies
- 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 leading to non-traditional, high-value forest products and renewable energies
- the Science Branch of the Canadian Forest Service, which undertakes research and development on the sustainable use of forest biomass for energy
- CanmetMATERIALS, which develops innovative materials and processing technologies for applications in energy production and transportation and improved energy efficiency in the materials and transportation sectors
- CanmetMINING, which delivers research, development and demonstration initiatives to improve energy efficiency in the mining sector through the use of innovative mining and mineral processing equipment and systems

## POLICY INSTRUMENTS

NRCan uses a variety of policy instruments in regard to energy supply and demand:

- 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

[2] *Key World Energy Statistics*, pg 19 and 27, International Energy Agency, www.iea.org/publications/freepublications/publication/key_world_energy_stats-1.pdf.

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

### Financial Incentives

NRCan uses financial incentives to encourage end-users of energy to adopt energy efficiency and renewable energy technologies and practices. In 2011–2012, the department offered financial incentives for ethanol and biodiesel production, energy efficiency improvements for homes, efficiency and renewable energy production at pulp and paper mills, and the implementation of highly innovative technologies in the forest products sector.

### 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 by using methods ranging from broad distribution to individual consultations with clients. This practice 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, conferences, Web sites, workshops, training, building-design software and promotional products.

### Voluntary Initiatives

Companies and institutions work with NRCan voluntarily to set and achieve energy efficiency objectives. The department's voluntary energy efficiency, alternative transportation fuels and renewable energy initiatives target the commercial/institutional and industrial sectors and organizations whose products are major factors in energy use. The department works in collaboration with other government organizations, jurisdictions and the United States to develop model energy codes in the commercial/institutional building sector, as well as tools to assist building owners' and managers' decision making. The initiatives further involve industry-government agreements and, for groups of large industrial energy users, commitments to develop energy efficiency improvement targets and action plans. The department 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 advancements and innovations in technology. NRCan's energy efficiency, alternative transportation fuels and renewable energy initiatives support the development and dissemination of more energy-efficient equipment, processes and technologies and alternative energy technologies. Research, development and demonstration also provides the scientific knowledge needed to develop the technologies, codes, standards and regulations required for the sustainable use of energy.

The department provides national leadership in energy science and technology by conducting research in its own laboratories and contracting research activities to other organizations. These initiatives are the only federal interdepartmental science and technology investment funds that focus on the energy sector and its economic and environmental effects.

**FIGURE INT-1** Moving the Market

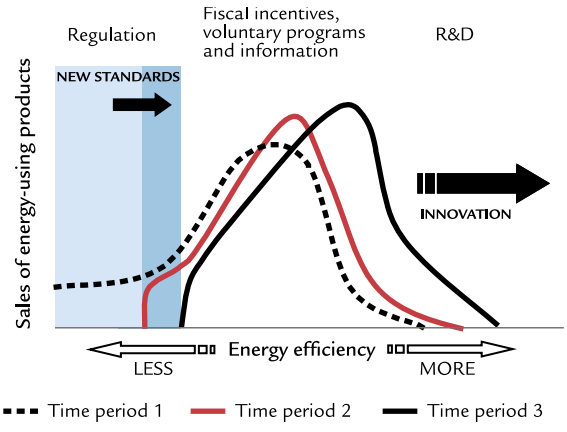


Figure INT-1 shows how these policy instruments work together to increase energy efficiency, that is, how they help to reduce the amount of energy required to complete a task or obtain a certain level of service. Energy performance regulations eliminate less efficient products from the market. Fiscal incentives, voluntary programs and information activities increase the number of people and organizations that take advantage of existing opportunities to use energy more efficiently. Research, development and demonstration increase the opportunities for achieving higher levels of efficiency in a particular type of energy use.

## MEASURING PROGRESS

The primary goal of NRCan's energy efficiency, alternative transportation fuels and renewable energy 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. The department monitors and tracks the following 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 the department's programs on changes in energy efficiency, energy intensity, greenhouse gas emissions and the use of alternative energy. In this sense, achievement of a targeted market outcome, or observable progress toward a market outcome, may be indicators of program effectiveness. Measuring progress toward an immediate market outcome can be difficult for research, development and demonstration 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 greenhouse gas emissions.

## DATA COLLECTION AND ANALYSIS

In 1991, NRCan launched the National Energy Use Database 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 database initiative plays several crucial roles directly related to the department's 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 database 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. These surveys gather information about energy-using equipment and buildings, measuring Canadians' energy use and monitoring the adoption of new technologies in the marketplace.

In July 2011, the department received preliminary data from the Survey of Commercial and Institutional Energy Use for reference year 2009. This represents the culmination of three years of work between NRCan's OEE and Statistics Canada. This survey combines the goals of two previously existing surveys: the Commercial and Institutional Consumption of Energy Survey and the Commercial and Institutional Building Energy Use Survey.

The survey collected both establishment-based and buildings-based data. The establishment-level data are used to inform energy specialists and consumers about recent energy consumption patterns in this sector of the Canadian economy. These data are also used in the OEE's energy efficiency model and energy trends analysis. The buildings-based data are used to build energy-intensity benchmarks for selected building types that will be included in the United States Environmental Protection Agency's ENERGY STAR Portfolio Manager benchmarking tool. The data will be used by the OEE in their work with the Environmental Protection Agency to adapt the benchmarking tool to meet Canadian needs. The Canadian adaptation of Portfolio Manager is a project that supports the Clean Energy Dialogue.

The database initiative also produces a comprehensive energy use database with accompanying publications to explain Canada's overall energy use and energy efficiency trends. All database initiative reports are available to the public, free of charge, both in hard copy and online at oee.nrcan.gc.ca/statistics.

## INTERNATIONAL CO-OPERATION

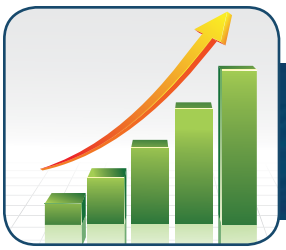
Continuing Canada's longstanding commitment to international co-operation and diplomacy, Canada participates in various international bodies regarding the supply and demand of energy. Such partnerships include the Asia-Pacific Economic Cooperation, the International Partnership for Energy Efficiency Cooperation, the Clean Energy Ministerial and the International Energy Agency. Through these and bilateral partnerships such as the U.S.-Canada Clean Energy Dialogue, Canada is a major player on the global energy stage.

## IN THIS REPORT

This nineteenth annual *Report to Parliament* focuses principally on energy efficiency, alternative transportation fuels and renewable energy initiatives that address secondary energy use. Trends in energy use and greenhouse gas 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 2011–2012 achievements and overall program targets. Chapter 4 explains clean energy science and technology 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 energy efficiency, alternative transportation fuels and renewable energy.

Appendix 1 contains information about NRCan's energy efficiency, alternative transportation fuels and renewable energy expenditures. Appendix 2 contains detailed information about the figure data presented in this report. Calculations of the estimated greenhouse gas savings in this report (excluding direct reductions from the Pulp and Paper Green Transformation program) 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

Canada is a large country spanning more than 9.9 million square kilometres with a rugged geography and a harsh climate that requires significant amounts of energy to sustain day-to-day life and operate businesses. Fortunately, Canada is endowed with an abundance of energy from a variety of sources, which allows Canadians to respond to these challenges and profit from this comparative advantage in energy.

In spite of this relative energy abundance, Canadians understand the value of energy and can be proud of their progress in energy efficiency. Through gains in energy efficiency, Canadians have saved almost $27 billion in 2009 compared to energy use patterns in 1990. In 2009, approximately $152 billion was spent on energy to heat and cool homes and offices and to operate appliances, vehicles and industrial processes.

## ENERGY USE AND GREENHOUSE GAS EMISSIONS

Energy has a variety of uses, which can be categorized into two general types: primary and secondary. Primary energy use includes 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 needed to transport energy supplies to the consumer. Secondary energy use is that used in final consumption for residential, commercial/institutional, industrial, transportation and agriculture needs. It is what turns on the light switches, runs the computers and operates the factories.

In 2009,[3] the amount of primary energy used in Canada was estimated at 11 897 petajoules[4] (PJ). Energy use has been increasing steadily over the decades as the population grows, homes get larger (and these larger homes are filled with more electronics) and more cars are purchased per household. However, in spite of this increase, the relative amount of energy required for each unit of output produced has decreased substantially.

### DID YOU KNOW?

About one petajoule of energy is required to operate the Montréal Metro during one year.[5]

Secondary energy use made up approximately 72 percent of primary energy use in 2009, or 8541.6 PJ. It was also responsible for 67 percent (463.9 megatonnes [Mt]) of total greenhouse gas emissions in Canada, including indirect emissions – those produced by electric utilities to meet end-use electrical demand.

While secondary energy use increased by 23 percent from 1990 to 2009, Canada's population grew 22 percent and the gross domestic product increased by 57 percent. Thus energy use grew less rapidly than the economy as a whole, indicating a marked improvement in the energy intensity of our economy per unit of output. On the other hand, total energy use grew slightly faster than the population.

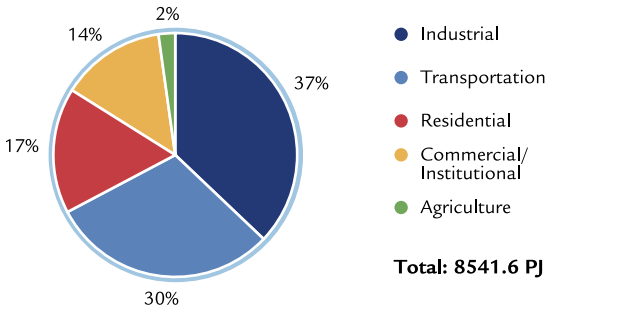
[3] Data in this chapter are presented for 1990–2009. Visit the Office of Energy Efficiency Web site to see data updates as they become available (oee.nrcan.gc.ca).

[4] One petajoule equals $1 \times 10^{15}$ joules.

[5] 2001 data.

The share of secondary energy used by each major economic sector does not vary much from year to year. For 2009, as demonstrated in Figure 1-1, the industrial sector was the largest energy user, accounting for 37 percent of total secondary energy use. 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.

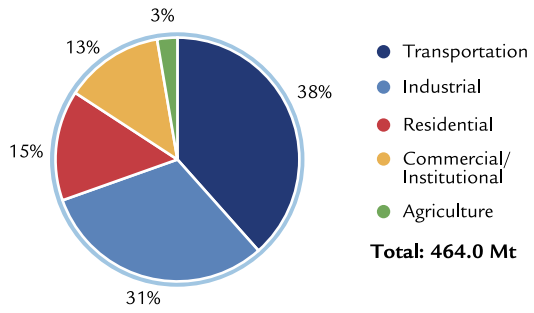
**FIGURE 1-1** Secondary Energy Use by Sector, 2009




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

Figure 1-2 illustrates the distribution of greenhouse gas emissions by sector. This report deals with energy-related greenhouse gas emissions, which comprise carbon dioxide, methane and nitrous oxide. Carbon dioxide accounts for most of Canada's greenhouse gas emissions. All subsequent references in this report to carbon dioxide and greenhouse gas include emissions that are attributable directly to secondary energy use and emissions that are attributable indirectly to electricity generation, unless otherwise specified.

**FIGURE 1-2** Greenhouse Gas Emissions From Secondary Energy Use by Sector, 2009




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

## ENERGY INTENSITY AND ENERGY EFFICIENCY

The term "energy intensity" refers to the amount of energy use per unit of activity (gross domestic product). 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.

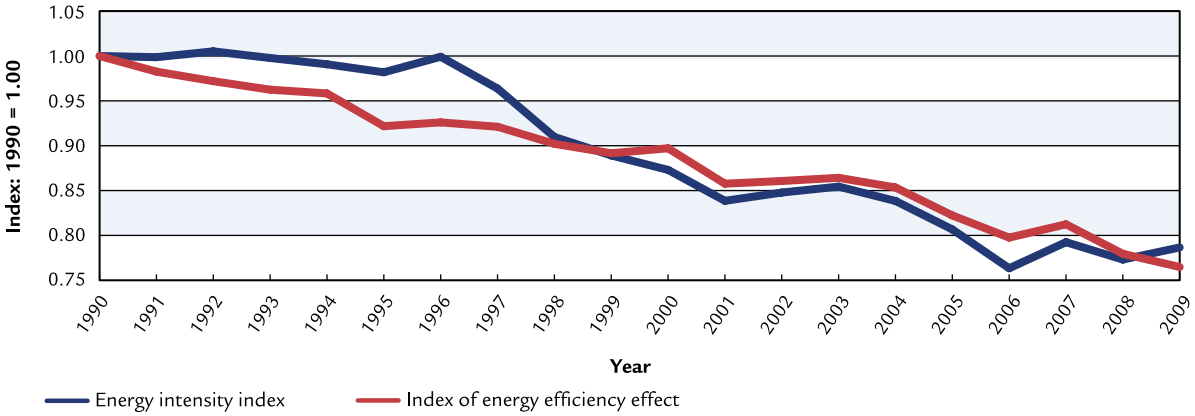
For example, of all the industrial processes, the production of aluminum (and alumina) is by far the most energy-intensive. To produce 1 tonne of aluminum requires almost 57 670 megajoules of energy (or 57 670 megawatt-hours of electricity). Other energy-intensive industries include petroleum refining, pulp and paper, iron and steel, cement, chemicals, smelting and refining and mining.

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 removed from 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 an index of annual variation in energy intensity with the OEE's index of energy efficiency, which tracks changes from 1990 to 2009. 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 gross domestic product. At the same time, the improvement in energy efficiency indicates how effectively energy is

**FIGURE 1-3** Energy Intensity and the Energy Efficiency Effect, 1990 to 2009




Source: Natural Resources Canada, Residential, Commercial/Institutional, Transportation, Industrial End-Use Models, Ottawa, 2011.

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 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 greenhouse gas 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 greenhouse gas 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 gross domestic product, 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.
- **Capacity utilization rate** refers to the proportion of the installed production capacity that is in use. In 2009, sectors such as mining, transportation, equipment, and iron and steel showed significant declines.
- **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 2009

| | Sectors | | | | | |
|---|---|---|---|---|---|---|
| | **Residential** | **Commercial/ institutional** | **Industrial** | **Transportation** | **Total*** | **Change** (%) |
| 1990 energy use (PJ) | 1282.1 | 867.0 | 2710.0 | 1877.9 | 6936.1 | |
| 2009 energy use (PJ) | 1422.3 | 1186.0 | 3168.4 | 2576.6 | 8541.6 | |
| Change in energy use (PJ) | 140.2 | 319.0 | 458.4 | 698.7 | 1605.5 | 23.1 |
| Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0 | | | | | | |
| Explanatory factor (change due to) | | | | | | |
| Activity | 492.3 | 341.2 | 1181.5 | 720.7 | 2735.7 | 39.4 |
| Weather | 33.0 | 8.8 | n/a | n/a | 41.8 | 0.6 |
| Structure | 10.0 | -0.9 | -706.8 | 288.1 | -409.6 | -5.9 |
| Service level | 75.5 | 117.9 | n/a | n/a | 193.4 | 2.8 |
| Capacity utilization | | | 576.5 | | 576.5 | 8.3 |
| Energy efficiency | -470.6 | -146.9 | -592.8 | -350.1 | -1560.4 | -22.5 |
| Other factors | | | | | 28.0 | 0.4 |

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0
*Total also includes energy use for agriculture.

Capacity utilization in the industrial sector can have an impact on the efficient use of energy. In 2008 and 2009, this became noticeable as the downturn in the economy forced many processes to operate far below potential, using energy for limited production or to keep idle processes ready in case demand picked up. To allow for a meaningful measurement of the long-term trend in energy efficiency, the influence of capacity utilization was removed. The adjustment was made back to 1990 and had the effect of smoothing out the trend in energy efficiency progress.

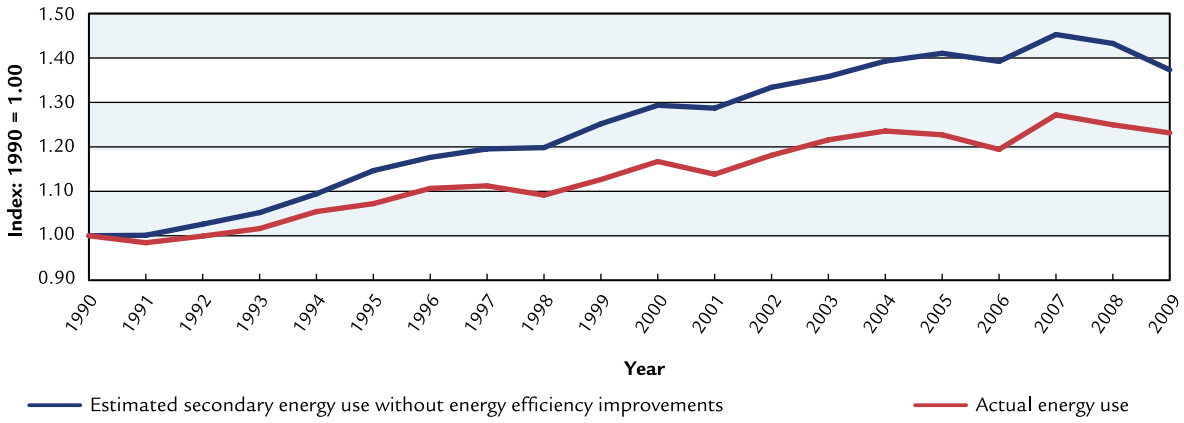
Consequently, in this chapter, energy efficiency is measured as the net result of total energy use minus the energy attributed to activity, weather, structure, service level and capacity utilization. However, other factors, such as individual consumer choice, may affect energy use and are not captured by the above standardized factors. The effects of activity, weather, structure, service level and capacity utilization may overstate or understate the "actual" change in energy use and energy efficiency improvements.

One of the greatest sources of untapped energy is the energy we waste. Energy efficiency in the Canadian economy is isolated and tracked in an effort to publicize this energy resource. This chapter examines all areas of the economy to determine what would have happened had there been no improvements and to identify, from the underlying data, areas that can continue to improve energy efficiency.

Energy efficiency has improved by 23.5 percent[6] since 1990. Without significant improvements in energy efficiency in end-use sectors, energy use would have actually increased 46 percent. These improvements reduced energy use by 1560 PJ, or the equivalent energy use of 26 million cars and passenger light trucks in 2009. This is estimated to have reduced greenhouse gas emissions by 81.1 Mt and saved Canadians $26.8 billion in 2009. The change in energy use between 1990 and 2009, actual and without energy efficiency improvements is shown in Figure 1-4.

[6] Based on the OEE index.

**FIGURE 1-4** Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009




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

## TRENDS IN RENEWABLE ENERGY

### DID YOU KNOW?

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

Canada is a leader in the production of renewable energy, with over 17.1 percent of its primary energy supply coming from renewable energy sources in 2010. 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 primarily due to the widespread use of hydroelectricity. In 2010, over 59 percent of Canada's electricity generation was provided by large and small hydroelectric plants, which generated 348 terawatt-hours (TWh) of electricity, down 4.6 percent from 365 TWh in 2009. Small hydro plants (i.e. less than 50 megawatts [MW]), representing an installed generating capacity of 3461 MW, provided about 2.7 percent of the total electricity generation in Canada.

In 2010, non-hydro renewable sources accounted for over 3 percent of Canada's electricity generation. In terms of annual additions to the installed capacity, wind energy is one of the fastest-growing sources of electricity in Canada. Its installed capacity increased from 139 MW in 2000 to 3967 MW in 2010 and to 5265 MW in 2011.

With almost 1700 MW of installed capacity in 2010, biomass (waste and virgin biomass and landfill gas) remains one of the main non-hydro renewable energy sources in Canada.

Solar photovoltaic energy also experienced high rates of capacity growth – about 45 percent average rate of growth annually between 1999 and 2011. So far, 2011 has been the best year for solar photovoltaic, with 204 MW of new installations for a total solar photovoltaic installed capacity in Canada of 495 MW.

The Canadian active, solar thermal, installed capacity in 2011 was 1 184 830 square metres ($m^2$), which is approximately 820 megawatts thermal ($MW_{th}$). The domestic market increase has averaged over 20 percent annually since 1998. In 2011, the solar thermal collector market in Canada was

approximately 163 435 $m^2$, approximately 18 percent fewer installations than in 2010 (199 490 $m^2$).

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 2010, approximately 11 265 ground-source heat pump units were installed in Canada. This is roughly 28 percent less than the 15 640 units installed in 2009. As of December 31, 2010, there were more than 95 000 units in operation in Canada, representing approximately 1045 $MW_{th}$ of installed capacity and producing an estimated 1420 gigawatt-hours equivalent annually.

As described in Chapter 5, in 2011–2012, NRCan carried out three renewable energy initiatives:

- Pulp and Paper Green Transformation Program – to increase energy efficiency and the production of renewable energy in Canadian pulp an paper mills
- Marine Renewable Energy Enabling Measures Program – to support the administering of marine renewable energy activity in the federal offshore
- Investments in Forest Industry Transformation program – which supports projects that promote innovative technologies in the forest sector (alternative energy systems could qualify for funding from this program)

## TRENDS IN RESIDENTIAL SECTOR

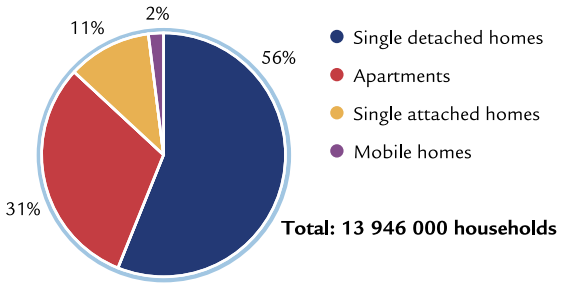
### Energy Use and Greenhouse Gas Emissions

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 lighting.

Canadians spent $26.8 billion on household energy needs in 2009. This sector accounted for 17 percent (1422.3 PJ) of secondary energy use and 15 percent (67.9 Mt) of greenhouse gases emitted in Canada.

The choices Canadians made with respect to their living space also factors into the amount of energy consumed in this sector. Average living space in 2009 was 11 percent higher than in 1990, while the number of individuals per household fell to 2.5 (from 2.8 in 1990). Furthermore, 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 2011–2012, the OEE's ecoENERGY Retrofit – Homes and ecoENERGY Efficiency for Housing programs aimed to improve the energy efficiency of single detached and attached houses.

**FIGURE 1-5** Canadian Housing Stock by Building Type, 2009



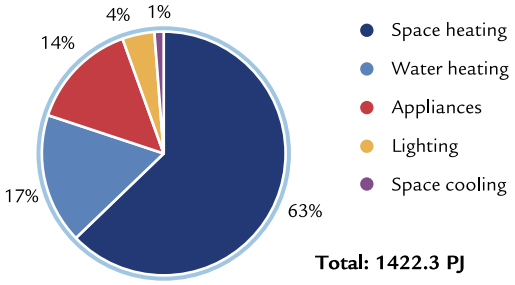

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Between 1990 and 2009, residential energy use increased by 11 percent, or 140.2 PJ. Much of this increase is due to a rise in the number of households, combined with increased average living space and higher penetration rate of appliances. But as homeowners gradually switched to cleaner energy sources to heat their homes (less greenhouse gas-intensive fuels), the associated greenhouse gas emissions actually fell by 0.8 percent during the same period.

Energy intensity (gigajoules/household) decreased 18 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, 2009




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

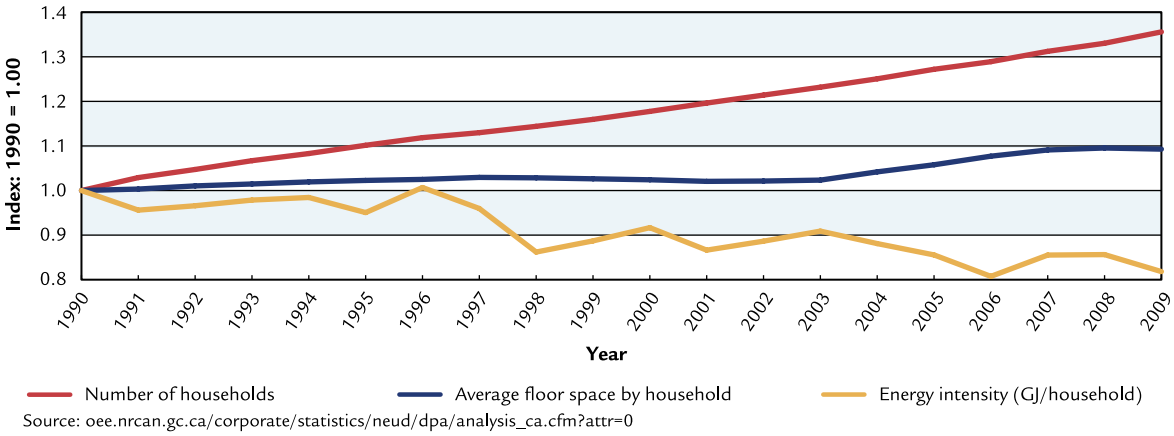
Five main factors influenced residential energy use between 1990 and 2009 – activity, weather, structure, service level and energy efficiency effect:

- Activity – As measured by combining a mix of households and floor space, energy use increased 38 percent (492.3 PJ). Growth in activity was driven by a 48 percent increase in floor area and by a rise of 36 percent in the number of households.
- Weather – In 2009, both the winter and summer were cooler than in 1990. The net result was an overall increase in energy demand of 33.0 PJ.
- Structure – The increase in the relative share of single family houses resulted in the sector using an additional 10.0 PJ of energy.
- Service level – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 75.5 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 470.6 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).

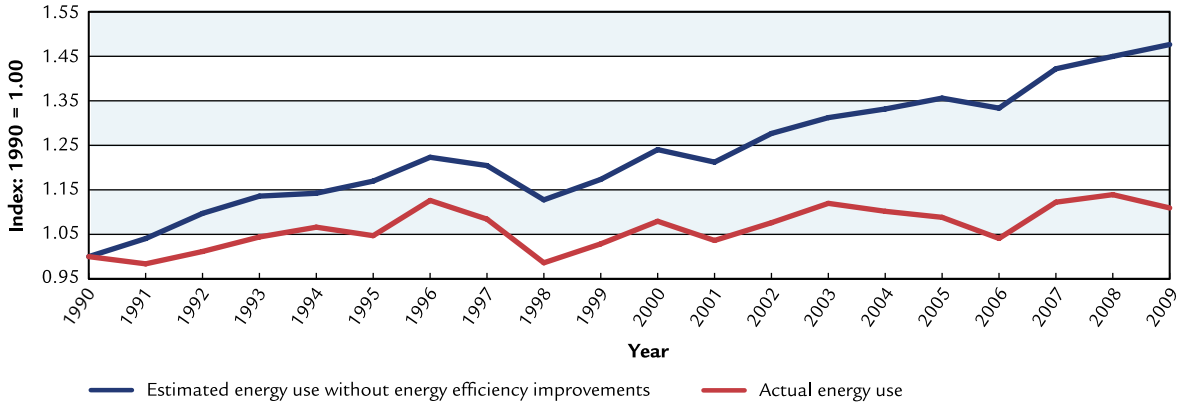
These increases were partially offset by significant improvements in energy efficiency. Service level increased energy demand because more Canadians warmed their homes during the winter months in 2009 than in 1990, and Canadians operated more appliances in 2009 than they did in 1990.

**FIGURE 1-7** Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2009




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

**FIGURE 1-8** Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009




Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2011.

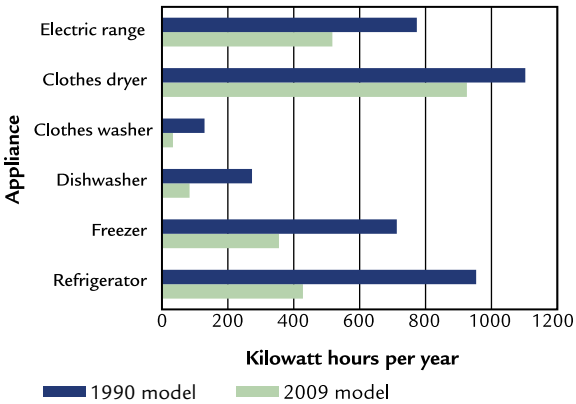
## Energy Efficiency

The change in residential energy use between 1990 and 2009 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 37 percent improvement in energy efficiency between 1990 and 2009 translated into $8.9 billion (or 470.6 PJ) in energy savings in 2009.

Figure 1-9 shows how average energy consumption of new appliances has improved, by comparing 1990 and 2009 models.

**FIGURE 1-9** Average Energy Consumption of New Electric Appliances, 1990 and 2009 Models




Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/res_00_16_e_5.cfm?attr=0.

### DID YOU KNOW?

The 470.6 PJ of energy efficiency savings in the residential sector translates into an average savings of $660 per Canadian household in 2009.

In 2011–2012, NRCan carried out the following initiatives to increase energy efficiency in the residential sector:

- ecoENERGY Retrofit – Homes
- ecoENERGY Efficiency for Housing
- ecoENERGY Efficiency for Equipment Standards and Labelling
- Clean Energy Systems for Buildings and Communities

# TRENDS IN COMMERCIAL/ INSTITUTIONAL SECTOR

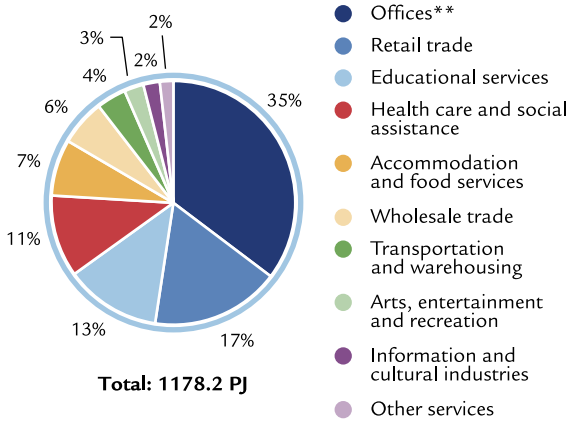
## Energy Use and Greenhouse Gas Emissions

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, space cooling and lighting, as well as operating auxiliary equipment (such as computers) and motors.

In 2009, commercial business owners and institutions spent $24 billion on energy to provide services to Canadians. This represented about 3 percent of the value of the gross domestic product related to the sector. The sector also accounted for 14 percent of total energy use in Canada and produced 13 percent of associated greenhouse gas emissions.

Between 1990 and 2009, commercial/institutional energy use (including street lighting) increased by 37 percent, from 867.0 PJ to 1186.0 PJ. Greenhouse gas emissions from the sector rose by 37 percent in the same period. However, between 2008 and 2009, greenhouse gas emissions including electricity-related emissions decreased by 5 percent. A combination of factors led to this change: a marked reduction in the emission factor related to electricity generation, which was caused by a significant decrease in coal input used to generate electricity in 2009 and an overall decrease in electricity consumption, especially in Ontario, where total energy consumption fell by 6 percent in 2009 and electricity consumption alone fell by 10 percent. This change was mainly attributable to a decrease in space cooling (summer in 2009 was cooler than in 2008).

**FIGURE 1-10** Commercial/institutional Energy Use by Activity Type*, 2009




**Total: 1178.2 PJ**

*Excludes street lighting

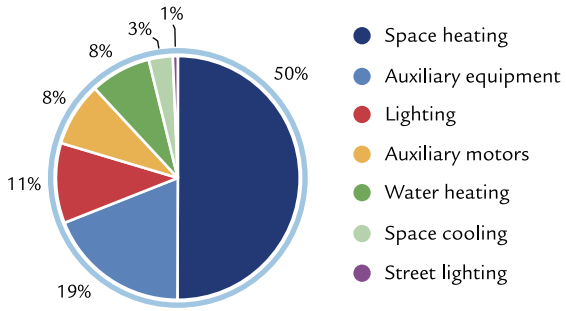
**Offices includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/com_00_1_e_5.cfm?attr=0

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 1-10). In 2009, offices accounted for 41 percent of the sector's energy demand. Retail trade (16 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 1-11, in 2009, the largest of these was space heating, which accounted for 50 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.

**FIGURE 1-11** Commercial/institutional Energy Use by Purpose, 2009




**Total: 1186 PJ**

Source:oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/com_00_1_e_5.cfm?attr=0

Five main factors influenced commercial/institutional energy use between 1990 and 2009 – activity, weather, structure, service level and energy efficiency effect:

- Activity – A 39 percent increase in floor space led to a 40 percent (341.2 PJ) growth in energy use and an increase of 17.5 Mt in greenhouse gas emissions.
- Structure – The effect of structure changes in the sector (the mix of activity types) was small

and therefore changed greenhouse gas-related emissions only marginally.

- Weather – In 2009, both the winter and summer were cooler than in 1990. The net result was an 8.8-PJ increase in energy demand in the commercial/institutional sector, mainly for space heating, which had the effect of increasing greenhouse gas 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 greenhouse gas emissions.
- 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.

### Energy Efficiency

Many of the energy efficiency improvements in the commercial/institutional sector are similar to those in the residential sector. They include 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 54 percent. However, actual energy use increased by only 37 percent between 1990 and 2009, resulting in energy savings of $3.0 billion in 2009 (see Figure 1-12).

Between 1990 and 2009, the estimated energy efficiency improvements resulted in energy savings of 147 PJ for this sector.

In 2011–2012, NRCan carried out the following initiatives to increase energy efficiency in the commercial/institutional sector:

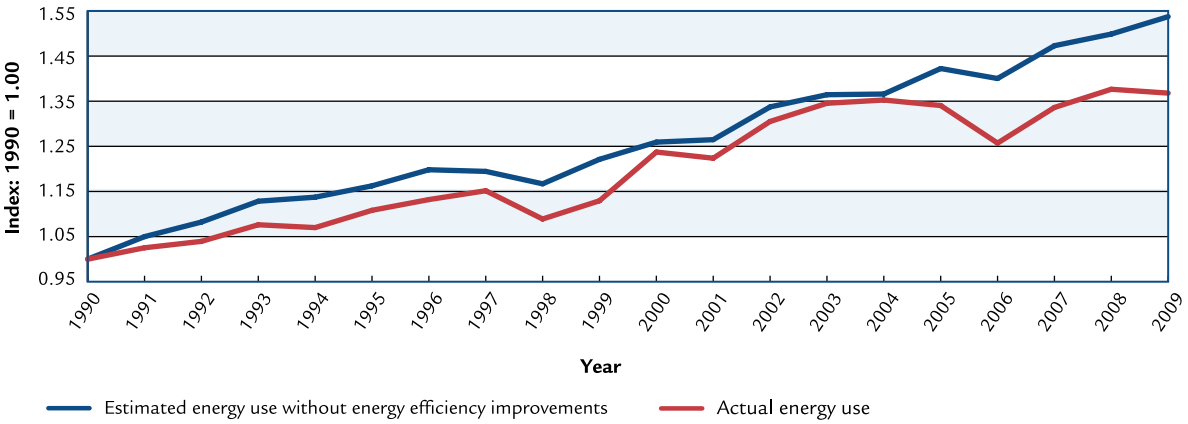
- ecoENERGY Efficiency for Buildings
- ecoENERGY Efficiency for Equipment Standards and Labelling
- Clean Energy Systems for Buildings and Communities

## 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 electricity generation. This sector uses energy in industrial processes as a source of motive power and to produce heat or generate steam. This sector alone spent $33.3 billion on energy in 2009.

**FIGURE 1-12** Commercial/institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009




Source: Natural Resources Canada, Commercial/Institutional End-Use Model, Ottawa, 2011.

Overall, industrial energy demand in 2009 accounted for 37 percent (3168.4 PJ) of secondary energy use and 31 percent (144.5 Mt) of greenhouse gas emissions (including electricity-related emissions). Between 1990 and 2009, actual industrial energy use increased by 17 percent, from 2710.0 PJ to 3168.4 PJ. The associated end-use greenhouse gases increased 8 percent, from 134.3 Mt to 144.5 Mt.

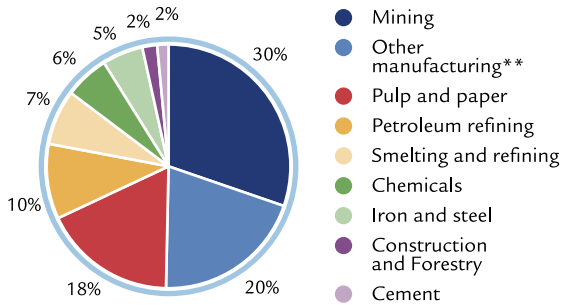
Energy use and greenhouse gas emissions decreased in 2009 compared with 2008. This change was caused by the downturn in economic activity which spanned the last half of 2008 and the first half of 2009.

Furthermore, energy intensity grew by 12 percent in 2009 while industries operated at only 68.6 percent of capacity, a drop of 8.4 percent from 2008. To illustrate the effect, capacity utilization was included in the factorization process of Canadian industry. The mining, transportation equipment and iron and steel industries exhibited significant declines in capacity utilization.

In the industrial sector, energy is used primarily to produce heat, generate steam or as a source of motive power. For example, coal is used by the cement industry to heat kilns. Numerous other industries use natural gas to fuel boilers for steam generation and electricity to power motors for pumps and fans. In 2009, energy was consumed primarily in mining, other manufacturing, pulp and paper production, and the petroleum refining industries. Mining alone accounted for 30.3 percent of total industrial energy demand (see Figure 1-13).

The cost of energy in production processes can vary significantly by industry. Generally, energy purchases account for only a small portion of total expenditures. However, for some relatively energy-intensive industries – such as cement, aluminum, pulp and paper, and iron and steel – this share was 10 percent or higher in 2009 (Figure 1-14). For cement, in particular, the share was 22.5 percent.

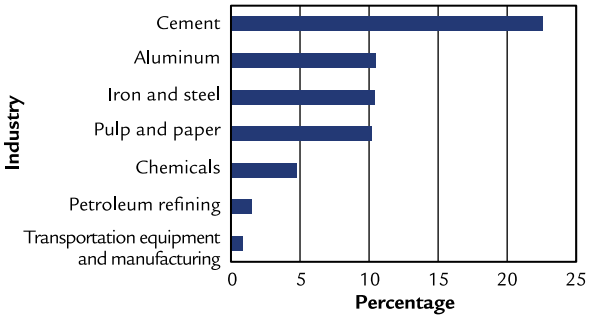
**FIGURE 1-13** Industrial Energy Use by Subsector – Including Electricity-related Emissions*, 2009




*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

Between 1990 and 2009 industrial greenhouse gas emissions, including electricity-related emissions, increased by only 8 percent. In fact, emission levels fell back to their 1997 level of 144 Mt. Much of the drop in greenhouse gas emissions was because of lower levels of activity in 2009.

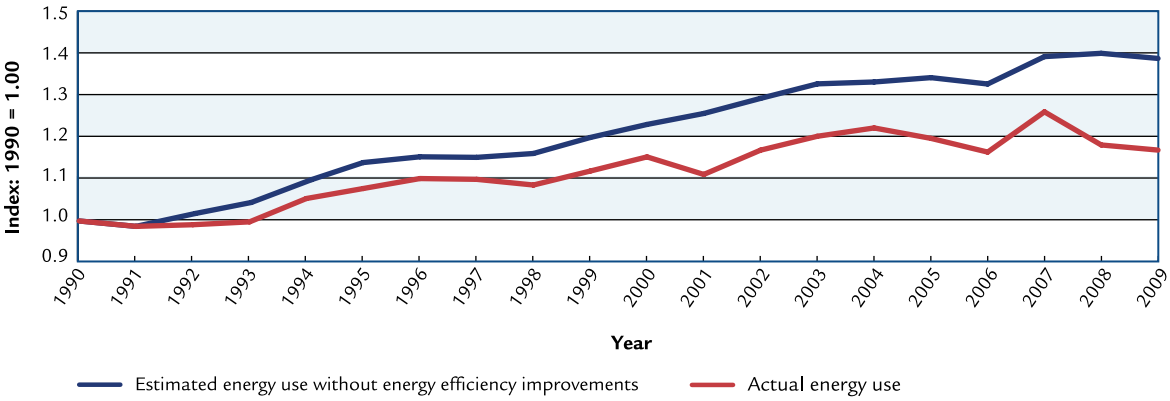
**FIGURE 1-14** Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2009




Source: Statistics Canada, CANSIM Table 301-0006.

As the Canadian economy evolves, so does the industrial make-up of greenhouse gas emissions. Increased production in the oil and gas industries has caused a larger share of direct greenhouse gas emissions for that industry, while other energy-intensive industries, such as pulp and paper, have reoriented operations and restructured to meet international competition resulting in a 60 percent decrease in greenhouse gas emissions and a smaller share of overall emissions.

**FIGURE 1-15** Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009




Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2011.

Four main factors influenced industrial energy use between 1990 and 2009 – activity, structure, capacity utilization and energy efficiency effect:

- Activity – The mix of gross domestic product, gross output and production units (activity measures) increased energy use by 44 percent, or 1181.5 PJ.
- 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 706.8 PJ.
- Capacity utilization – The capacity utilization effect increased industrial energy use by 576.5 PJ.
- Energy efficiency – Improvements in the energy efficiency of the industrial sector avoided 592.8 PJ of energy use and 27.0 Mt of greenhouse gas emissions.

## Energy Efficiency

In 2009, Canadian industry saved $6.2 billion in energy costs because of energy efficiency improvements, or 592.8 PJ of energy. This translates into 27.0 Mt of avoided greenhouse gas emissions. The change in energy use between 1990 and 2009 and the estimated energy savings attributed to energy efficiency are shown in Figure 1-15.

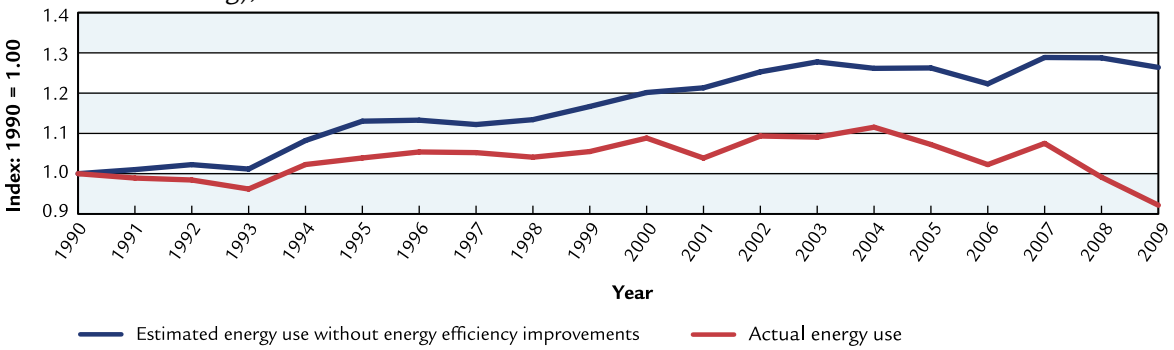
Energy efficiency improvements in the form of more efficient capital and management practices are important factors in managing energy use and decreasing energy intensity. Since 1990, energy efficiency in the industrial sector has improved 10 percent, largely because of improvements in energy intensity. However, the 2009 analysis also incorporated an assessment of the influence of variation in capacity utilization. If capacity utilization were factored out of the analysis, manufacturing energy efficiency savings actually grows to 688.5 PJ in 2009.

The energy savings made by some industries because of the energy efficiency improvements were offset by increases in consumption by the upstream mining, industrial gas and petrochemical subsectors.

From 1990 to 2009, the upstream mining share of industrial energy use grew from 8 percent to 27 percent. This change reflects not only growth in production but also a shift from conventional to the significantly more energy-intensive, unconventional oil production. To provide a clearer assessment of efficiency gains in the rest of the industry, the factorization analysis was produced without the upstream mining sector and with capacity utilization factored out. Without upstream mining, Canadian industries improved energy efficiency by 35 percent, or avoided using 881.5 PJ of energy (see Figure 1-16).

In 2011–2012, NRCan carried out the following initiatives to increase energy efficiency in the industrial sector:

**FIGURE 1-16** Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2009




Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2011.

- ecoENERGY Efficiency for Industry
- ecoENERGY Efficiency for Equipment Standards and Labelling
- Clean Energy Systems for Industry

## TRENDS IN TRANSPORTATION

### Energy Use and Greenhouse Gas Emissions

Canada's transportation sector is diverse and is responsible for moving people and goods over immense distances, varied geography and often intense weather conditions. Consequently, transportation has the largest energy bill of any sector in 2009. Although the sector (individuals and companies) spent $63.4 billion on energy (90 percent more than the second-place industrial sector), it actually uses only 30 percent of total energy in Canada (37 percent for the industrial sector). The large energy bill is due to the notably higher cost of transportation fuels compared to the prices of energy used in other sectors. The transportation sector includes road, air, rail and marine transport.

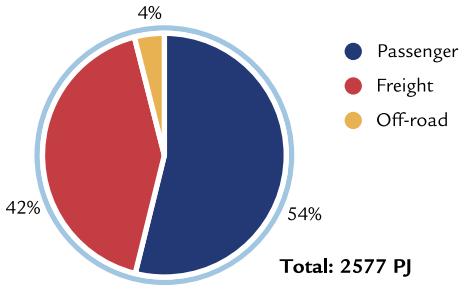
The transportation sector used 2576.6 PJ of energy in 2009 (a 1 percent decrease from 2008) and accounted for the largest portion of Canadian end-use greenhouse gas emissions at 38 percent (178.3 Mt). Much of the decrease in transportation energy use in 2009 occurred in marine and heavy truck transport and can be associated with a decline in economic activity.

**DID YOU KNOW?**

According to the *IEA Scoreboard 2011 – Implementing energy efficiency policy: Progress and challenges in IEA member countries*, Canada had the highest proportion of air travel in 2008, as measured by passenger-kilometres, amongst the International Energy Agency member countries.

The transportation sector consists of three subsectors: passenger, freight and off-road. In 2009, passenger modes consumed more than half (54 percent) of total transportation energy use, while freight transportation accounted for 42 percent; off-road represented only 4 percent (see Figure 1-17).

**FIGURE 1-17** Transportation Energy Use by Mode, 2009




Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablestrends2/tran_ca_7_e_4.cfm?attr=0

The passenger subsector has three modes: road, rail and air. The freight subsector, as defined by NRCan, is composed of road, rail, air and marine modes. All of NRCan's transportation energy use programs focus on the energy used in road transportation. Between 1990 and 2009, total transportation energy use increased by 37 percent, from 1877.9 PJ to 2576.6 PJ, and the associated greenhouse gas emissions rose 36 percent, to 178.3 Mt from 131.4 Mt.

Within the transportation sector, freight was by far the fastest growing subsector, accounting for 62 percent of the change in total transportation energy use. Most of this increase was attributable to the increased use of heavy trucks, which are more energy-intensive than other modes. Passenger transportation energy use increased by 19 percent (226.8 PJ), while freight transportation energy use increased by 67 percent (432.0 PJ).

Three main factors influenced passenger transportation energy use between 1990 and 2009 – activity, structure and energy efficiency effect:

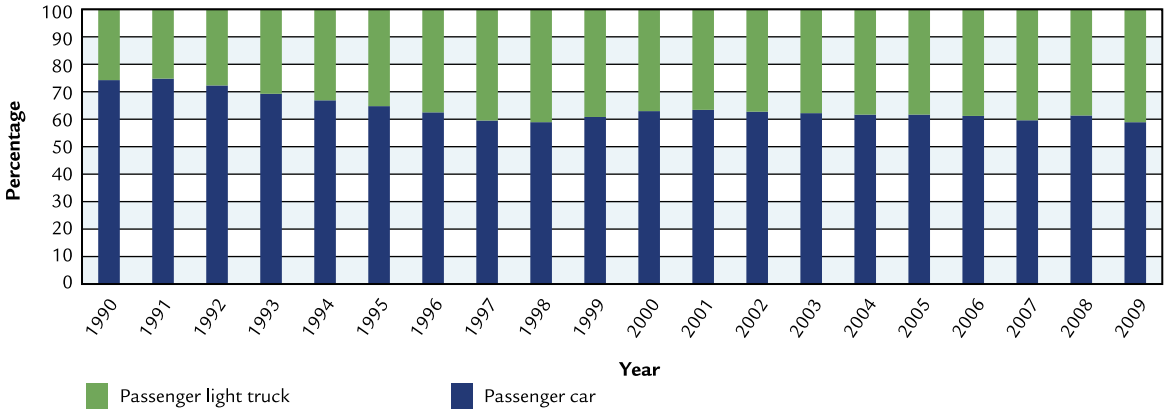
- Activity – The activity effect (i.e. passenger-kilometres travelled) increased energy use by 45 percent, or 457.5 PJ, with a corresponding 31.1-Mt increase in greenhouse gas emissions. Light truck and air transportation led the growth in passenger-kilometres (and therefore, activity effect), with respective increases of 161 percent and 84 percent.
- Structure – Changes to the mix of transportation modes, or the relative share of passenger-kilometres travelled by air, rail and road, are used to measure changes in structure. The popularity of minivans and sport utility vehicles increased the activity share of light trucks compared with other modes, contributing to a 32.4-PJ increase in energy consumption and a 2.2-Mt increase in greenhouse gas emissions.
- Energy efficiency – Improvements in the energy efficiency of passenger transportation saved 263.3 PJ of energy and 17.9 Mt of energy-related greenhouse gas 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 2009 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. tonne-kilometres moved) increased energy use 41 percent, or 263.2 PJ, and caused a corresponding 18.7-Mt increase in greenhouse gas emissions. This increase in the number of tonne-kilometres was mainly due to an increase of 173 percent in heavy-trucks activity and an increase of 41 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. 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-United States trade and the just-in-time delivery demanded by clients, thus contributing to a more intensive use of truck transportation. Hence, the structure effect contributed to a 255.6-PJ increase in energy use and an 18.1-Mt increase in greenhouse gas emissions.
- Energy efficiency – Improvements in the energy efficiency of freight transportation saved 86.8 PJ of energy and 6.2 Mt of greenhouse gas emissions. Improvements in freight trucks (light, medium and heavy trucks) were a large contributor, representing 79 percent of the savings.

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

**FIGURE 1-18** Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2009



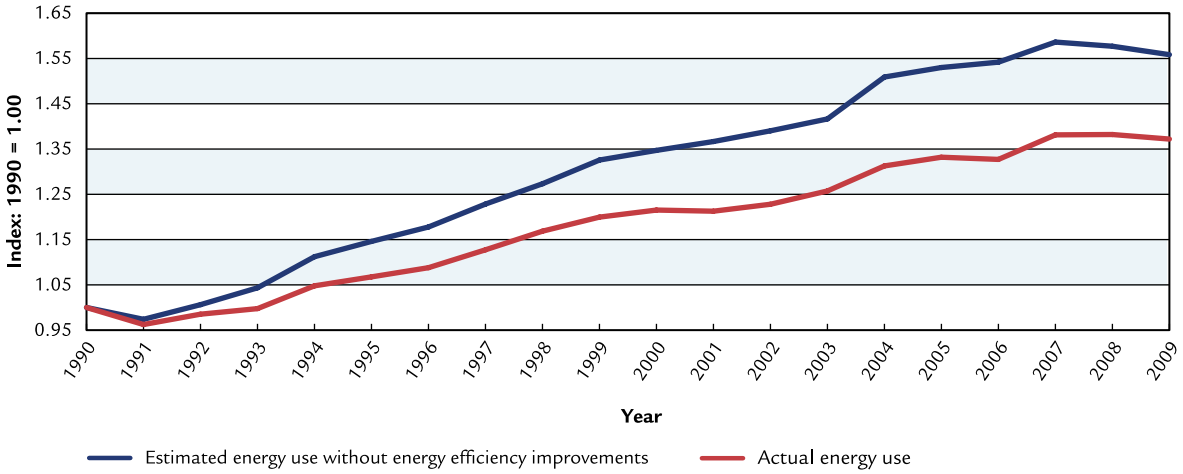

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

had a significant effect on the increase in passenger energy use.

## Energy Efficiency

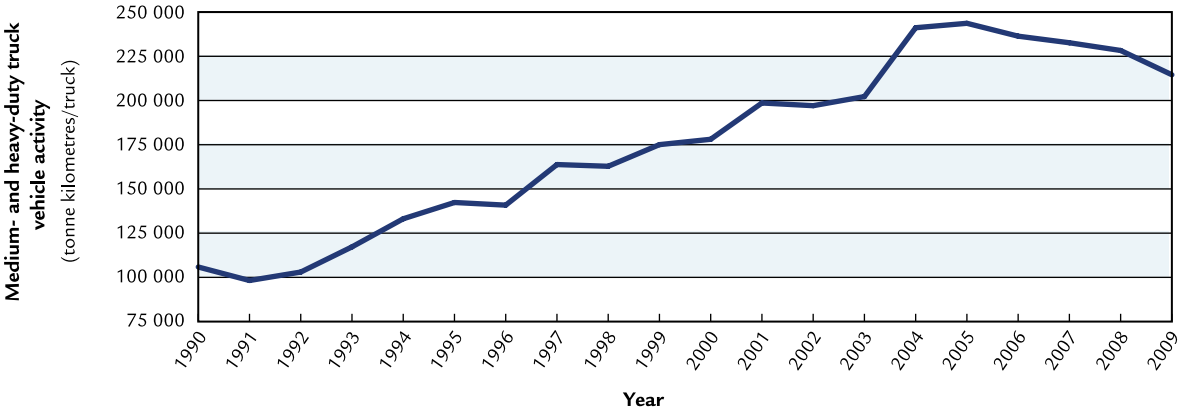
Between 1990 and 2009, energy efficiency in the transportation sector improved 19 percent, saving $8.7 billion or 350.1 PJ of energy. Without improvements in energy efficiency, increases attributable to activity and structure would have increased transportation energy use by 58 percent (see Figure 1-19). These savings were largely due to improvements in the efficiency of passenger and light-duty vehicles. Because this segment comprises a large share of vehicles on the road, savings generated by efficiency improvements had a significant impact on total energy use.

**FIGURE 1-19** Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009




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

**FIGURE 1-20** Average Activity per Truck, 1990 to 2009




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

Figures 1-20 and 1-21 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2009. Improved fleet practices, caused by an increase in the competitiveness (brought about by just-in-time inventory practices) in the transportation sector and by the introduction of electronic engines, have improved fuel efficiency in medium- and heavy-duty trucks.

In 2011–2012, NRCan carried out the following initiatives to increase energy efficiency in the transportation sector:

- ecoENERGY Efficiency for Vehicles
- Clean Transportation Energy

## TRENDS IN ALTERNATIVE AND RENEWABLE FUELS

Alternative transportation fuels are fuels that are 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 that covers a range of fuels made from renewable energy sources that are naturally replenished in a relatively short period. The

**FIGURE 1-21** Trucking Energy Intensity, 1990 to 2009


Source: Natural Resources Canada, Transportation End-Use Model, Ottawa, 2011.

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 biodiesel is primarily produced from recycled greases, animal fats and canola oil.

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 and renewable diesel. Cellulosic ethanol can be made from non-conventional sources, such as agricultural residues, forest residues and waste materials, whereas renewable diesel can be made from many of the same types of feedstocks as traditional biodiesel, such as recycled greases, animal fats and canola oil.

### Renewable Fuels Production

Renewable fuels production in Canada has increased since the emergence of ethanol in Manitoba in the 1980s. Between 2005 and 2011, biofuel production capacity increased from 228 million litres (L) to 1.96 billion L: 1.73 billion L of ethanol and 225 million L of biodiesel. In 2011, approximately 1.66 billion L of ethanol were produced, and ethanol was part of about 5.9 percent of gasoline sales (an increase of 1.61 percent from 2010).

On December 15, 2010, Environment Canada's the *Renewable Fuels Regulations* (the Regulations) came into force. The Regulations require that gasoline produced or imported have an average annual renewable fuel content of at least 5 percent based on volume. The Regulations also require an average of 2 percent renewable content in diesel fuel and heating oil, subject to technical feasibility, effective July 2011. Technical feasibility was demonstrated through the National Renewable Diesel Demonstration Initiative that was led by NRCan.

In 2011–2012, NRCan carried out initiatives to increase the use and production of renewable and alternative fuels under the following programs:

- ecoENERGY for Biofuels
- ecoENERGY for Alternative Fuels
- 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 the Canadian Transportation Sector: Deployment Roadmap* brought together stakeholders that represented 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 that stem 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/alternative-fuels/natural-gas-deployment-roadmap.

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.

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 the department 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 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; and, at the request of manufacturers during this reporting period, domestic water heaters. In these cases, 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, the seasonal energy efficiency ratio for central air conditioners, and the energy factor for domestic hot water.

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.

In September 2011, the Government of Canada announced funding for the ecoENERGY Efficiency program, which includes support for the continuation of energy efficiency standards and labelling efforts. Further savings of 35 petajoules (PJ) of energy and 4 megatonnes (Mt) of emissions are expected to result in 2020 from additional standards and complimentary voluntary efforts contained in the ecoENERGY Efficiency program.

## 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 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 Efficient Electrical End-use Equipment implementing agreement that facilitates co-operation among various Organisation for Economic Co-Operation and Development countries on specific projects. Canada is participating in a mapping and benchmarking study as well as one on standby power.

Canada has also been a participant in the Super-efficient Equipment and Appliance Deployment initiative, which is an initiative under the Clean Energy Ministerial and also a task group

under the International Partnership for Energy Efficiency Co-operation. The initiative has focused on furthering international collaboration on standards development, international best performers awards and tools to help procurement agencies identify and purchase high efficiency products.

The 2009 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."

In the last report, *Improving Energy Performance in Canada – Report to Parliament Under the* Energy Efficiency Act *For the Fiscal Year 2010–2011*, NRCan fulfilled the first of the above reporting requirements, indicating that our standards are as stringent as about 90 percent of those compared.

An internal study was undertaken to estimate the country-wide energy consumption resulting from the use of energy-using products prescribed under the Regulations. This fulfills the second reporting requirement and is summarized here.

In the residential sector, efficiency standards have been prescribed for more than 30 energy-using product categories, which represent almost three quarters (74 percent) of total residential energy use in Canada. This can be broken down by energy-using product category, as illustrated in Table 2-1. For example, 97 percent is used by a regulated product as is 65 percent of energy used for space heating. Some of the energy use not covered by the Regulations may be covered in future years when new regulatory proposals are introduced. For example, a regulatory proposal is being developed for line voltage thermostats, a component of electric baseboard heaters, which use 14 percent of residential energy use and are currently not regulated.

The Regulations also address products specifically marketed to the commercial sector. Energy efficiency standards have been prescribed for more than 20 commercial product categories, which represent more than 30 percent of total commercial energy use in Canada. This can be broken down by energy-using product category, as illustrated in Table 2-1. For example, 85 percent of the energy used for lighting is used by regulated products as is 67 percent of the energy used by auxiliary motors.

Key commercial energy-using products that are not currently regulated at the federal level include commercial water heaters (electric, gas and oil-based), space heating and cooling equipment (gas and oil-fired boilers, oil-fired furnaces, infrared heaters, duct furnaces, electric baseboards, rooftop units, air handlers, make-up air units), and auxiliary equipment. Many of these products are currently the subject of regulatory proposals and are likely to be included in future amendments to the Regulations.

Finally, efficiency standards have been prescribed for several products commonly used in the industrial sector, most notably dry-type transformers and motors, which comprise 38 percent of industrial electricity use and 8 percent of total industrial energy use in Canada.

In keeping with its mandate to strengthen and expand Canada's commitment to energy efficiency, the Office of Energy Efficiency (OEE) at NRCan continues to endeavour to update the Regulations. The upcoming amendment to the Regulations that is scheduled for pre-publication in the coming year, if adopted, would tighten efficiency standards for eight product categories – gas-fired water heaters, oil-fired water heaters, commercial self-contained refrigerating devices, packaged terminal air conditioners and heat pumps, chillers, general service fluorescent lamps, general service incandescent reflector lamps, and room air conditioners.

**TABLE 2-1** Energy Use from Regulated Products, 2009

| Product category | Total energy use (PJ)[1] | Estimated energy use from regulated products (PJ) | Energy use from regulated products (%) |
|---|---|---|---|
| Residential sector | | | |
| Space heating | 893.2 | 580.4 | 65 |
| Water heating | 245.8 | 238.9 | 97 |
| Appliances | 205.2 | 168.2 | 82 |
| Lighting | 60.6 | 44.2 | 73 |
| Space cooling | 17.4 | 17.0 | 97 |
| **Total residential** | **1422.3** | **1048.7** | **74** |
| Commercial sector[2] | | | |
| Space heating | 594.0 | 144.6 | 24 |
| Water heating | 96.0 | 0.0 | 0 |
| Auxiliary equipment | 225.0 | 12.8 | 6 |
| Auxiliary motors | 100.0 | 67.5 | 67 |
| Lighting | 126.0 | 107.6 | 85 |
| Space cooling | 38.0 | 20.2 | 54 |
| Street lighting | 8.0 | 1.4 | 18 |
| **Total commercial** | **1186.0** | **354.2** | **30** |
| Industrial sector[3] | | | |
| **Total industrial** | **2991.9** | **250.7** | **8** |

Notes
1 Figures are based on preliminary 2009 data from the National Energy Use Database.
2 Excludes spill-over of residential products in the commercial sector.
3 Excludes spill-over of residential and commercial products in the industrial sector.

## COMPLIANCE AND ENFORCEMENT

The Regulations outline some responsibilities of 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 emphasizes self-monitoring, reporting, voluntary compliance and collaboration. However, the Act prescribes specific enforcement measures when dealers violate the law.

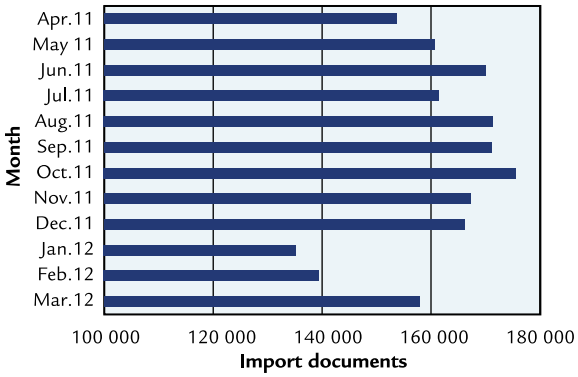
To monitor compliance with the Regulations, the department captures information from energy efficiency reports and import documents. Section 5 of the Act requires dealers to provide energy efficiency reports when they market a new product model. The required information includes the energy performance 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 the department to verify that there is a matching energy efficiency report. The department can then confirm that all products entering Canada meet the required energy performance levels and can take action when necessary.

NRCan processed more than 1.93 million records (records from April 1, 2011 to March 31, 2012) relating to the importation of regulated energy-using products to Canada in 2011–2012.

Figure 2-1 illustrates the volume of import documents received, in paper form and electronically, per month during the 2011–2012 fiscal year.

**FIGURE 2-1** Volume of Monthly Import Documents




Source: OEE Equipment Database.

More than 3.62 million new or revised model numbers were submitted to NRCan for entry into the department's equipment database (records from April 1, 2011 to March 31, 2012) 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 12 amendments have resulted in a reduction of 26.03 Mt in aggregate annual greenhouse gas emissions in 2010 (see Table 2-2).

During 2011–2012, the department conducted the analysis and consultation necessary to implement Amendment 11, the second amendment of the Clean Air Regulatory Agenda. Amendment 11 was published in October 2011 and came into effect in April 2012. Regulatory amendment 12, which delayed the implementation of standards for light

**TABLE 2-2** Estimated Impact of the *Energy Efficiency Regulations*, 2010 and 2020 (Aggregate Annual Savings)

| **Product** (amendment number in brackets) | **Energy savings** (PJ) | | **Greenhouse gas 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 water heaters, 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 |
| Change to implementation dates for general service lighting (12) | 0.00 | 0.07 | 0.00 | -0.01 |
| **Total** | **185.15** | **336.47** | **26.03** | **44.75** |

bulbs for two years, was also published November 2011. Analysis and legal drafting of the provisions of Amendment 13 were mostly completed in 2011–2012. The department also responded to the Government's regulatory reform commitments by aligning its regulatory planning for energy efficiency standards with the recently announced "One-for-One" rule and small business lens.

The final 2020 projected energy efficiency impacts of the published and soon-to-be pre-published amendments (Amendments 10 to 13) are savings of 105.61 PJ of energy and 11.22 Mt of greenhouse gas emissions.

## LABELLING AND PROMOTION

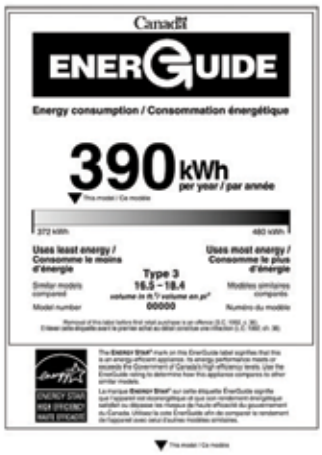
### EnerGuide Label

Since 1978, the EnerGuide label has given Canadians the opportunity to compare the energy consumption of appliances (see Figure 2-2). 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 within the range of products within its category, allowing the customer to consider the most energy-efficient choice.

EnerGuide directories that list energy ratings for major appliances and room air conditioners are published annually. They are distributed to consumers, retailers and appliance salespeople. In fulfilling requests for information, electric utilities and provincial governments also distribute the directories. Online directories for all appliances and heating and cooling equipment are published on the Web site of the 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 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. In

**FIGURE 2-2** EnerGuide Label




2011, manufacturers of domestic water heaters asked NRCan to allow them to voluntarily use the EnerGuide label to indicate the energy use of their products as well. The expansion of the voluntary rating program to this product category will help Canadian consumers make better purchase decisions in these highly competitive product categories.

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.

## ENERGY STAR 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). NRCan administers the ENERGY STAR program in Canada under a letter of 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 2-3** 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. In Canada, organizations apply to become participants in the ENERGY STAR initiative, thereby pledging to promote the brand and the concept of energy efficiency in both their operations and consumer literature. NRCan, in turn, offers its support in the way of promotional and educational tools for retailers and manufacturers. This year, several retailer training products were developed to ensure sales personnel knew how to market the most efficient products to consumers.

### DID YOU KNOW?

By replacing your home's five most frequently used incandescent light bulbs with ENERGY STAR qualified products, you can save $70 each year in electricity costs. The *lumen* value (light output) of the bulb is more important than *wattage* (energy use). Remember, for newer lighting technologies such as CFLs (compact fluorescent lamps) and LEDs (light-emitting diodes), the light bulbs can produce the same lumen output by using fewer watts than traditional incandescent bulbs.

The criteria for efficiency specifications for appliances and heating and cooling products 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, 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 products that meet higher efficiency standards. 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, in 2011-2012,

Hydro-Québec offered rebates for ENERGY STAR compact fluorescent lamps, Hydro One (Ontario), BC Hydro and FortisBC™ offered rebates on a variety of ENERGY STAR qualified appliances throughout the year, and the utilities of Newfoundland and Labrador offered rebates on ENERGY STAR qualified windows. The Ontario Power Authority had retailer incentive programs and coupon rebates for consumers to purchase ENERGY STAR qualified products, and Manitoba Hydro ran incentive programs for ENERGY STAR qualified commercial kitchen equipment.

ENERGY STAR was also a qualifying criterion for sales tax exemptions in Saskatchewan and Ontario for the purchase of home heating equipment. Organizations across Canada, especially utilities, have used ENERGY STAR as a campaign driver to promote replacement with, or purchase of, higher efficiency products.

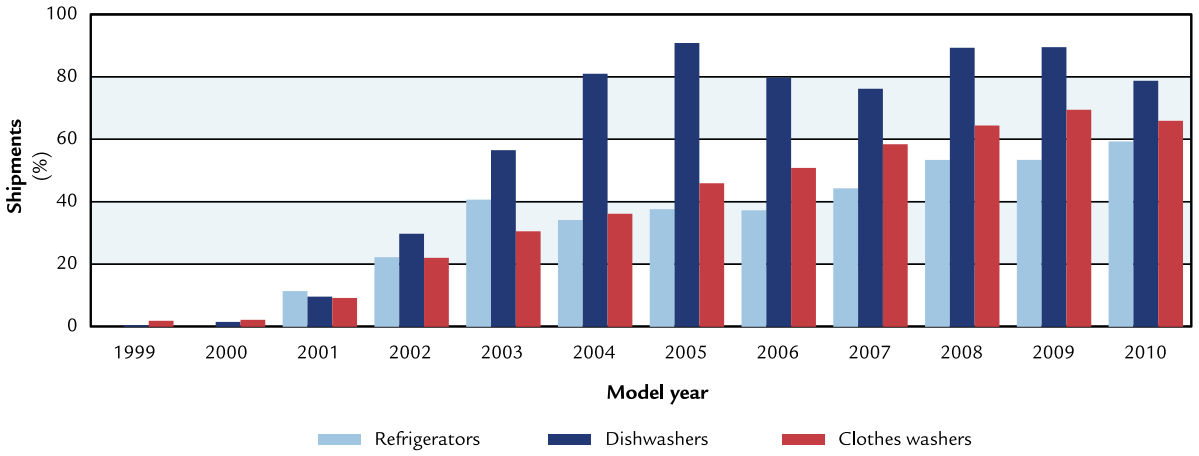
Continuous promotion of ENERGY STAR qualified appliances has paid off. Industry statistics for 2010 show an increase in market penetration from almost nil in 1999 to 59 percent for refrigerators, 66 percent for clothes washers and 79 percent for dishwashers (see Figure 2-4). The increase in market penetration 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 routinely 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 and kitchen equipment to vending machines. With more products added to the ENERGY STAR lineup this year, NRCan offered a commercial kitchen purchasing guide for commercial and institutional kitchen managers, owners, and those purchasing for large restaurant chains in Canada. 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 and keeps its interactive cost calculators and purchasing tool kits up to date. This ensures that procurement professionals have access to useful data and tools that help them compare energy cost savings and reductions in greenhouse gas emissions associated with the purchase of ENERGY STAR qualified products. This information is needed to make a solid business case for investing in more efficient equipment, in spite of the "first price tag" – which is often a barrier in bulk purchases of energy-using equipment.

**FIGURE 2-4** ENERGY STAR Qualified Appliances as a Percentage of Total Shipments in Canada, 1999 to 2010

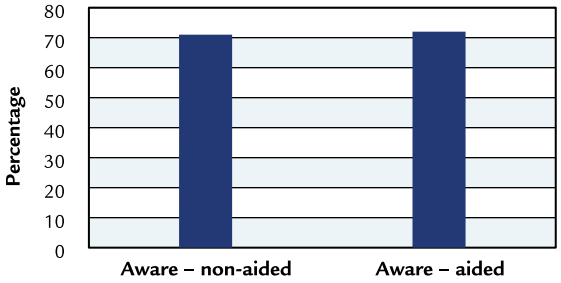



Source: *Energy Consumption of Major Household Appliances Shipped in Canada, Trends for 1990–2010.*

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. For example, in the ENERGY STAR for New Homes initiative, a builder or homeowner must also consider purchasing ENERGY STAR qualified appliances, lighting products and other optional equipment to reach the highest efficiency standards to earn the ENERGY STAR mark, in addition to incorporating major components in the construction of the home that meet or exceed ENERGY STAR specifications. Canada continues to expand the range of product types included in its ENERGY STAR agreement with four product categories added in 2011 and stringency increased for more than17 others.

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




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

## ENERGY STAR Most Efficient Designation

Under Phase 1 of the Clean Energy Dialogue between Canada and the United States, NRCan and the United States collaborated to enhance the ENERGY STAR program. In 2011, the Environmental Protection Agency and the Department of Energy launched an initiative called "Most Efficient" to identify and promote the most efficient products among those that qualify for the ENERGY STAR label in selected product categories. Canada reciprocated by conducting market analysis to determine the potential for the program in Canada. Under Phase 2 of the Clean Energy Dialogue, the department is initiating similar improvements to replicate elements of the Most Efficient program in Canada.

Availability of the Most Efficient program will advance highly efficient products in the Canadian marketplace. Most Efficient product categories and performance criteria ensure that products that earn this recognition demonstrate efficiency performance that is truly exceptional or leading edge – consistent with the interests of environmentally motivated consumers and early adopters. These products are "the best of the best" in terms of energy performance. By choosing these energy-efficient products, consumers can decrease their energy consumption, save money on their energy bills and reduce greenhouse gas emissions.

**FIGURE 2-6** ENERGY STAR Most Efficient Logo

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 across all sectors and increase the production and use of alternative transportation fuels in Canada. The OEE manages several initiatives under the suite of ecoENERGY programs, including

- ecoENERGY Efficiency, which features the following program components:
  - ecoENERGY Efficiency for Buildings
  - ecoENERGY Efficiency for Housing
  - ecoENERGY Efficiency for Equipment Standards and Labelling
  - ecoENERGY Efficiency for Industry
  - ecoENERGY Efficiency for Vehicles
- ecoENERGY Retrofit – Homes
- ecoENERGY for Alternative Fuels
- ecoENERGY for Biofuels
- Federal Buildings Initiative

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

## ecoENERGY EFFICIENCY

The ecoENERGY Efficiency program is investing $195 million over five years to maintain the Government of Canada's momentum to improve energy efficiency in Canada – at home, at work and on the road. These efforts will make the housing, building, and equipment stock more energy-efficient, energy performance more visible and industry and vehicle operations more efficient.

Improving energy efficiency will contribute to a cleaner environment and reduce greenhouse gas emissions while saving Canadians money and making the most of our natural resources. The ecoENERGY Efficiency program is expected to result in energy savings of 36 to 44 petajoules by March 31, 2016.

Details on each of the featured components of the ecoENERGY Efficiency program can be found below.

## ecoENERGY EFFICIENCY FOR BUILDINGS

### Objective

ecoENERGY Efficiency for Buildings, a component of the ecoENERGY Efficiency program, supports the development and implementation of energy codes, benchmarking tools, training and information materials to improve the energy efficiency of commercial and institutional buildings in Canada.

### Description

The ecoENERGY Efficiency for Buildings program component will improve the efficiency of new and existing buildings in Canada's commercial and institutional sector. Activities include

- providing technical, policy and financial support to the National Research Council of Canada to upgrade the 2011 National Energy Code of Canada for Buildings, resulting in publication of the 2015 version of the energy code. The updated code will ensure improved minimum performance for new buildings, which, in 2020, will make up 25 percent of the building stock. NRCan will work with the National Research Council, the federal organization responsible for code development, and will collaborate with provincial, territorial and

municipal government authorities responsible for code adoption. In addition, information, tools, training and best practices will be shared with responsible jurisdictions to encourage compliance to the code and energy efficiency in new buildings.

- developing and releasing new guidelines for the renovation of existing buildings that are not addressed by the improvements in the 2015 edition of the National Energy Code of Canada for Buildings. Existing buildings will account for 75 percent of the stock in 2020.
- adapting and introducing the United States Environmental Protection Agency ENERGY STAR program's Portfolio Manager benchmarking tool in Canada. Based on the United States experience, it is expected that this tool will be used in up to 6 percent of commercial and institution floor space in Canada by 2015–2016 (3000 to 4000 buildings). The benchmarking tool will provide building owners with a consistent way of comparing the energy performance of buildings, prompting them to make building improvements.
- developing and providing information, tools and training to encourage energy efficiency action through workshops such as NRCan's Dollars to $ense and others; NRCan's Web site; face-to-face and Web-enabled events; and collaborative arrangements to foster capacity building, transfer knowledge and support the implementation of energy management projects and practices.

### DID YOU KNOW?

The National Energy Code of Canada for Buildings 2011 is now available for provinces and territories to adopt. The 2011 code is 25 percent more stringent than the previous code, which translates into $1.7 million in savings through the lifetime of a typical 10-storey building. The 2011 code calls for the highest energy performance in North America, and 10 provinces and territories are considering adopting or adapting it.

### Key 2011–2012 Achievements

- The 2011 National Energy Code of Canada for Buildings was published.
- CanQuest – a building energy simulation software tool for energy code compliance – was launched.
- A new Dollars to $ense recommissioning workshop was launched.
- A Co-operative Research and Development Agreement with the U.S. Environmental Protection Agency was signed.
- More than 1250 participants were trained.
- Four partnerships, collaborative arrangements and/or agreements were signed.

***For more information:***
oee.nrcan.gc.ca/buildings

## ecoENERGY EFFICIENCY FOR HOUSING

### Objective

ecoENERGY Efficiency for Housing, a component of the ecoENERGY Efficiency program, encourages the construction and retrofit of low-rise residential housing, making the housing stock more energy-efficient.

### Description

ecoENERGY Efficiency for Housing, will increase the energy efficiency of Canadian housing, as measured by increased energy performance of houses that participate in its initiatives. Activities include

- the EnerGuide Rating System, which is a standard measure of the energy performance of new and existing homes. The rating allows individuals to compare the energy performance of one house against another. For new homes, this rating and labelling system plays an important role in the construction of energy-efficient new homes. For existing homes, the EnerGuide Rating System is used to evaluate home energy efficiency and to provide guidance for homeowners who want to make energy improvements to their house. It is

also used as a part of the application process for incentives, through programs such as ecoENERGY Retrofit – Homes and its complementary regional programs. Getting an EnerGuide evaluation is promoted as the first step in smart home renovation.

- the ENERGY STAR for New Homes initiative, which promotes construction of new homes that are more energy-efficient than those built to minimum building code requirements. The increased efficiency of these homes translates into reduced energy costs for homeowners. ENERGY STAR qualified homes are now available in many regions in Canada.
- the R-2000[7] Standard, which is a voluntary standard administered by NRCan and is delivered through a network of service organizations and professionals across Canada.

  All R-2000 homes are constructed by licensed and trained builders, evaluated, inspected and tested by independent third-party inspectors, and are certified by the Government of Canada. R-2000 certified houses are significantly more energy-efficient than those built to minimum building code requirements and have additional elements such as clean air features and high levels of insulation. This translates into energy savings, increased comfort and a healthier environment for the homeowner.

Figure 3-1 shows the number of R-2000 certified houses and ENERGY STAR labelled houses from 1990 to 2011.

## Key 2011–2012 Achievements

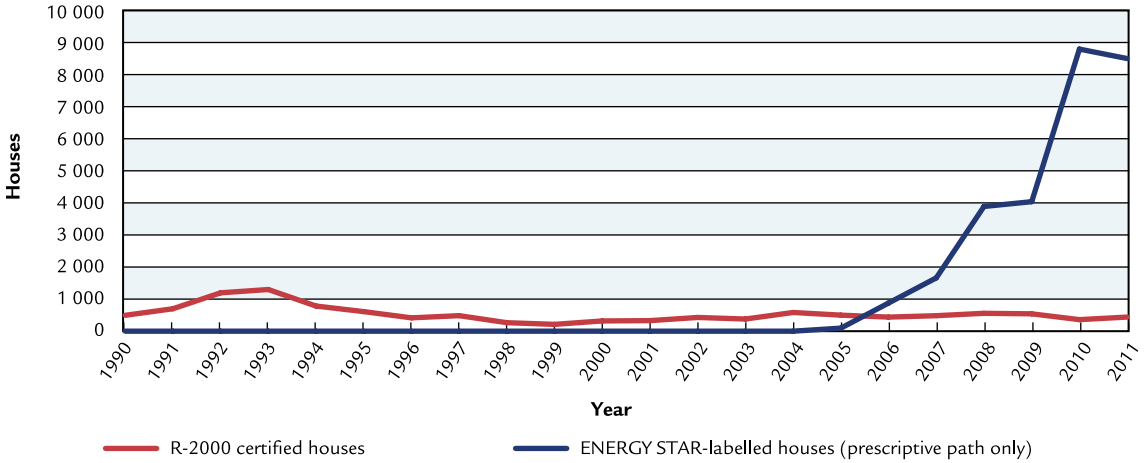
- More than 800 builders, energy professionals and trades people were trained.
- More than 230 000 energy labels were issued.
- Twenty-two agreements were established with delivery networks, non-governmental programs, provinces/territories and utilities.
- Seven jurisdictions are using the EnerGuide Rating System in the development or implementation of codes and regulations.

***For more information:***

oee.nrcan.gc.ca/housing

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

**FIGURE 3-1** Number of R-2000 House Certifications and ENERGY STAR Prescriptive-labelled Houses, 1990 to 2011




Source: NRCan national housing database and internal data.

## ecoENERGY EFFICIENCY FOR EQUIPMENT STANDARDS AND LABELLING

### Objective

The objective of ecoENERGY Efficiency for Equipment Standards and Labelling, a component of the ecoENERGY Efficiency program, is to eliminate the worst energy performers and accelerate the introduction of more energy-efficient products in Canada's equipment stock. To do this, the component will introduce new and more stringent regulated minimum energy efficiency performance standards and deploy enabling initiatives and strategies to ensure that there are continued improvements and a growing market share of energy-efficient products.

### Description

The ecoENERGY Efficiency for Equipment Standards and Labelling program component builds on the success of previous programs by supporting three integrated elements to improve the efficiency of energy-using products sold in Canada and thus reduce greenhouse gas emissions. Activities include

- continuing to implement regulated minimum energy efficiency standards through amendments to the *Energy Efficiency Regulations*.

  These standards will eliminate the worst performing products from the Canadian marketplace. Standards may be proposed for the following 16 products:

  - battery charging systems
  - walk-in refrigerator/freezers
  - residential refrigerators, refrigerator-freezers
  - small electric motors
  - room air conditioners
  - residential dishwashers
  - ceiling fan lighting
  - residential clothes dryers
  - pool heaters
  - HID lamps
  - microwave ovens
  - televisions
  - fluorescent lamp ballasts
  - low-voltage dry-type transformers
  - residential clothes washers
  - commercial household-style clothes washers

  Additional standards will be considered consistent with developments in other jurisdictions.

  This program component will include ongoing support for core activities such as standards development through the national standards system for energy efficiency and delivering an effective service-oriented compliance and enforcement regime.

- enhancing labelling and promotion programs that have historically helped introduce new and more stringent standards and that are closely aligned with United States developments.

  Enhancements include a pilot program that focuses on the best performers of ENERGY STAR qualified products that will be launched as "Most Efficient." Refrigerator-freezers, washing machines, central air conditioners and televisions will be included in the Most Efficient pilot.

  The ecoENERGY Efficiency for Equipment Standards and Labelling program component will also continue to update and develop ENERGY STAR information material, tools and promotional and training activities. These efforts help procurement officials incorporate ENERGY STAR into purchasing decisions and demonstrate the energy and cost savings associated with choosing ENERGY STAR qualified products.

- accelerating the introduction of new high-efficiency products to the market by providing support for product showcases, deployment and monitoring.

- Integrated systems, high performance combustion systems and advanced lighting are examples of applications that may be showcased.

### Key 2011–2012 Achievements

- The Most Efficient ENERGY STAR designation was introduced.
- Four market barrier assessments were completed for regulated products (refrigerators, clothes dryers, oil furnaces and mobile furnaces).
- Four technology assessments were undertaken.
- Four test standards were developed and published as National Standards of Canada.
- Amendments 11 and 12 to the Energy Efficiency Regulations were published.

***For more information:***
oee.nrcan.gc.ca/equipment

## ecoENERGY EFFICIENCY FOR INDUSTRY

### Objective

ecoENERGY Efficiency for Industry, a component of the ecoENERGY Efficiency program, aids the adoption of an energy management systems standard and accelerates energy-saving investments and the exchange of best-practices information within Canada's industrial sector.

### Description

The ecoENERGY Efficiency for Industry program component provides information and training to improve the energy efficiency of Canadian industrial companies. Activities include

- supporting the Canadian Industry Program for Energy Conservation, which offers networking opportunities for industry to share information, identify common needs and best practices and improve energy efficiency in more than 25 industrial sectors.
- supporting early implementation of the new International Organization for Standardization ISO 50001 Energy Management Systems standard. The recent publication of the Canadian version of this new standard by the Canadian Standards Association will help Canadian industry establish the systems and processes necessary to take a structured approach to improving energy efficiency, use, consumption and intensity. Use of the standard will help Canadian industries remain competitive for the long run.
- providing Dollars to $ense energy management training workshops to help industrial companies reduce energy use by improving energy management practices.
- providing newsletters, reports, guides, manuals and publications to increase awareness of industrial energy efficiency.

### Key 2011–2012 Achievements

- Pilots for implementing the ISO 50001 Energy Management Systems standard under the Clean Energy Dialogue (Global Superior Energy Performance Initiative) were completed.
- A new Dollars to $ense Energy Management Information Systems workshop was launched to support improved energy management practices.
- More than 1950 participants were trained through energy conferences, webinars and Dollars to $ense workshops.
- NRCan entered into seven partnerships, collaborative arrangements and/or agreements.
- NRCan supported adopting the new ISO 50001 as the national energy management standard for voluntary use by Canadian organizations.

#### DID YOU KNOW?

Two Canadian companies are now certified under the new ISO 50001 energy management systems standard, which was adopted by Canada in June 2011. This voluntary standard provides organizations with a structured framework to manage energy to increase efficiency, reduce costs and improve performance. It allows companies to demonstrate corporate environmental responsibility in the global marketplace.

***For more information:***
oee.nrcan.gc.ca/industry

## ecoENERGY EFFICIENCY FOR VEHICLES

### Objective

ecoENERGY Efficiency for Vehicles, a component of the ecoENERGY Efficiency program, aims to raise awareness regarding the impact of vehicle choice and driving style on fuel efficiency and the environment through information products, decision-making tools and training.

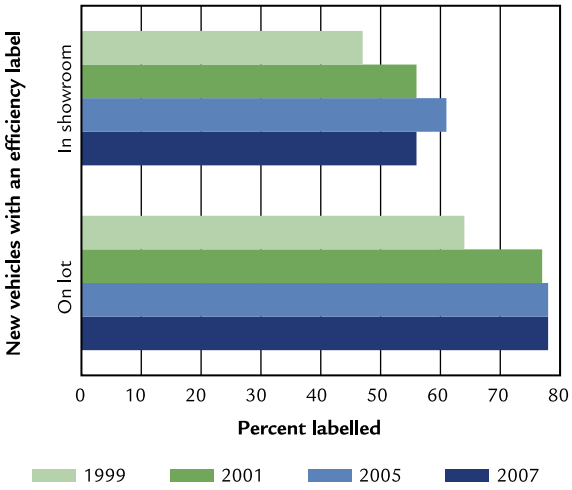
### Description

The ecoENERGY Efficiency for Vehicles program component offers fuel-efficient driver training, provides energy information to vehicle consumers and encourages fleet managers to make their operations as energy-efficient as possible. Activities include

- helping Canadians understand the links between their driving behaviour and fuel consumption through fuel-efficient driver training and other tools is a key pillar of ecoENERGY Efficiency for Vehicles:
  - Auto$mart targets novice light-duty vehicle drivers.
  - SmartDriver targets drivers in the commercial and institutional fleet sector.
  - Commercial and institutional fleets will also have access to additional practical advice, tools and strategies offered through FleetSmart.
- ecoENERGY Efficiency for Vehicles also focuses on providing consumers with the information they need to make decisions about purchasing energy-efficient vehicle and equipment. This includes
  - continuing to produce the *Fuel Consumption Guide* and provide on-line consumer fuel efficiency information
  - introducing updated energy efficiency labels for light-duty on-road vehicles
  - developing a new consumer awareness initiative that recognizes fuel-efficient tires for light-duty vehicles
- ecoENERGY Efficiency for Vehicles will also introduce a Canadian version of the SMARTWAY Transport Partnership, a successful program launched by the U.S. Environmental Protection Agency in 2004:
  - SmartWay connects freight shippers with an interest in greening their operations to a list of endorsed energy-efficient freight carriers.
  - Participants are benchmarked against each other by using data they submit that describes their energy use and emissions.

Figure 3-2 shows the use of new vehicle fuel efficiency labelling and Figure 3-3 shows the company average fuel consumption versus Canadian voluntary standards.

**FIGURE 3-2** New Vehicle Fuel Efficiency Labelling



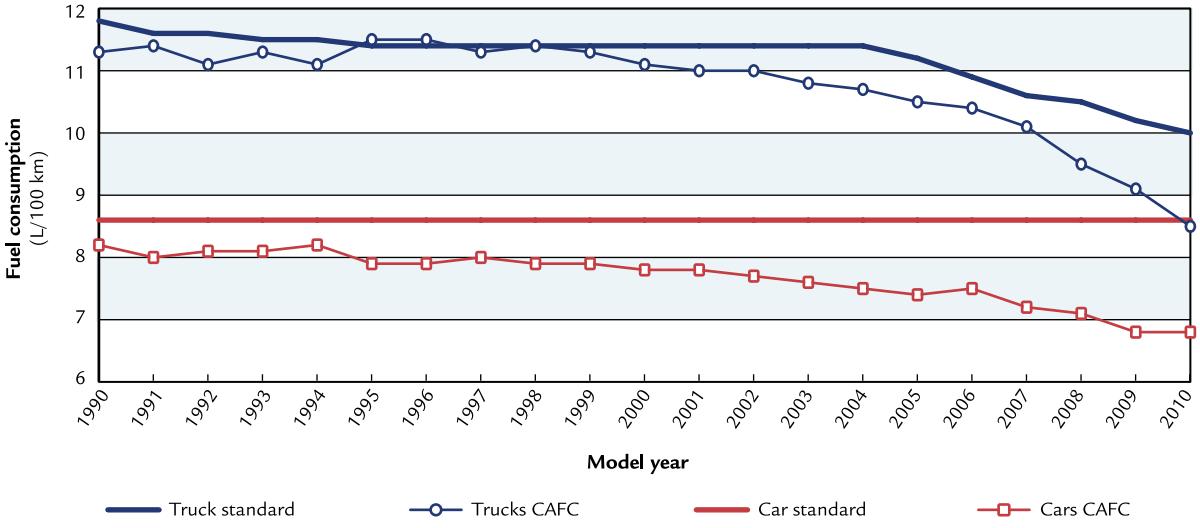

Source: Corporate Research Associates, *2007 EnerGuide Label for Vehicles and Fuel Consumption Guide Audit Survey: Final Overall Report, May 2007*.

### DID YOU KNOW?

If every driver of a light-duty vehicle avoided idling for 3 minutes a day, collectively over one year, we would save 630 million litres (L) of fuel, more than 1.4 million tonnes of greenhouse gas emissions and $819 million annually in fuel costs.[8]

[8] Assuming an average fuel price of $1.30/L.

**FIGURE 3-3** 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

### Key 2011–2012 Achievements

- In 2010–2011, the development of a SmartWay Transport Partnership network started. The focus will be on on-road freight movement, which will help both shippers and carriers improve their fuel efficiency and reduce their carbon footprint.
- New fuel-efficient driving instructional material for both light-duty vehicle drivers and medium- and heavy-duty vehicle professional drivers was developed.
- More than 210 000 new drivers and 4300 fleet drivers were trained in efficient driving practices.

***For more information:***
vehicles.nrcan.gc.ca

## ecoENERGY RETROFIT – HOMES

### Objective

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

### Description

Initiated on April 1, 2007, the $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. Originally a four-year program, an additional one-year investment of $400 million was allocated in 2011–2012.

ecoENERGY Retrofit – Homes used NRCan's EnerGuide Rating System to help homeowners make smart energy retrofit decisions for their home. With this system, an energy advisor performs a professional evaluation of the energy efficiency characteristics of the house, including a diagnostic test to determine air leakage. The energy advisor prepares a detailed, personalized checklist of the recommended, most effective upgrades for the property owner, including the EnerGuide pre-retrofit energy rating of the house. The property owner then chooses which upgrades to have done.

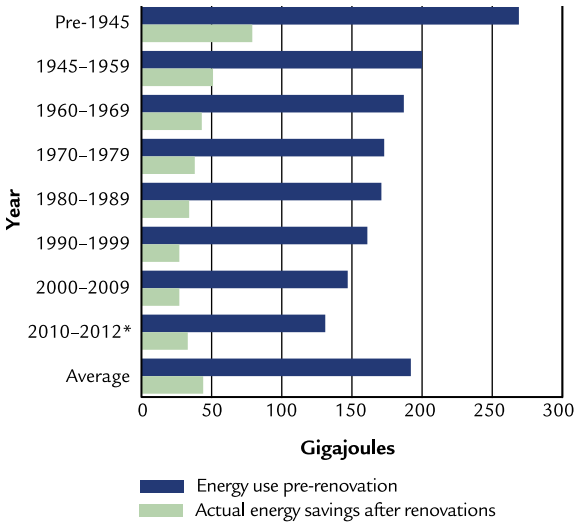
Under ecoENERGY Retrofit – Homes, after the retrofit work was completed, the advisor performed a post-retrofit energy evaluation and assigned a new energy-rating label, and the property owner was then entitled to a grant.

Along with ecoENERGY Retrofit – Homes, 12 of 13 provinces and territories offered complementary incentive programs. Five of these continue to

offer incentive programs, making ongoing use of NRCan's EnerGuide Rating System and its national infrastructure (file processing, quality assurance, technical support, software, etc.).

Figure 3-4 illustrates the energy use and savings gained per household before and after renovations.

**FIGURE 3-4** Residential Energy Use and Energy Savings per Household, Pre-1945 to 2010–2012




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

### Key Program Achievements

- From 2007 to 2012, the ecoenergy Retrofit–Homes program provided incentives to more than 640 000 homeowners. As a result of this program, these homeowners are now saving over $400 million on their annual energy bills and are lowering their energy consumption by an average of 20 percent.
- This program developed the infrastructure for home energy assessments and labelling, and more than 2000 energy advisors have been trained by service organizations since the programs' inception.
- It is estimated that the ecoENERGY Retrofit–Homes program has triggered more than $8 billion in economic activity and has created and protected thousands of jobs.
- Fourteen regional organizations have developed their own energy efficiency programs for homes, and utility and municipality programs are also emerging, all of which use the EnerGuide Rating System and its energy advisors to perform energy evaluations.

## ecoENERGY FOR ALTERNATIVE FUELS

### Objective

ecoENERGY for Alternative Fuels is a five-year $3.0-million program that will help Canada's emerging alternative fuel industries by supporting education and outreach efforts as well as codes and standards development for natural gas.

### Description

The ecoENERGY for Alternative Fuels' activities were identified in the *Natural Gas Use in the Canadian Transportation Sector Deployment Roadmap* as key areas where governments can facilitate the deployment of medium- and heavy-duty natural gas vehicles in Canada.

Education and outreach activities include establishing two local support networks that will act as information hubs for natural gas end-users (i.e. medium- and heavy-duty fleets) and other key stakeholders (e.g. vehicle and equipment manufacturers). The hubs – which are modeled after the United States Clean Cities Program – will provide "on-the-ground" resources to end-users who would like to obtain information about alternative fuelling options such as natural gas. The hubs' primary activities will be delivering education and outreach materials, responding to stakeholder inquiries and organizing workshops.

As a complement to the hubs, the program will launch a Web portal that will ensure consistent, fact-based information is available to investors, end-users and other stakeholders. To achieve this objective, the Web portal will contain information provided by a range of expert sources (e.g. natural gas suppliers, equipment providers and end-users).

In addition to education and outreach, the ecoENERGY for Alternative Fuels program will

support work on codes and standards. One area of focus will be harmonizing codes and standards for compressed natural gas vehicles and infrastructure with those of the United States and provinces. This program will also develop new codes and standards for liquefied natural gas vehicles and infrastructure.

### DID YOU KNOW?

Canada is one of the world's largest producers of natural gas and has one of the most extensive natural gas pipeline distribution networks in the world. Canada's abundant natural gas resources can be used in all of the nation's major economic sectors, including transportation.

### Key 2011–2012 Achievements

- Two codes and standards committees actively worked on developing and updating the natural gas codes and standards.
- Stakeholders were notified of the availability of new research, analysis and studies.
- Three new studies related to codes and standards were completed.

***For more information:***
oee.nrcan.gc.ca/alternative-fuels

## ecoENERGY FOR BIOFUELS

### Objective

To support the production of renewable alternatives to gasoline and diesel and encourage the development of a competitive renewable fuels industry in Canada.

### 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 and sales. The program will invest up to $1.48 billion over nine years, starting April 1, 2008, in support of biofuel production in Canada and the *Renewable Fuels Regulations*.

This program is expected to increase domestic production capacity and develop a competitive domestic renewable fuel industry. The program targets 2.5 billion L of domestic production capacity by December 2012, specifically 2 billion L of renewable alternatives to gasoline and 500 million L of renewable alternatives to diesel fuel.

To receive an incentive, eligible recipients sign a contribution agreement with NRCan, meet the requirements of the *Canadian Environmental Assessment Act* and comply with all other applicable federal, provincial and municipal environmental legislation.

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

- reduce the greenhouse gas emissions that result 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?

Agro-industry residues such as animal fat, restaurant cooking oil, non-food-grade virgin oil or agricultural surplus once destined for a landfill are now a commodity in the biodiesel business.

### Key 2011–2012 Achievements

- As of March 31, 2012, contribution agreements were signed with all eligible producers. Together these 30 agreements represent the capacity to produce 1807 million L per year of ethanol and 494 million L per year of biodiesel by December 2012.

***For more information:***
oee.nrcan.gc.ca/biofuels

## FEDERAL BUILDINGS INITIATIVE

### Objective

To help Government of Canada organizations implement energy efficiency upgrades that lead to reduced energy and water use, greenhouse gas emissions and operating costs.

### Description

The Federal Buildings Initiative facilitates energy efficiency retrofit projects in Canadian federal organizations (departments, agencies and Crown corporations).

The initiative provides tools, training, model documents (energy performance contracts, requests for proposals), 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 initiative's experience for help in designing their own energy efficiency programs using energy performance contracting.

Since its inception in 1991, the initiative has helped upgrade thousands of square metres of federal building floor space, saving $43 million in energy costs and reducing greenhouse gas emissions by approximately 285 kilotonnes per year.

#### DID YOU KNOW?

An energy performance contract uses private-sector dollars to pay for energy efficiency improvements. Typically, under this arrangement, an energy service company is hired to assess a facility, identify possible energy savings, recommend and implement energy efficiency improvements, and guarantee the energy savings. The energy savings pay for the cost of the retrofit over the contract period.

### Key 2011–2012 Achievements

- One hundred and eighty people were trained through customized Dollars to $ense training for nine Department of National Defence air force bases across Canada.
- The National Research Council Canada was helped to finalize its energy performance contract for the retrofit of the federal laboratory located at 100 Sussex Drive, Ottawa.
- The following departments were helped to undertake opportunity assessments toward the development of energy performance projects: Natural Resources Canada, Department of National Defence (air force base in Cold Lake, Alberta), Environment Canada laboratories in Ontario, Agriculture Canada laboratory in Alberta and five Health Canada laboratories in Ontario.

***For more information:***

oee.nrcan.gc.ca/fbi

CHAPTER 4

# Clean Energy Science and Technology

## INTRODUCTION

Natural Resources Canada (NRCan) invests in research, development and demonstration of new and emerging clean energy science and technology that produces economic, social and environmental benefits for Canadians. NRCan's Office of Energy Research and Development and CanmetENERGY lead the federal government's energy science and technology operations.

NRCan, through CanmetENERGY and the Office of Energy Research and Development, undertakes and funds projects and activities in the following strategic areas:

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

The Office of Energy Research and Development oversees the management of the Program of Energy Research and Development, the ecoENERGY Technology Initiative, the Clean Energy Fund and the ecoENERGY Innovation Initiative.

These programs collectively allocated more than $248 million in the 2011–2012 fiscal year across the six strategic areas. 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 research, development and demonstration initiatives. The work undertaken was delivered in partnership with CanmetENERGY, other government departments and agencies and the private sector.

CanmetENERGY, with its three laboratories across Canada, generates and provides knowledge and technologies to advance the development and use of innovative solutions that contribute 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.

This chapter describes in detail the programs, activities and 2011–2012 key achievements of the Office of Energy Research and Development, CanmetENERGY and other partners in energy science and technology.

***For more information:***

nrcan.gc.ca/eneene/science/resres-eng.php
canmetenergy.nrcan.gc.ca/home

## PROGRAM OF ENERGY RESEARCH AND DEVELOPMENT

### Objective

To fund research and development designed to ensure a sustainable energy future for Canada in the best interests of its economy and the environment.

### Description

The Program of Energy Research and Development is a federal, interdepartmental program operated by NRCan. The program funds research and development designed to ensure a sustainable energy

future for Canada in the best interests of both our economy and our environment.

Thirteen federal departments and agencies participate in the program:

- Agriculture and Agri-Food Canada
- Atomic Energy of Canada Limited
- Canada Mortgage and Housing Corporation
- Environment Canada
- Fisheries and Oceans Canada
- Health Canada
- Aboriginal Affairs and Northern Development Canada
- Industry Canada
- National Defence
- National Research Council Canada
- Natural Resources Canada
- Public Works and Government Services Canada
- Transport Canada

These departments and agencies may collaborate with

- the private sector
- associations
- other funding agencies such as the National Sciences and Engineering Research Council of Canada, the Industrial Research Assistance Program and Sustainable Development Technology Canada
- universities
- provincial and municipal governments and research organizations
- international organizations

Efficiencies are sought in energy production, distribution and end use.

The program budget for the 2011–2012 fiscal year was approximately $48 million. Of that amount, $13.5 million was allocated to 12 federal departments and agencies that are program partners, mostly to improve the science supporting Canadian regulations related to energy production and use. The remaining $34.5 million was allocated to energy research and development programs managed and performed in NRCan, approximately 59 percent of which contributed to improved energy efficiency and the integration of renewable energy sources in Canada.

***For more information:***
nrcan.gc.ca/energy/science/programs-funding/1509

## 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 initiative is a component of ecoACTION, the Government of Canada's actions toward clean air and greenhouse gas emissions reductions. It is a $230-million investment in clean energy science and technology. The funding helps in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use. Part of the funding has been allocated to the demonstration of carbon capture and storage. Nine projects have been selected in this area. Spending in the 2011–2012 fiscal year was nearly $52 million.

### Program Highlights/Achievements

- Husky Oil Operations Ltd. has started operation at their Lloydminster, Saskatchewan, upgrading facility and has started capturing carbon dioxide ($CO_2$) at the rate of 100 000 tonnes of carbon dioxide per year. The $CO_2$ will be sequestered in depleted oil wells located in Lashburn and Tangleflags, Saskatchewan.
- Enhance Energy Inc. has completed front end engineering studies and is moving ahead to implement the Alberta Carbon Trunk Line to enable the transportation of $CO_2$ gathered in the Alberta Industrial Heartland to enhance oil recovery at oil fields in central Alberta.

***For more information:***
nrcan.gc.ca/energy/science/1335

## CLEAN ENERGY FUND

### Objective

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

### Description

The $795-million Clean Energy Fund, a component of Canada's Economic Action Plan announced in 2009, provides funding for the research, development and demonstration of promising technologies to support the Government of Canada's commitments to reducing greenhouse gas emissions. Approximately 33 percent of the 2011–2012 Clean Energy Fund 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 Clean Energy Fund expenditures for the 2011–2012 fiscal year were approximately $110 million. Of that amount, approximately $53.7 million was allocated to large-scale demonstration projects and approximately $36.4 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 $19.8 million was allocated to research and development.

### Key 2011–2012 Achievements

- The year 2011–2012 marked the third of five years in the delivery of the Clean Energy Fund small-scale demonstrations component. In the year 2011–2012, 16 contribution agreements continued, one new agreement was signed, two projects were terminated, and two more projects continued negotiations toward an agreement. Also, to utilize unused funds, a mid-cycle call for proposals was held, which resulted in seven successful project enhancements.
- Approximately $36 million was disbursed to 17 active, small-scale demonstration projects, with more than $63 million in additional funding from the private sector, universities and other government organizations.
- More than 12 megawatts (MW) of renewable energy generation were installed in fiscal year 2011–2012, marking the first year of significant renewable energy project commissioning. Some of the systems installed included a 5-megawatt thermal ($MW_{th}$) biomass district heating system, part of "La Cité Verte" housing project in Québec, Quebec, and 6 MW of wind turbines in Prince Edward Island, which will be combined in the following years with energy storage technologies to manage variable wind power generation.

***For more information:***
nrcan.gc.ca/energy/science/programs-funding/1482

## ecoENERGY INNOVATION INITIATIVE

### Objective

To support energy technology innovation to produce and use energy in a cleaner and more efficient way. This initiative is a key component of the Government of Canada's actions to achieve real emissions reductions, while maintaining Canada's economic advantage and its ability to create jobs for Canadians. The ecoENERGY Innovation Initiative will also help in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use.

### Description

The initiative received initial funding of $97 million in Budget 2011, with additional funds of $184 million announced in spring 2012 to bring the total program funds to $281 million over five years. The initiative supports energy technology innovation to produce and use energy in a cleaner and more efficient way through research and development projects and demonstrations in five key strategic areas: energy efficiency; clean electricity and renewables;

bioenergy; electrification of transportation; and unconventional oil and gas.

### Key 2011–2012 Achievements

- The ecoENERGY Innovation Initiative was launched in August 2011 with requests for letters of interest for research and development (internal and external) and demonstration projects.
- In fiscal year 2011–2012, $16 million was allocated to federal laboratories for 111 projects to be completed within the fiscal year.
- Approximately $65 million were also allocated to federal labs for 71 research and development projects that will take place between 2012 and 2016.
- The call for external demonstration and research and development letters of interest led to 246 demonstration and 436 research and development submissions. The letters of interest review was followed by a request for full proposals for those submissions that met the criteria. By the end of the 2011–2012 fiscal year, the initiative had selected 24 demonstration projects and 44 research and development projects to proceed to a rigorous review process.

***For more information:***
ecoenergyinnovation.nrcan.gc.ca

## 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 greenhouse gas emissions.

### Description

CanmetENERGY plays a leadership role in the research, development and demonstration 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 links 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 programs.

CanmetENERGY is active in conceiving, developing and optimizing energy-efficient space and water heating, ventilation, air-conditioning and refrigeration technologies, heat pumps, 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, in particular with renewables, and adaptation to the Canadian context.

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

intelligent building 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.

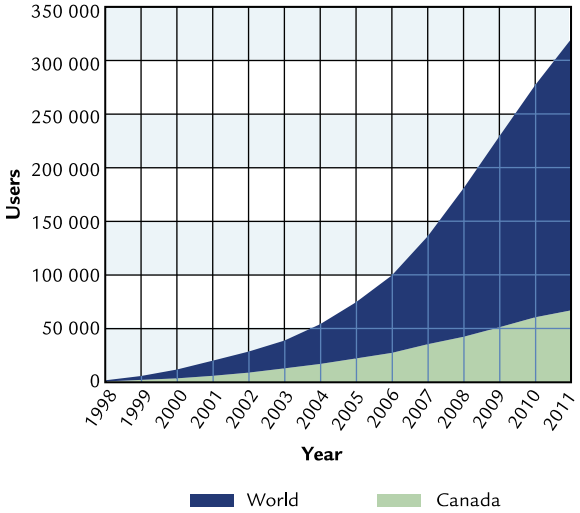
### DID YOU KNOW?

Testing conducted by CanmetENERGY in 2011 at the Canadian Centre for Housing Technologies (a facility collaboratively run by NRCan, the National Research Council and Canada Mortgage and Housing Corporation) has shown that significant (>50 percent) energy savings can be achieved by using ultra-high efficiency, cold-climate, mini-split heat pump technologies in a zoned heating/cooling application, when used with a high efficiency gas fireplace as backup in the heating season. The test results have significant implications for retrofit programs.

## Key 2011–2012 Achievements

- CanmetENERGY's RETScreen®[9] Clean Energy Project Analysis Software had another milestone year. The number of RETScreen users increased to more than 319 000 people in every country and territory of the world (see Figure 4-1). In addition, more than 400 colleges and universities globally are now using RETScreen for teaching and research. The new *RETScreen Plus* energy management software tool, developed in co-operation with the NASA Langley Research Center and the Austria-based Renewable Energy and Energy Efficiency Partnership, was released in 36 languages. In June 2011, the first RETScreen Conference & Training Institute was held in Niagara Falls, Ontario. This event brought together 270 key clean energy stakeholders from 40 countries.

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




Source: NRCan/RETScreen Customer Database.

- Working to improve the reliable measurement of energy in communities, CanmetENERGY has taken a leadership role in the development of integrated community energy mapping and modeling. CanmetENERGY provided support and acted as scientific authority on the Tract and Neighbourhood Data Modelling project. Led by the Province of British Columbia, with collaboration from municipalities, utilities, academic and private sectors, the project developed a new map-based method for creating the community energy and emissions inventory reports for buildings at the neighbourhood or census-tract scale.
  - During summer heat peaks, most residential electricity is used for air conditioning. To address this, CanmetENERGY conceived a zoning strategy and partnered with private, public and academic sector organizations to develop, demonstrate and conduct a field

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

trial. CanmetENERGY partnered with the Ontario Power Authority and local utilities to consider using a zoning strategy in smart grid applications with utility-controlled thermostats similar to that currently being offered for traditional systems through the peak saver program. A statistically representative sample of field test homes has shown that air-conditioning loads can be cut by more than 50 percent during utility peaks, while providing superior comfort to the traditional peak saver approach.

- The EQuilibrium™ Communities Initiative assisted five projects in integrating their community planning and improving the energy efficiency of their buildings and energy systems. Improvements in Edmonton-based Station Pointe, for example, moved to a passive house design concept for the high-rise condominium (a first) to reduce the energy used to heat and cool buildings by over 90 percent and will now be treating the community's waste water on site.

- The commercialization of the DABO™ software developed by CanmetENERGY is performed by IFCS, a Montréal-based company. DABO is a software tool that enables continuous optimization of building operation, to achieve and maintain energy reductions while maintaining indoor comfort conditions. DABO includes modules for fault detection and diagnosis of mechanical systems and commissioning. It helps to perform commissioning and recommissioning in buildings equipped with a central control system and to maintain energy savings and corresponding greenhouse gas emissions reductions in the range of 10 to 30 percent.

- CanmetENERGY developed knowledge and expertise on $CO_2$ as a refrigerant or heat transfer fluid. This natural refrigerant is now largely adopted in Canadian supermarkets and is starting to be implemented in ice rinks. $CO_2$ has a much lower global warming potential than synthetic refrigerants and has high heat transfer properties. Its use in refrigeration helps to significantly reduce the energy consumption and greenhouse gas emissions of refrigeration systems. Sobeys recently announced that $CO_2$ will be the new standard for the refrigerant used in all stores of the supermarket chain. The chain has already implemented this natural refrigerant in 23 of its Quebec stores.

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

## CLEAN ELECTRIC POWER GENERATION

### Objective

To develop and apply technologies for renewable electricity production and for cleaner power generation from fossil fuels, with the goal of increasing efficiency and achieving the reduction and, ultimately, the elimination of emissions of acid rain precursors, greenhouse gases, 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 science and technology 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 links between utilities, industry and academia
- conducting nationwide resource assessments and mapping

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

### DID YOU KNOW?

The latest (2012) edition of the *Canadian Electrical Code, Part 1,* now includes, for the first time, Section 64 on Renewable Energy Systems. This new section covers fuel cells, small and large wind power, hydrokinetic and micro-hydropower systems.

### DID YOU KNOW?

One means of reducing industrial emissions of greenhouse gases, and thereby addressing climate change issues, is to incorporate carbon capture and storage technologies at large point-source industrial facilities. However, the additional cost of carbon capture and storage technologies to the industry and the efficiency penalty incurred through these technologies are major barriers to the deployment and adoption of the technologies. NRCan researchers are exploring newer designs and systems that have the potential to reduce the aforesaid costs while at the same time improving on efficiencies. If successful, these technologies would help Canadian and international industries address the global problem of climate change.

## Key 2011–2012 Achievements

- CanmetENERGY was a co-chair of the national Smart Grid Technology and Standards Task Force that completed an exhaustive review of the current status and future needs of the electric power industry. The task force includes more than 50 active experts across eight stakeholder groups in Canada. The roadmap report with 17 recommendations was submitted to the Canadian National Committee of the International Electrotechnical Commission and the Standards Council of Canada. This national strategic plan will encourage the adoption of harmonized standards during a period in which Canadian provinces are investing in modernizing the electricity power system.
- CanmetENERGY's *Oxy-fuel combustion for power generation and carbon-dioxide ($CO_2$) capture* was published by Woodhead. This is a first of its kind publication in this technology area that highlights the research conducted at CanmetENERGY over many years and includes contributions from researchers around the world.

- Foster Wheeler, a boiler manufacturer, has successfully demonstrated oxy-combustion circulating fluid bed reactor technology at the 30-$MW_{th}$ scale at the CIUDEN Technology Development Centre for $CO_2$ Capture in Spain. This success is due in part to an extensive test program conducted at the CanmetENERGY 0.8-$MW_{th}$ fluid bed to characterize the potential design fuels and sulphur sorbents. The test was done both in air and oxy combustion modes. This program was a collaboration with CanmetENERGY and Spain's Empresa Nacional de Electricidad.
- Due in part to tests carried out at CanmetENERGY, Pratt & Whitney Rocketdyne has successfully demonstrated their compact gasification technology that uses Canadian coal and oil sands petroleum coke in collaboration with Alberta Innovates – Energy and Environment Solutions at the scale of 20 tonnes per day.
- The Marine Renewable Energy Technology Roadmap was unveiled at the Ocean Renewable Energy Group annual conference in Montréal in November 2011. Designed to secure Canada as a world leader in marine renewable development, the roadmap outlines Canada's collaborative efforts to advance the commercialization of marine energy technologies while improving its global competitiveness. More than 100 organizations contributed to the roadmap.
- In November 2011, the Drake Landing Solar Community was recognized for its innovative excellence by winning the Energy Globe World Award from the Energy Globe Foundation. The prize jury included international organizations such as the World Bank and the European Renewable Energy Council. This is a first for the department and the first time a Canadian project has achieved such a distinction. Initiated and led by CanmetENERGY, the Drake Landing project is the first large-scale, solar, seasonal storage system in North America.
- A study that examines the impact of cold climates on the electricity production from 24 wind farms in Canada was completed in 2011. This study compared the actual production output of these wind farms against a potential production based on the actual wind conditions and identified a potential lost opportunity of between 1.6 and 27.4 percent of the wind farms total potential annual production. The study also examined the technologies available to mitigate the impact of cold climates on wind farm electricity production (blade ice reduction systems), which will be the focus of future research and development.

### DID YOU KNOW?

In 2011, the Canadian Photovoltaic industry drove $584 million of economic output and provided direct employment for approximately 5100 hours. Key innovative photovoltaic companies in Canada have raised more than $95 million in government and venture capital funding. In addition, private companies are dedicating more than $20 million annually for photovoltaic research and development in Canada.

Source: CanmetENERGY (2012), *Sector Profile for Solar Photovoltaics in Canada*

***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 greenhouse gas 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 science and technology 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 science and technology 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 2011–2012 Achievements

- A catalytic converter capable of reducing nitrogen oxide emissions from diesel engines has been developed to the prototype testing phase at CanmetENERGY, with the assistance of an emission control manufacturer. Testing was completed on small diesel engines and is planned to be tested in diesel-powered mining equipment at the CANMET Mining and Minerals Sciences Laboratories. An effective catalyst capable of retrofit on mining equipment would dramatically reduce the energy expenditure and operating cost of ventilation for mines, while allowing engine designers to design for full energy efficiency.
- CanmetENERGY developed a unique optimization algorithm to redesign complex heat exchanger network in industry. This algorithm was tested as part of demonstration projects in two oil refineries, showing potential energy savings of over 20 percent in crude preheat trains of these refineries. This could result in energy savings of more than $7 million per year for these two cases. The algorithm will be made available to the industry and its consultants by the end of 2012 by being embedded in the CanmetENERGY integration software that is used to identify and evaluate heat recovery opportunities in industrial processes.
- A tool that improves recovery boiler operation, the heart of the Kraft pulp and paper process, was developed and implemented. Increased throughput and efficiency, reduced carryover and emissions as well as more stable downstream processes were obtained. As a result, a 3.5 percent increase in steam production was identified at the Fibrek mill in Saint-Félicien, Quebec. This additional steam can be used to produce 1.6 MW of additional electricity or to reduce heavy oil consumption at the plant, leading to increased revenues and competitiveness for the mill. CanmetENERGY now plans to deploy this low cost technology for the rest of the industry.

- CanmetENERGY has developed knowledge and expertise on a device known as an ejector that can produce cold from waste heat for industrial applications. The ejector uses energy from flue gases to cool incoming air for an industrial process. The free energy thus recovered from the outgoing gases improves the process and reduces the fossil fuel requirements. The technology will be deployed internationally in 2014.

### DID YOU KNOW?

CanmetENERGY-Varennes is the national centre of expertise for process integration. Process integration is a powerful approach to optimizing energy use and power generation in industrial facilities. To date, 53 large and medium-sized companies benefit from process integration, resulting in energy cost savings of $54 million annually and a reduction in direct greenhouse gas emissions of 311 kilotonnes per year.

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

## ENVIRONMENTALLY SUSTAINABLE OIL AND GAS

### Objective

To provide science and technology for the continued, secure supply of affordable, cleaner and more efficient fossil fuels, with little or no adverse environmental impact on greenhouse gas and criteria air contaminant 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.

Science and technology is a key tool used by NRCan to make significant progress toward meeting its water and tailings, greenhouse gas 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 2011–2012 Achievements

- Fundamental research conducted at CanmetENERGY identified the properties behind the fast settling rates of the high-temperature froth treatment. This discovery allows for the targeting of particular conditions that will generate greater treatment efficiencies. Shell Canada began operation of the treatment technology in 2012. This treatment improves energy efficiency by 10 percent and reduces water use by 10 percent but the mechanism behind these improvements was unknown. Through CanmetENERGY's research, the properties behind these efficiencies were discovered.
- CanmetENERGY discovered a new mechanism of emulsion stabilization for the naphtha froth treatment process. This new discovery should lead

to the development of specialized demulsifiers, which enhance the removal of water/oil emulsions from the bitumen by using the naphtha process. Enhancing the removal of the emulsion will decrease corrosion and increase bitumen quality for direct pipelining. The naphtha froth treatment process is currently used by Canadian Natural Resources Limited, Suncor Energy Inc. and Syncrude Canada Ltd. oil sands operations.

- CanmetENERGY has developed analytical methods to measure solubility parameters to reduce compatibility and fouling issues and developed new methods for measuring total acid values and crude corrosivity to address pipeline and refinery corrosion concerns. Knowledge from this work was used to respond to policy, media and parliamentary questions concerning the corrosivity of transporting oil sands crude in pipelines. As well, a collaborative project with the Alberta government and industry was initiated that is using this knowledge to develop technologies to selectively remove problematic chemicals to improve oil sands crude value and reduce the environmental impacts from upgrading and refining.
- In 2012, UOP LLC announced that its new process technology was selected by National Refinery Limited in Pakistan. This new design is based on a slurry hydrocracking process previously developed by CanmetENERGY. This technology will help refiners get a higher-value product from each barrel of crude by maximizing diesel and lubricant production from petroleum residue. National Refinery Limited selected the technology to produce 40 000 barrels per day of diesel fuel and 4500 barrels per day of lube base oils.
- CanmetENERGY's researchers found and measured the extent to which chemicals similar to those that typically would be added in an oil sand operation (corrosion inhibitors, flocculants, emulsifiers and detergents) adsorb minerals and organic-coated minerals that would be found in an oil sand area. These values are the factors needed to model contaminant transport in groundwater, an important aspect in determining the sustainability of reclaimed oil sand tailings ponds.

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

## CLEAN TRANSPORTATION ENERGY

### Objective

To research, develop and deploy innovative, energy-efficient and clean transportation energy technologies, with the goal of reducing transportation greenhouse gas emissions while improving urban air quality and offering economic opportunities for Canadian industry.

### Description

CanmetENERGY works with domestic and international stakeholders ranging from original equipment manufacturers and associations to universities and federal departments, focusing on three principal technology areas: hybrid and electric vehicles, advanced fuels and technologies, and hydrogen and fuel cells. CanmetENERGY is actively engaged in the development of safety, codes and standards, as well as technology roadmaps related to transportation.

At this time, 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 supporting research and development of on-board energy-storage and power systems, such as batteries and fuel cells. Following the development of the Canadian Electric Vehicle Technology Roadmap in 2010, CanmetENERGY continues to play a significant role in coordinating stakeholders and delivering on the recommendations from the roadmap.

Research and development in advanced fuels such as natural gas, biodiesel, and ethanol and in their related technologies is strengthening Canadian industries that now include world-leading technology providers and are exporting commercial products world-wide. CanmetENERGY is also leveraging

capacity for advanced fuels and technology research through national and international collaborative efforts such as the Canadian Natural Gas Roadmap Technical Advisory Group and the Advanced Motor Fuels Agreement of the International Energy Agency.

With regard to hydrogen and fuel cell technologies, long-term investments and partnerships led by CanmetENERGY have resulted in world-leading scientific breakthroughs and demonstrations. Today, Canadian technology is used in more than 60 percent of all hydrogen and fuel cell demonstrations worldwide. Canada also exports more than 90 percent of its hydrogen and fuel cell technology. CanmetENERGY continues to support research and development in hydrogen production, hydrogen storage, fuel cell utilization and safety, codes and standards. Cost reductions, performance and harmonization of standards remain the critical goals.

### DID YOU KNOW?

The British Columbia transit fleet is operating the world's largest hydrogen fuel cell-powered bus fleet. The fleet is fuelled by the world's largest hydrogen fuelling station, dispensing up to 1000 kilograms per day since it went into service in 2010.

### Key 2011–2012 Achievements

- CanmetENERGY helped establish the Natural Gas Roadmap Implementation Committee, which supports the implementation of the recommendations from the *Natural Gas Use in the Canadian Transportation Sector Deployment Roadmap*, published in January 2011. In addition, CanmetENERGY is co-chairing the Natural Gas Roadmap Technical Advisory Group, which provides advice and guidance on industry, government and academic research, development and demonstration efforts.
- CanmetENERGY worked in partnership with Hydrogenics to develop a new, megawatt-scale, very compact, proton exchange membrane electrolyser stack platform that is suitable for large energy storage capacity for smart grid and renewable energy applications. Hydrogenics is a Canadian company with expertise and world leadership in designing, building and commissioning alternate energy systems. The new stack is designed to produce 570 kilograms per day of hydrogen fuel and would occupy only 0.26 cubic metres of space. The convergence of the electric distribution grid with the gas distribution and storage infrastructure opens up a new world of flexibility and adaptive capacity for energy in Canada.

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

## SUSTAINABLE BIOENERGY

### Objective

To assist Canadian industry in the research, development and demonstration of bioenergy technologies, thereby increasing the production and use of bioenergy, which generates environmental and economic benefits.

### Description

CanmetENERGY supports the research, development and demonstration 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 expertise in biomass energy conversion technology 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 research, development and demonstration, technical and socio-economic studies, end-use demonstrations and testing, feasibility studies, process analysis, verification, testing and improvement, emissions reductions, modelling, conference and workshop support, information dissemination, International Energy Agency collaboration and committees, stakeholder education, and standards development.

NRCan leads the Canadian Biomass Innovation Network, which was formed to direct federal research and development on bioenergy and bioproducts. Clients include the agricultural and forestry sectors (biomass producers and bioenergy consumers), municipalities and industrial partners.

The network supports strategic research and development in bioenergy, biofuels, bioproducts and industrial bioprocesses to reduce fossil-fuel energy consumption, directly or indirectly reduce greenhouse gas and criteria air contaminant emissions.

The network is managed by Agriculture and Agri-Food Canada, Environment Canada, Industry Canada, National Research Council Canada, NRCan and the Natural Sciences and Engineering Research Council of Canada.

## Key 2011–2012 Achievements

- Private industry research that has been developed through contribution agreements managed by CanmetENERGY has been used to introduce fuel gas gasifiers for application in combined heat and power in Prince George and Vancouver, British Columbia. These installations exploit local sources of woody biomass and will be evaluated for performance in real-world operation.
- Using pyrolysis oil in commercial boilers was tested at CanmetENERGY with the active participation of a pyrolysis oil producer and a burner design company (Brais Malouin and Associates, inc.). Critical parameters were identified for the combustion of the oil so that it would meet current safety and operation practice standards. As well, components that would need further improvement were identified. This represents the first controlled combustion of the oil in a commercial-scale application.

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

CHAPTER 5

# Renewable Energy

## RENEWABLE ENERGY USE

In 2010, renewable sources accounted for 17.1 percent of Canada's total primary energy supply and about 62 percent of Canadian electricity generation and 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 | 61.2 | 1.9 |
| 2007 | 76 888 | 61.9 | 1.4 |
| 2008 | 78 419 | 62.4 | 2.0 |
| 2009 | 80 658 | 62.6 | 2.9 |
| 2010 | 80 905 | 62.0 | 0.3 |

Source: Statistics Canada, *Electric Power Generating Stations*

**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 | |

### 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.

Hydro is the main source of electricity in Canada, accounting for 59 percent of the electricity generated in 2010. Canada's hydro supply is dominated by large-scale projects developed by electric utilities.

Of the 75 104 megawatts (MW) of installed hydro capacity, 3461 MW come from small hydro sites (capacity less than 50 MW), representing 2.7 percent of Canada's total installed electricity capacity. Significant potential remains for additional large and small run-of-river hydroelectric development in most provinces and territories.

## Biomass

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

Biomass supply typically takes the following forms:

- forest sector – 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 4.4 percent of Canada's total primary energy supply comes from bioenergy. In terms of renewable energy supply, bioenergy is second only to hydro power (which generates 12.3 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 2010, 685 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 (868 MW) came from wood refuse used by the forest 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 2010, the biomass installed generating capacity was 1700 MW, of which 8.6 percent was from landfill gas plants (112 MW) and municipal solid waste plants (35 MW). Approximately 200 million litres of fuel ethanol are produced annually in Canada from cereal grain and corn. Biodiesel is also produced in small quantities, but production is increasing. Canada has the potential to increase its bioenergy production in a sustainable manner.

## Earth Energy

As a result of the sun heating the surface of the planet, and because of the insulating qualities of the earth itself, the temperature 1 or 2 metres (m) 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. The pumps are electrical systems that use the relatively constant temperature of the ground to provide heating, cooling and hot water for homes and commercial buildings.

For this reason, a ground-source heat pump is also known as an earth energy system. During winter, earth energy systems remove heat from the earth by using a liquid, typically an antifreeze solution or water, that circulates within an underground loop. The system 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. Earth energy systems supply less than 1 percent of the market for space and water heating and cooling in Canada.

In 2010, approximately 11 265 ground-source heat pumps were installed in Canada. This is roughly 28 percent less than the 15 640 pumps installed in 2009. As of December 31, 2010, more than 95 000 pumps were in operation in Canada, representing about 1045 megawatts of thermal energy (MWth) of installed capacity and producing an estimated 1420 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, 2011, 5265 MW of wind power had been installed in Canada. This makes Canada the country with the ninth largest installed wind energy capacity.

The best year in terms of wind power installations was 2011, with 1298 MW of new wind power generating capacity installed across the country, representing a 33 percent increase from the 2010 level (3967 MW) (see Figure 5-1). In fact, Canada ranks the sixth in the world in terms of new installations in 2011. Federal and provincial policies continue to spur growth in the Canadian wind industry.

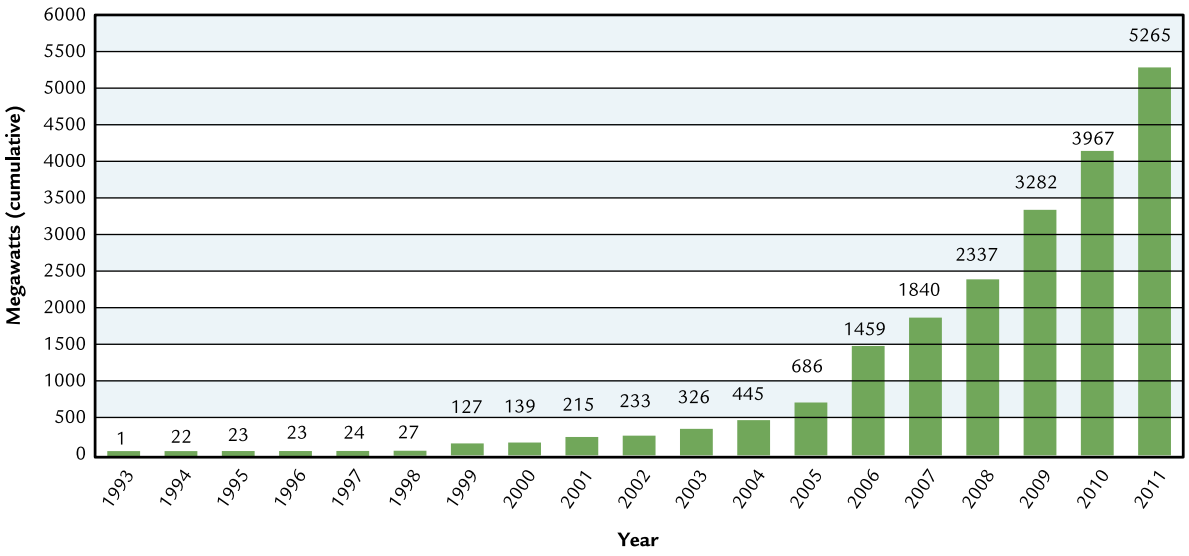
Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairie provinces. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses.

## 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

**FIGURE 5-1** Canadian Wind Power Capacity, 1993 to 2011 - cumulative




Source: Natural Resources Canada and the Canadian Wind Energy Association

- solar electric (photovoltaic) systems – solar radiation is used to produce electricity

The Canadian active, solar thermal installed capacity in 2011 was 1 184 830 $m^2$, which is approximately 820 $MW_{th}$. The domestic market increase has averaged over 20 percent annually since 1998. In 2011, the solar thermal collector market in Canada was approximately 163 435 $m^2$, approximately 18 percent fewer installations than in 2010 (199 490 $m^2$).

Solar photovoltaic energy also experienced high rates of capacity growth – about 40 percent average growth rate annually between 1992 and 2011 – even though it started from a low baseline. So far, 2011 has been the best year for solar photovoltaic energy, with an estimated total installed capacity of 495 MW, representing an increase of 204 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 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.

## MARINE RENEWABLE ENERGY ENABLING MEASURES PROGRAM

### Objective

The objective of the Marine Renewable Energy Enabling Measures program is to draft a federal policy framework for administering marine renewable energy activity in the federal offshore by fiscal year 2015–2016.

### Description

The program will propose a policy framework to the Government of Canada on the future administration of marine renewable energy in the federal offshore.

The first of two phases of the program will research and analyse Canada's policy instruments, including relevant legislation and regulations, consult with stakeholders, and examine international marine renewable energy management regimes. The information gathered will help develop a policy paper. The paper will also highlight issues that need to be addressed to develop an efficient and effective policy framework for administration.

The second phase will consult further with stakeholders on the policy paper and develop a policy framework for the government's approval.

### Key 2011–2012 Achievements

- Identified, developed and attained initial legal opinions of governance model options.
- Examined marine regulatory regimes in eight countries.
- Initiated informal consultations within Natural Resources Canada, the Department of Fisheries and Oceans, and the National Energy Board.

## PULP AND PAPER GREEN TRANSFORMATION PROGRAM

### Objective

The Pulp and Paper Green Transformation Program has accomplished its objective of improving the environmental performance of Canadian pulp and paper mills.

#### DID YOU KNOW?

The Pulp and Paper Green Transformation Program and the Transformative Technologies Program of Natural Resources Canada provided the funding for the Biogas Production from Mill Effluent Streams project of AV Cell Inc. in Atholville, New Brunswick. The project demonstrates the advantages of product diversification for pulp and paper mills. In collaboration with FPInnovations, the mill installed innovative, new technologies for the production and capture of biogas from mill effluent streams. This biogas can be burned to generate power, thereby replacing the use of fossil fuels.

### Description

The $1-billion program operated from June 2009 to March 31, 2012, and supported environmentally friendly investments in Canada's pulp and paper industry in areas such as energy efficiency and renewable energy production. The program funded 98 projects at 43 mills across Canada, supporting approximately 14 000 jobs. The program was highly successful, with more than 99 percent of available funding being used by pulp and paper companies for a variety of projects that have significant environmental benefits.

### Key Achievements

Projects funded under the program

- added nearly 200 MW of renewable electrical capacity
- produced enough renewable thermal energy to continuously heat 70 000 homes
- produced energy savings equivalent to the energy used to heat all of the houses in the city of Québec on an ongoing basis
- reduced the direct greenhouse gas emissions of the Canadian pulp and paper sector by over 10 percent from 2009 levels (because of reduced use of fossil fuels on mill sites)
- reduced mills' water use by nearly 11 million cubic metres per year – the amount of water needed to fill 4000 Olympic-sized swimming pools

#### DID YOU KNOW?

Pulp and Paper Green Transformation Program projects are expected to reduce the Canadian pulp and paper sector's consumption of Bunker C (heavy) oil by 40 percent!

***For more information:***

cfs.nrcan.gc.ca/pages/231

## INVESTMENTS IN FOREST INDUSTRY TRANSFORMATION

### Objective

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

### Description

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

## Key 2011–2012 Achievements

- The program's second and final call for proposals, which closed in September 2011, received 57 applications representing $1.2 billion in project proposals. Nearly $300 million were requested.
- The response to the program's calls for proposals demonstrates significant appetite within the Canadian forestry sector for implementing highly innovative technologies; almost 30 percent of the projects proposed were world-first applications of new technologies.
- Renewable bioenergy is an important area for technology investments in this sector. Fifty percent of the applications were for bioenergy-related projects, including cogeneration, torrefaction, gasification and pyrolysis.
- The program supported four first-in-Canada projects in 2011–2012, which represents $26 million invested since the program's inception in 2010.

### DID YOU KNOW?

The Investments in Forest Industry Transformation program contributed $2.11 million to install a Turboden Organic Rankine Cycle system that will turn biomass-based waste heat into power at the Nechako Lumber Co. Ltd. mill in Vanderhoof, British Columbia. This is the first project of its kind in a Canadian mill, with potential to inspire significant replication across the sector. In fact, the technology provider, Pratt & Whitney Power Systems, has already announced plans for two similar systems at another forest products site in British Columbia.

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

CHAPTER 6

# Co-operation

## INTRODUCTION

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

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

Municipal governments and agencies participate in NRCan's energy efficiency, alternative transportation fuels and renewable energy 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.

For alternative fuels, there is a Natural Gas Roadmap Implementation Committee that consists of a range of industry stakeholders who are uniquely positioned to guide the implementation of the roadmap's specific recommendations.

Internationally, Canada engages bilaterally with key partner countries and multilaterally with a number of international organizations focused on energy efficiency, alternative transportation fuels and renewable energy. This collaboration is detailed in this chapter.

### Green Municipal Fund

The Government of Canada endowed the Federation of Canadian Municipalities, a non-profit organization, with $550 million to establish the Green Municipal Fund to provide a long-term, sustainable source of funding for municipal governments and their partners. The fund 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 fund agreement, the Government of Canada (represented by NRCan and Environment Canada) participates in governing 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 federation's board of directors approves projects in light of the council's recommendations. As of March 31, 2012, the federation has committed $613 million to support 934 green initiatives across Canada. Note that these are net amounts (approvals minus withdrawals and cancelled projects).

More details can be found in the *Green Municipal Fund Annual Report 2011–2012* at fcm.ca/home/about-us/green-municipal-fund-council/annual-reports.htm.

### Natural Gas Roadmap Implementation Committee

NRCan facilitated the development of a deployment roadmap for natural gas use in the Canadian transportation sector, which was released in January 2011. Working in partnership, governments at all levels, industry and academic and non-governmental organizations identified opportunities and challenges associated with deploying natural gas vehicles. The roadmap includes 10 recommendations in four key areas: de-risking investment and early adoption; addressing information gaps; increasing capacity to sustain markets; and ensuring on-going competitiveness.

After the roadmap was released, the Natural Gas Roadmap Implementation Committee was established with representatives from a range of industry stakeholders who are uniquely positioned to guide the implementation of the roadmap's recommendations. The committee supports implementing the recommendations and assesses progress against key milestones. The committee recommends to stakeholders how the natural gas community could respond to future developments, such as changes in market conditions and technological innovations.

The committee oversees an outreach and education working group and a technical advisory group. The groups

- facilitate creating a Web site about alternative transportation fuels and two local support networks that will deliver education and outreach materials to fleets and other stakeholders
- work in partnership with key stakeholders on codes and standards for alternative fuel vehicles and infrastructure with the goal of enhancing the capacity within the standards community to harmonize, align and update the codes and standards

## 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 energy efficiency, alternative transportation fuels and renewable energy 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.

### Energy and Mines Ministers' Conference

The annual Energy and Mines Ministers' Conference is the primary forum for federal, provincial and territorial ministers to discuss shared challenges and priorities affecting the energy and mining sectors in Canada.

In 2007, the Energy and Mines Ministers' Conference released *Moving Forward on Energy Efficiency in Canada: A Foundation for Action*. This document highlighted the value of reducing energy waste, while recognizing the vital role that governments can play in advancing energy efficiency as investors in programs and as policy-makers and regulators who help shape the marketplace by reducing barriers to action.

At the 2011 conference, ministers approved a *Collaborative Approach to Energy* and its associated action plan. The focus on a balanced supply-demand approach to energy demonstrates the importance of energy efficiency within a broader suite of energy policies. More specifically, the action plan provided concrete examples of planned federal, provincial and territorial government collaboration:

- Publish a more stringent model energy code for buildings and commit to a cycle of further improvements.

- Collaborate on a next-generation home energy rating system to support labelling, codes and incentives.
- Improve the energy efficiency of energy-using products purchased by Canadians.
- Strengthen business capacity to finance energy efficiency projects in the built environment.
- Advance the energy efficiency of freight transportation in Canada.
- Improve industrial energy performance by adopting the ISO 50001 Energy Management Systems standard.
- Collaborate with the goal of identifying and implementing new trends in integrated community energy planning.

## STEERING COMMITTEE ON ENERGY EFFICIENCY

Established in 2004 under the auspices of the Energy and Mines Ministers' Conference, the Steering Committee on Energy Efficiency is tasked with establishing a coordinated, complementary agenda for energy efficiency in the built environment and equipment, industry and transportation sectors. In fiscal year 2011–2012, the federal, provincial and territorial members of the committee met to discuss issues related to energy efficiency across their respective jurisdictions.

The committee's work is coordinated by three working groups that operate under its auspices and respond to the direction of energy ministers. These working groups develop concrete energy efficiency initiatives consistent with the themes and ideas of federal, provincial and territorial ministers:

- The Built Environment and Equipment Working Group, formed in 2003 has established a dialogue on the built environment and equipment sectors among NRCan, provincial and territorial governments and agencies, utilities, industry and non-governmental organizations. This dialogue enhances the alignment of built environment and equipment strategy among jurisdictions.
- The Transportation Working Group on Energy Efficiency, formed in 2005, improves energy efficiency in Canada's transportation sector by enhancing the alignment of transportation energy efficiency activities among federal, provincial and territorial jurisdictions. It also seeks opportunities for further collaboration and new initiatives.
- The Industry Working Group on Energy Efficiency, formed in 2006, promotes the exchange of information among industrial energy end-users and authorities, agencies, utilities, and jurisdictions involved in the design, development and delivery of industry energy efficiency programs in Canada.

Following the 2011 Energy and Mines Ministers' Conference, the committee met to establish the work plans of the three working groups for 2011–2012 and began work on an integrated energy efficiency paper to serve as follow-up to the 2007 *Moving Forward on Energy Efficiency in Canada: A Foundation for Action*. This paper was released at the 2012 Energy and Mines Ministers' Conference in September 2012.

### Building Energy Codes Collaborative

The Building Energy Codes Collaborative is a federal-provincial-territorial committee supported by the Energy and Mines Ministers' Conference, the Steering Committee on Energy Efficiency and NRCan. The collaborative comprises representatives from provincial/territorial code and energy ministries, departments and agencies; NRCan; and the Canadian Codes Centre. The collaborative's objectives 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 of Canada for Buildings, 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 Model National Energy Code of Canada for Houses 1997

In 2007, the Canadian Commission on Building and Fire Codes approved the plan submitted by NRCan and the collaborative for updating the 1997 code. The National Research Council of Canada updated the code and NRCan provided $4 million and technical expertise. Revision took four years and the National Energy Code of Canada for Buildings was published in 2011 in an objective-based format. It complements objective-based model national construction codes issued in 2010.

### Federal-Provincial-Territorial Smart Grid Working Group

The 2011 Energy and Mines Ministers' Conference action plan also tasked an intergovernmental Smart Grid Working Group to investigate the role of smart grids as a critical energy technology for enabling Canada's transition to a lower-carbon emission economy.

This working group relied on the collaborative efforts of provincial ministries and NRCan to develop a smart grid reference manual, a jurisdictional scan of smart grid projects across the country and a synthesis report that would highlight key Canadian issues in smart grids. The working group also outlined four recommendations in advance of the 2012 Energy Mines and Ministers Conference. NRCan's Office of Energy Research and Development served as the secretariat to this working group and CanmetENERGY contributed content to the jurisdictional scan and reference manual.

### National Advisory Council on Energy Efficiency

An important source of strategic advice on matters related to energy efficiency is the National Advisory Council on Energy Efficiency. Created in 1998 as an innovative government organization, it provides the OEE with a broad range of opinions on all matters related to energy efficiency, connecting the OEE to the latest innovation and thinking in the field. The council fulfills its functions by

- assessing and advising on the OEE's strategic approach to meeting federal policy objectives
- advising the OEE on its performance, business planning and reporting on progress
- considering issues related to accelerating growth in energy efficiency in the Canadian economy
- developing new measures to increase the impact and reach of NRCan's energy efficiency and biofuels programs and activities

Council membership is drawn from across Canada. It includes representatives from various levels of government, academia, economic sectors, energy utilities and non-governmental organizations. The council met twice during the 2011–2012 fiscal year to advise and guide the OEE on the most effective way to achieve its mission.

All provinces and territories engage in energy efficiency activities and/or deliver energy efficiency, alternative transportation fuels and renewable energy 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 significantly reduce 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.

All provinces have been promoting the use of renewable energy through various incentives, including voluntary renewable energy targets and legislated renewable portfolio standards, and procurement of renewable energy through requests for proposals, standard offer and feed-in tariff programs.

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

Provincial and territorial governments and utilities use federal energy efficiency, alternative transportation fuels and renewable energy 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. Five provinces have ongoing incentive programs that use NRCan's EnerGuide Rating System.
- Canadians in many 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 several 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 seven Canadian jurisdictions to develop or implement energy performance requirements in their building codes or municipal bylaws.
- All the provincial and territorial government bodies responsible for driver education, except 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 motor vehicle licensing bureaus.

## Co-operation Agreements

NRCan's memorandum of agreement on energy efficiency, alternative transportation fuels and renewable energy with the Agence de l'efficacité énergétique du Québec (now Bureau de l'efficacité et de l'innovation énergétiques du Québec) provided for the two governments to consult and share information, co-ordinate activities in Quebec, and create opportunities for joint projects. Furthermore, the management committee established under the agreement reviews policy and program developments, progress on joint program initiatives and areas for further co-operation. NRCan is working with the Bureau de l'efficacité et de l'innovation énergétiques du Québec to deliver services under the ecoENERGY programs.

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

- managing the licensing agreement for local delivery of ecoENERGY Retrofit – Homes
- continuing to process payments by the OEE's Buildings Division for the former EnerGuide for Existing Buildings program. Though the program is 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 to help refrigerated facilities (ice and curling rinks, supermarkets, warehouses) reduce their energy consumption and greenhouse gas emissions through the Programme d'optimisation en réfrigération. This program is based on the CoolSolution[10] approach developed by CanmetENERGY. CanmetENERGY provides technical support and training for consultants and decision makers.

NRCan has entered into several contribution agreements over the years with the Yukon Energy Solutions Centre in Whitehorse on projects related to energy efficiency. The centre provides technical services and programs for the Yukon population and undertakes outreach and public education activities.

NRCan promotes energy efficiency and renewable energy with the provinces and territories. Notable collaborations include working with the following:

- the Manitoba Office of the Fire Commissioner, which is a special operating agency of Manitoba Labour and Immigration, to engage Manitoba stakeholders in a review of the Manitoba Energy Code Advisory Committee recommendations to establish minimum code requirements for energy and water efficiency in new and renovated Part 3 buildings in the province
- Efficiency NB, Conserve Nova Scotia (now Efficiency 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 these provinces
- 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 steps required for construction sector compliance with the 2011 National Energy Code of Canada for Buildings and investigate the costs, enforcement and industry-capacity impacts of the code
- Productivity Alberta, industry associations and utilities to provide energy management training to companies across Canada through Dollars to $ense workshops
- Climate Change Central (now named C3), 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

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

### 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.

The NextGen Biofuels Fund™ facilitates establishing first-of-a-kind, large, demonstration-scale facilities for the production of next-generation biofuels and co-products in Canada; improves the sustainable development impacts arising from the production and use of biofuels; and encourages 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. Sustainable Development Technology Canada supports up to 40 percent of eligible project costs.

In 2011–2012, Sustainable Development Technology Canada approved funding for the front-end development phase of one project, assessed two other applications and received two indications of interest. Together these five key projects would represent a total investment of $467.5 million.

### Atlantic Energy Gateway

The Atlantic Energy Gateway initiative was a 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 2011–2012, eight collaborative research studies were commissioned and completed. The studies provide insight into the challenges and opportunities involved in maximizing the benefits of developing clean energy in the Atlantic region.

## INTERNATIONAL CO-OPERATION

NRCan co-operates with several international organizations in energy efficiency, alternative transportation fuels and renewable energy program areas and supports bilateral and/or multilateral co-operation in these areas with countries and regions such as the United States, China, the European Union, India, Mexico and Russia.

Canada benefits from this co-operation by

- learning about improved ways of designing and delivering energy efficiency, alternative transportation fuels and renewable energy 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
- sharing Canadian tools and expertise with other international partners to achieve common environmental and energy security goals

### DID YOU KNOW?

Canada is considered a world leader in energy efficiency. The International Energy Agency found that Canada was second only to Germany in its rate of energy efficiency improvement among 16 major energy-using countries, over the 1990–2008 period. Canada has a severe climate, energy-intensive economic structure and a small, highly-dispersed population, which makes it especially challenging to reduce energy use. Nevertheless, Canada continues to make significant gains in comparison to countries such as the United States, the United Kingdom, Japan and Denmark, which face some, but not all of these circumstances.

## International Energy Agency

The International Energy Agency, based in Paris, France, is an autonomous agency of the Organisation for Economic Co-operation and Development. The agency runs a comprehensive program of energy co-operation among its 28 member countries, including Canada. Agency member governments have committed to sharing energy information, coordinating energy policies and co-operating on the development of national energy programs that address energy security, economic development and environmental protection. The agency and its governing board are helped by several standing groups and special committees, which bring together energy specialists from member countries.

The Standing Group on Long-term Co-operation is the key agency committee on the policy side. The standing group

- analyses policies to promote conservation and the efficient use of energy
- analyses measures to increase long-term energy security while protecting the environment
- monitors energy developments in member countries
- 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 standing group's Energy Efficiency Working Party provides advice on and direction to the agency's work on specific energy efficiency issues. The OEE represents Canada on the working party. In 2011, the agency released a report that recognized Canada as one of the top five agency member countries that has fully or partially implemented the agency's recommendations on energy efficiency.

Canada's international energy research and development objectives are mainly advanced through the agency's working parties, implementing agreements and experts groups that are under the Committee for Energy Research and Technology. The Government of Canada is committed to the agency and is an active member that fully supports its mandate to ensure reliable, affordable and clean energy for its 28 member countries and beyond. NRCan continues to support the structure, purpose and intent of the agency's four main areas of focus: energy security, economic development, environmental awareness and engagement worldwide. NRCan contributed $807,000 to agency implementing agreements in 2011–2012. 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. One such agreement is the agency Implementing Agreement for a Co-operating Programme on Efficient Electrical End-use Equipment. This agreement brings together energy efficiency policy-makers from Asia, Europe and North America to support policy development in the field of efficient appliances and equipment (e.g. solid state lighting, electric motor systems and standby power).

Canada also co-operates with research centres in agency member countries on several research and development and technology agreements and programs outside the agency. NRCan, together with Foreign Affairs and International Trade Canada, facilitates research and development and commercial business ventures abroad by Canadian firms by undertaking a wide variety of activities. These activities include participating in various agency tasks and supporting technical and trade-oriented workshops and conferences.

CanmetENERGY was named the operating agent of the new agency 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 greenhouse gas 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 36 research organizations, academia and private companies.

Canada participates in the agency Implementing Agreement on Heat Pumping Technologies (end-use technologies), the agency Heat Pump Program. CanmetENERGY is chairing the program, which includes 14 counties. The program objective is to increase the adoption of heat pump technology in buildings and industries for heating, cooling and refrigeration applications, thereby reducing energy use and greenhouse gas emissions. Program activities include an information service performed by the Heat Pump Centre in Sweden, international collaborative projects (annexes) in research and development, demonstration, deployment, workshops, analysis studies and a triennial conference. The next International Energy Agency Heat Pump Conference will be held in Montréal, Quebec, in 2014, organized by the Canadian GeoExchange™ Coalition, with the support of NRCan.

CanmetENERGY is participating in

- Annex 34 - thermally driven heat pumps for heating and cooling
- Annex 35 - application of industrial heat pumps with LTE-Hydro-Québec
- Annex 38 - solar and heat pump systems

In early 2012, NRCan and the Korea Institute of Energy Research reinstated the memorandum of understanding between the two organizations. Under this, CanmetENERGY developed two joint, multi-year projects with the institute and the Korean Ministry of Knowledge Economy. The projects focus on simulations, technology development and laboratory studies of highly integrated and efficient advanced hybrid microgeneration energy systems and their optimal integration into housing, buildings and communities. The institute intends to demonstrate the systems developed under these projects during the 2018 Olympic Winter Games, hosted by Korea in their "$CO_2$-free Olympic Village."

Canada also participates in the agency's Implementing Agreement for Renewable Energy Technology Deployment. Created in 2005, the agreement is a policy-focused, technology cross-cutting platform that brings together the experience and best practices of some of the world's leading countries in the renewable energy area with the expertise of renowned consulting firms and academia. The mandate of the agreement is to examine topical issues that influence the use of renewable energy and to help accelerate the market introduction and deployment of renewable energy technologies. The agreement informs decision makers and other stakeholders by undertaking studies and delivering reports, and it gathers strategic information by organizing and attending international events on related issues. A list of completed and ongoing projects and events is available on the agreement Web site at www.iea-retd.org.

From its genesis under the Clean Energy Ministerial in 2010, the International Smart Grid Action Network is the agency implementing agreement for a co-operative program on smart grids. This program is open to agency member and non-member countries and provides a mechanism for government-to-government collaboration on technologies, practices and systems and promotes the adoption of enabling government policies for smart grid. Canada is participating in three Annexes. CanmetENERGY is the official signatory body to the network and is providing a leadership role on the steering committee for these Annexes:

- Annex 1, Inventory of policy drivers and technology projects, is building a smart grid inventory of projects across all participating countries.
- Annex 2, Case study of smart grid demonstrations and pilots, presents in-depth case studies on several of those projects that are already achieving results and can offer valuable lessons learned and best practices.
- Annex 4, Insights for decision makers, will produce materials to support decision makers in making decisions about smart grid policy and programs and in engaging their stakeholders.

In addition to CanmetENERGY, SmartGrid Canada and the Ontario Ministry of Energy lead Canada's efforts on these initiatives.

## International Partnership for Energy Efficiency Co-operation

NRCan participated in the development of the agreement establishing the International Partnership for Energy Efficiency Co-operation. This partnership of Canada and 14 other economies supports the on-going energy efficiency work of participating developed and emerging countries, which collectively account for over 75 percent of global gross domestic product and energy-use. The partnership's Executive Committee and Policy Committee both continued to meet in 2011–2012 and Canada was elected Policy Committee Chair for 2012–2013. A key component of the partnership's organizational structure is task groups that pursue projects that may interest most, but not all, member countries. Canada currently participates in the Global Superior Energy Performance Partnership and the Super-efficient Equipment and Appliance Deployment Task Groups.

In the Global Superior Energy Performance Partnership, participants are working to achieve continuous improvements in the energy performance of industrial facilities and commercial buildings, including through the implementation of energy management systems.

Super-efficient Equipment and Appliance Deployment partners are working to

- pull super-efficient appliances and equipment into the market through co-operation on measures like awards, procurement and incentives
- increase the efficiency levels of equipment and appliances by bolstering national or regional policies such as minimum efficiency standards and labelling programs
- strengthen programs through coordinated, cross-cutting technical analysis work

## United Nations

NRCan contributes to the United Nations work on energy efficiency, alternative transportation fuels and renewable energy as opportunities arise.

An important Canadian contribution is RETScreen® International, which is managed under the leadership of 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 Co-operation

Asia-Pacific Economic Co-operation is a dialogue group better known by its acronym: APEC. The OEE is a member of the APEC Expert Group on Energy Efficiency and Conservation, which reports to the APEC Energy Working Group. One of the key tasks of the expert group is updating and maintaining the APEC Energy Standards Information System. This database provides public information on the appliance and equipment energy standards and regulations of member countries. It also provides links to experts and information related to standards and regulations used by APEC members and other economies. NRCan contributes regularly to the database by providing updated information on Canadian equipment standards and labelling and new initiatives.

The OEE also provide annual updates to the *Compendium of Energy Efficiency Policies of APEC Economies*. The compendium is a comprehensive report on recent goals, action plans, policies and measures for energy efficiency improvements in 20 APEC economies. This allow for transparency in the implementation of the region's aggregate goal to reduce energy intensity by 45 percent between 2005 and 2035.

## Clean Energy Ministerial

The Clean Energy Ministerial forum was launched by the United States in July 2010 to accelerate the world's transition to clean energy technologies. The

forum's 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 International Energy Agency.

Canada is active in four forum initiatives:

- Global Superior Energy Performance Partnership (also a task group under the International Partnership for Energy Efficiency Co-operation)
- Super-efficient Equipment and Appliance Deployment (also a task group under the International Partnership for Energy Efficiency Co-operation)
- Carbon Capture, Use and Storage Action Group
- International Smart Grid Action Network (also an International Energy Agency implementing agreement)

### U.S.-Canada Clean Energy Dialogue

The U.S.-Canada Clean Energy Dialogue was launched by Prime Minister Harper and President Obama in February 2009. The objective of the dialogue is to enhance bilateral collaboration on the development of clean energy technologies to reduce greenhouse gas emissions. To implement the objectives, Action Plan I was presented to the leaders in September 2009.

NRCan participated in the three working groups that were created:

- Electricity Grid
- Clean Energy Research and Development
- Carbon Capture and Storage

After activities under Action Plan I were completed, Action Plan II was released to specify the next suite of activities for the coming years.

Under Action Plan I, the Electricity Grid Working Group focused on activities to facilitate the long-term transition to a modernized electricity system based on clean and renewable generation. Priority areas for collaboration included clean electricity trade; the smart grid and clean power technologies; power storage technologies; and capacity building in the electricity sector. In addition, during fiscal year 2011–2012, the working group completed a study of offshore, renewable energy regulatory frameworks of several European countries. Subsequently, the working group and the industry association Smart Grid Canada launched Canada's Smart Grid Repository – an online, publicly accessible compendium of information on smart grid projects implemented in Canada.

Research and development drives technological discovery and innovation, which are key ingredients in developing the low-carbon energy system of the future. During Action Plan I, the Clean Energy Research and Development Working Group facilitated greater cross-border research and development collaboration and policy dialogue by connecting Canadian and U.S. experts and institutions in priority areas for the Clean Energy Dialogue. The priority areas included future biofuels, clean engines and vehicles, and energy efficiency in homes and buildings. Also included is work to expand collaboration on the ENERGY STAR labelling program and develop a Canadian version of the U.S. ENERGY STAR building benchmarking program to help building owners, managers and operators and energy utilities track, benchmark and manage energy consumption. Strengthening collaboration in these areas through joint research, development and deployment will help reduce greenhouse gas emissions while strengthening both countries' economies and creating new jobs.

### United States

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

NRCan's OEE signed a memorandum of understanding with the U.S. Environmental Protection Agency in September 2005. In it, they share the common goal of achieving greater energy efficiency and reducing greenhouse gas emissions through the work of their respective freight energy efficiency programs: FleetSmart and the SmartWay®

Transport Partnership. These two programs use a voluntary approach with the on-road freight sector to increase energy efficiency. Currently, the memorandum is being renewed to further the work on harmonizing program efforts under the SmartWay Transport Partnership in Canada and the United States.

## APPENDIX 1

# Natural Resources Canada's Energy Efficiency, Alternative Transportation Fuels and Renewable Energy Initiatives and Expenditures, 2011–2012

(millions of dollars)

| **Energy Efficiency and Alternative Transportation Fuels**[1] | **$418.9** |
|---|---|
| ecoENERGY Efficiency for Buildings | |
| ecoENERGY Efficiency for Housing | |
| ecoENERGY Efficiency for Equipment Standards and Labelling | |
| ecoENERGY Efficiency for Industry | |
| ecoENERGY Efficiency Vehicles | |
| ecoENERGY Retrofit – Homes | |
| ecoENERGY for Alternative Fuels | |
| ecoENERGY for Biofuels | |
| Federal Buildings Initiative | |
| National Energy Use Database | |

(millions of dollars)

| **Energy Efficiency – Energy Science and Technology**[2] | **$75.9** |
|---|---|
| Clean Energy Systems for Buildings and Communities | |
| Clean Electric Power Generation | |
| Clean Energy Systems for Industry | |
| Environmentally Sustainable Oil and Gas | |
| Clean Transportation Energy | |
| Sustainable Bioenergy | |

| **Alternative Energy – Renewable Energy Sources** | **$552.6** |
|---|---|
| Pulp and Paper Green Transformation Program | |
| Investments in Forest Industry Transformation | |
| Marine Renewable Energy Enabling Measures Program | |
| Wind Power Production Incentive[3] | |
| Initiative to Purchase Electricity From Emerging Renewable Energy Sources[4] | |

| **Total** | **$1,047.4** |
|---|---|

[1] The Energy Efficiency and Alternative Transportation Fuels total does not include the Sustainable Development Technology Canada – NextGen Biofuels Fund™. For details on this fund, see the text box on page 71.

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

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

[4] The Initiative to Purchase Electricity from Emerging Renewable Sources is fully committed, but incentives were paid out up 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*. Some adjustments to the original Statistics Canada data were required and are documented in Appendix A of Natural Resources Canada's *Energy Use Data Handbook, 1990 to 2009*. The differences that exist between this report and *Canada's Energy Outlook* relate to the sector allocations of energy-use data from the *Report on Energy Supply and Demand in Canada*.

**Figure 1-1: Secondary Energy Use by Sector, 2009**

| Sector | Industrial | Transportation | Residential | Commerical/ institutional | Agriculture | Total |
|---|---|---|---|---|---|---|
| Energy use (PJ) | 3168.4 | 2576.6 | 1422.3 | 1186.0 | 188.3 | 8541.6 |
| Percentage | 37.1 | 30.2 | 16.7 | 13.9 | 2.2 | 100.0 |

**Figure 1-2: Greenhouse Gas Emissions From Secondary Energy Use by Sector, 2009**

| Sector | Transportation | Industrial | Residential | Commerical/ institutional | Agriculture | Total |
|---|---|---|---|---|---|---|
| GHG emissions (Mt) | 178.3 | 144.5 | 67.9 | 60.9 | 12.4 | 464.0 |
| Percentage | 38.0 | 31.0 | 15.0 | 13.0 | 3.0 | 100.0 |

**Figure 1-3: Energy Intensity and the Energy Efficiency Effect, 1990 to 2009**

| Index (1990 = 1.00) | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 0.77 | 0.79 |
| Index of energy efficiency effect | 1.00 | 0.98 | 0.97 | 0.96 | 0.96 | 0.92 | 0.93 | 0.92 | 0.90 | 0.89 | 0.90 | 0.86 | 0.86 | 0.86 | 0.85 | 0.82 | 0.80 | 0.81 | 0.78 | 0.76 |

**Figure 1-4: Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009**

| Index (1990 = 1.00) | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Estimated secondary energy use without energy efficiency improvements | 1.00 | 1.00 | 1.03 | 1.05 | 1.09 | 1.15 | 1.18 | 1.20 | 1.20 | 1.25 | 1.29 | 1.29 | 1.33 | 1.36 | 1.39 | 1.41 | 1.39 | 1.45 | 1.43 | 1.37 |
| 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 | 1.25 | 1.23 |

**Figure 1-5: Canadian Housing Stock by Building Type, 2009**

| Dwelling type | Housing stock by building type (thousands) | Percentage |
|---|---|---|
| Single detached homes | 7835 | 56 |
| Apartments | 4294 | 31 |
| Single attached homes | 1549 | 11 |
| Mobile homes | 278 | 2 |
| **Total** | **13 946** | **100** |

**Figure 1-6: Residential Energy Use by End Use, 2009**

| Activity | Energy use (PJ) | Percentage |
|---|---|---|
| Space heating | 893.2 | 63 |
| Water heating | 245.8 | 17 |
| Appliances | 205.2 | 14 |
| Lighting | 60.6 | 4 |
| Space cooling | 17.4 | 1 |
| **Total** | **1422.3** | **100** |

**Figure 1-7: Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2009**

| Index (1990 = 1.00) | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1.36 |
| 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 | 1.10 | 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 | 0.82 |

**Figure 1-8: Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009**

| Index (1990 = 1.00) | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1.48 |
| 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 | 1.11 |

**Figure 1-9: Average Energy Consumption of New Electric Appliances, 1990 and 2009 Models**

| Appliance | 1990 model (KWh/yr) | 2009 model (KWh/yr) |
|---|---|---|
| Refrigerator | 956 | 430 |
| Freezer | 714 | 356 |
| Dishwasher | 277 | 88 |
| Clothes washer | 134 | 37 |
| Clothes dryer | 1103 | 921 |
| Electric ranges | 772 | 518 |

**Figure 1-10: Commercial/institutional Energy Use by Activity Type,* 2009**

| Activity type | Energy use (PJ) | Percentage |
|---|---|---|
| Offices** | 415.8 | 35 |
| Retail trade | 201.6 | 17 |
| Educational services | 149.4 | 13 |
| Health care and social assistance | 128.2 | 11 |
| Accommodation and food services | 88.1 | 7 |
| Wholesale trade | 71.8 | 6 |
| Transportation and warehousing | 46.2 | 4 |
| Arts, entertainment and recreation | 30.4 | 3 |
| Information and cultural industries | 25.7 | 2 |
| Other services | 21.0 | 2 |
| **Total** | **1178.2** | **100** |

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

**Figure 1-11: Commercial/institutional Energy Use by Purpose, 2009**

| Purpose | Energy use (PJ) | Percentage |
|---|---|---|
| Space heating | 593.7 | 50 |
| Auxiliary equipment | 224.8 | 19 |
| Lighting | 126.0 | 11 |
| Auxiliary motors | 100.5 | 8 |
| Water heating | 95.6 | 8 |
| Space cooling | 37.8 | 3 |
| Street lighting | 7.8 | 1 |
| **Total** | **1186.2** | **100** |

**Figure 1-12: Commercial/institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009**

| Index (1990 = 1.00) | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1.50 | 1.54 |
| 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 | 1.38 | 1.37 |

**Figure 1-13: Industrial Energy Use by Subsector – Including Electricity-related Emissions,* 2009**

| Subsector | Energy use (PJ) | Industrial energy use (%) |
|---|---|---|
| Mining | 959.0 | 30.3 |
| Other manufacturing** | 635.9 | 20.1 |
| Pulp and paper | 560.4 | 17.7 |
| Petroleum refining | 315.1 | 9.9 |
| Smelting and refining | 231.5 | 7.3 |
| Chemicals | 185.3 | 5.8 |
| Iron and steel | 171.7 | 5.4 |
| Construction and Forestry | 62.2 | 2.0 |
| Cement | 47.4 | 1.5 |
| **Total** | **3168.5** | **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 1-14: Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2009**

| Industry | Energy cost of total production cost (%) |
|---|---|
| Cement | 22.5 |
| Aluminum | 10.4 |
| Iron and steel | 10.3 |
| Pulp and paper | 10.1 |
| Chemicals | 4.7 |
| Petroleum refining | 1.4 |
| Transportation equipment and manufacturing | 0.8 |

**Figure 1-15: Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009**

| Index (1990 = 1.00) | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Estimated energy use without energy efficiency improvements | 1.00 | 1.00 | 1.02 | 1.04 | 1.10 | 1.14 | 1.15 | 1.15 | 1.16 | 1.20 | 1.23 | 1.26 | 1.29 | 1.33 | 1.33 | 1.34 | 1.33 | 1.39 | 1.40 | 1.39 |
| 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 | 1.18 | 1.17 |

**Figure 1-16: Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2009**

| Index (1990 = 1.00) | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Estimated energy use without energy efficiency improvements | 1.00 | 1.01 | 1.02 | 1.01 | 1.09 | 1.13 | 1.13 | 1.12 | 1.13 | 1.17 | 1.20 | 1.21 | 1.25 | 1.27 | 1.26 | 1.26 | 1.22 | 1.29 | 1.29 | 1.27 |
| 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 | 0.99 | 0.92 |

**Figure 1-17: Transportation Energy Use by Mode, 2009**

| Mode | Energy use (PJ) | Percentage |
|---|---|---|
| Cars | 639.9 | |
| Passenger light trucks | 467.6 | |
| Motorcycles | 4.3 | |
| School buses | 14.2 | |
| Urban transit | 32.4 | |
| Intercity buses | 5.9 | |
| Passenger air | 238.4 | |
| Passenger rail | 3.1 | |
| **Passenger total** | **1405.8** | **54.6** |
| Freight light trucks | 188.1 | |
| Medium trucks | 151.4 | |
| Heavy trucks | 560.6 | |
| Freight air | 4.7 | |
| Freight rail | 84.8 | |
| Marine | 88.0 | |
| **Freight total** | **1077.6** | **41.8** |
| **Off-road total** | **93.2** | **3.6** |
| **Total transportation energy use** | **2576.6** | **100.0** |

**Figure 1-18: Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2009 (percentage)**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 58.9 |
| 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 | 41.1 |

**Figure 1-19: Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009**

| Index (1990 = 1.00) | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Estimated energy use without energy efficiency improvements | 1.00 | 0.97 | 1.01 | 1.04 | 1.11 | 1.15 | 1.18 | 1.23 | 1.27 | 1.33 | 1.35 | 1.37 | 1.39 | 1.42 | 1.51 | 1.53 | 1.54 | 1.59 | 1.58 | 1.56 |
| 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 | 1.37 |

**Figure 1-20: Average Activity per Truck, 1990 to 2009 (tonne kilometres/truck)**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total medium- and heavy-duty truck vehicle activity | 105 857 | 98 224 | 103 003 | 117 235 | 133 122 | 142 338 | 140 834 | 163 787 | 162 805 | 175 047 | 178 076 | 198 602 | 197 073 | 202 218 | 241 152 | 243 657 | 236 377 | 232 651 | 228 287 | 214 559 |

**Figure 1-21: Trucking Energy Intensity, 1990 to 2009 (megajoules/tonne kilometre)**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total medium- and heavy-duty trucks energy intensity | 3.75 | 3.78 | 3.78 | 3.62 | 3.41 | 3.48 | 3.41 | 3.33 | 3.17 | 3.02 | 3.04 | 2.84 | 2.81 | 2.92 | 2.61 | 2.64 | 2.73 | 2.84 | 2.94 | 3.05 |

**Figure 2-1: Volume of Monthly Import Documents**

| Month | Total |
|---|---|
| Apr. 11 | 153 636 |
| May 11 | 160 605 |
| Jun. 11 | 169 903 |
| Jul. 11 | 161 377 |
| Aug. 11 | 171 319 |
| Sep. 11 | 171 026 |
| Oct. 11 | 175 552 |
| Nov. 11 | 167 188 |
| Dec. 11 | 166 106 |
| Jan. 12 | 135 131 |
| Feb. 12 | 139 418 |
| Mar. 12 | 157 858 |
| **Total** | **1 929 119** |

**Figure 2-4: ENERGY STAR Qualified Appliances as a Percentage of Total Shipments in Canada, 1999 to 2010**

| Appliance | 1999 (%) | 2000 (%) | 2001 (%) | 2002 (%) | 2003 (%) | 2004 (%) | 2005 (%) | 2006 (%) | 2007 (%) | 2008 (%) | 2009 (%) | 2010 (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dishwashers | 0.6 | 1.6 | 9.7 | 29.8 | 56.5 | 80.9 | 90.8 | 79.7 | 76.2 | 89.3 | 89.5 | 78.7 |
| Clothes washers | 1.9 | 2.2 | 9.2 | 22.1 | 30.6 | 36.2 | 45.9 | 50.8 | 58.4 | 64.4 | 69.4 | 65.9 |
| Refrigerators | .. | .. | 11.4 | 22.3 | 40.7 | 34.2 | 37.6 | 37.3 | 44.3 | 53.4 | 53.4 | 59.3 |

**Figure 2-5: ENERGY STAR Awareness Levels in Canada, 2010**

| | Percentage |
|---|---|
| Aware – non-aided | 71 |
| Aware – aided | 72 |

**Figure 3-1: Number of R-2000 Housing Certifications and ENERGY STAR Prescriptive-labelled Houses, 1990 to 2011**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R-2000 certified houses | 495 | 699 | 1196 | 1299 | 784 | 610 | 416 | 484 | 265 | 213 | 319 | 329 | 428 | 379 | 583 | 500 | 439 | 483 | 557 | 541 | 360 | 440 |
| ENERGY STAR labelled houses (prescriptive path only) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 95 | 878 | 1662 | 3888 | 4037 | 8794 | 8500 |

**Figure 3-2: New Vehicle Fuel Efficiency Labelling**

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

**Figure 3-3: 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 3-4: Residential Energy Use and Energy Savings per Household, Pre-1945 to 2010–2012**

| | Pre–1945 | 1945–1959 | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2009 | 2010–2012* | Average |
|---|---|---|---|---|---|---|---|---|---|
| Energy use pre-renovation (GJ) | 269 | 200 | 187 | 173 | 171 | 161 | 147 | 131 | 192 |
| Actual energy savings after renovations (GJ) | 79 | 51 | 43 | 38 | 34 | 27 | 27 | 33 | 44 |

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

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

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canada | 778 | 2265 | 3684 | 6050 | 9017 | 13 001 | 17 130 | 22 262 | 27 456 | 35 529 | 42 447 | 51 323 | 60 621 | 67 074 |
| **World total** | **1841** | **5864** | **11 903** | **20 164** | **29 616** | **38 882** | **54 189** | **74 657** | **99 663** | **135 119** | **180 870** | **229 299** | **277 099** | **319 871** |

**Figure 5-1: Canadian Wind Power Capacity, 1993 to 2011 – Cumulative (MW)**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wind power capacity (MW, cumulative) | 1 | 22 | 23 | 23 | 24 | 27 | 127 | 139 | 215 | 233 | 326 | 445 | 686 | 1459 | 1840 | 2337 | 3282 | 3967 | 5265 |