Natural Resources Canada
Ressources naturelles Canada

Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act* For the Fiscal Year 2012–2013

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Natural Resources Canada's Office of Energy Efficiency
Leading Canadians to Energy Efficiency at Home, at Work and on the Road

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Foreword

This twentieth *Report to Parliament Under the* Energy Efficiency Act outlines the government's actions in energy efficiency and highlights selected successes that are keeping our businesses competitive, expanding jobs and growth while helping Canadian consumers save money. Natural Resources Canada (NRCan) helps this nation deliver energy efficiency and energy technology innovations and research to ensure that Canadians have the best-in-class and most up-to-date energy efficiency programs and policies; cutting edge research, development and demonstration (R,D&D); and the latest clean energy science and technology.

The *Energy Efficiency Act* (the Act) requires that the Minister of Natural Resources table an annual report before Parliament on the administration of the Act in the previous fiscal year. The Act also gives the Government of Canada the authority to make and enforce regulations concerning minimum energy performance levels, labeling requirements and the collection of data on energy use for energy-using products and products that affect energy use.

NRCan's Office of Energy Efficiency (OEE) provides the analytical capacity so that Canada can deliver this annual assessment of trends in energy use and energy saved, as well as related greenhouse gas (GHG) emissions in Canada. These results are shared in this report and published in the technical report *Energy Efficiency Trends in Canada*.

NRCan makes its publications and other documents on energy efficiency available to Canadians and others through a comprehensive Web site. The site provides details on programs and offers practical, up-to-date information and tips for all energy users. For more information, visit the Web site at nrcan.gc.ca/energy/efficiency.

CHAPTERS IN THIS REPORT

This twentieth annual Report to Parliament focuses principally on energy efficiency, alternative transportation fuels and renewable energy initiatives that address secondary energy use, that is, energy used by businesses and consumers.

Chapter 1 of the report discusses the 20-year trends history. This section offers an important annual measure of how far we have come since 1990, and helps Canadians consider where we want to go in the future. It describes in greater detail the energy efficiency trends in Canada's residential, commercial/institutional, industrial, transportation and renewable energy sectors.

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 2012–2013 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.

Chapter 6 describes domestic and international co-operation in energy efficiency, alternative transportation fuels and renewable energy.

Appendix 1 contains NRCan's energy efficiency, alternative transportation fuels and renewable energy initiatives and expenditures for 2012–2013.

Appendix 2 contains detailed information about the figure data presented in this report. Calculations of

the estimated GHG savings in this report are based on Environment Canada's standardized emissions factors as described in its publication *Canada's Greenhouse Gas Inventory*.

The following areas within NRCan manage the initiatives that drive energy efficiency improvements in Canada:

- **Office of Energy Efficiency**, which delivers programming to improve energy efficiency and the use of alternative transportation fuels in all sectors of the Canadian economy
- **CanmetENERGY**, which provides scientific and engineering expertise in support of clean energy R,D&D initiatives and the development of codes and standards, regulations, policies and programs
- **Office of Energy Research and Development**, which coordinates the department's energy research and development (R&D) planning and funding allocations
- **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
- **Policy, Economics and Industry Branch of the Canadian Forest Service**, which delivers funding for the commercialization of innovative technologies across the forest sector leading to non-traditional, high-value forest products and renewable energies
- **Science Branch of the Canadian Forest Service**, which undertakes R&D on the sustainable use of forest biomass for energy
- **CanmetMATERIALS**, which develops and transfers innovative materials and processing technologies that enable improved energy efficiency in the energy production, buildings/industry and transportation sectors
- **CanmetMINING**, which delivers R,D&D initiatives to improve energy efficiency in the mining sector by using innovative mining and mineral processing equipment and systems

Message from the Minister

I am pleased to introduce the twentieth edition of the *Report to Parliament on Improving Energy Performance in Canada*. This year's report provides a detailed view of Canada's substantial and ongoing progress in responsible energy use across all sectors of the economy. Canada's efficiency gains over the past 20 years have been remarkable, and continue to win recognition on the international stage. The International Energy Agency (IEA) acknowledges our consistently strong record on energy efficiency — ranking Canada second among 15 countries in energy efficiency improvements between 1990 and 2010.

Canadians have significantly improved their energy efficiency since the first *Improving Energy Performance in Canada* was presented to Parliament 20 years ago. The IEA notes that Canada's energy efficiency has improved by over 25 percent since 1990, and that Canadian consumers and businesses saved $32 billion in energy costs in 2010 because of energy efficiency improvements made during this period. Estimates indicate that, in 2011, Canadian consumers and businesses saved more than $34 billion in energy costs.

Specialized programs and national standards are helping Canadians continue to reduce their consumption through responsible energy use. The new *National Energy Code of Canada for Buildings* recently published by the Government of Canada establishes a benchmark of 25 percent improvement in energy efficiency over the previous code and will generate $70 million in savings for Canadians by 2015–2016.

As the demand for responsible energy use is felt around the world, it has also opened up a $300-billion market for Canadian businesses. This market will expand rapidly as China, India and other emerging economies increase their investments in energy efficiency products and services. The strength of this growing demand clearly indicates that investing in energy efficiency will not only help businesses reduce energy bills and save money but also stimulate the research, development and export of energy-efficient technologies and products — a winning result for end-users, entrepreneurs, the environment and Canada's local and national economies, all at the same time. As a result of energy efficiency, Canadian industries avoided over $6 billion in energy costs in 2010 – enough energy to heat more than 8 million Canadian households for one year. For these reasons, responsible energy use will always be a good investment for Canada — saving dollars for consumers, improving the bottom line for businesses and expanding our economy.

The Honourable Greg Rickford, P.C., M.P.

Canada's Minister of Natural Resources and Minister for the Federal Economic Development Initiative for Northern Ontario

Executive Summary

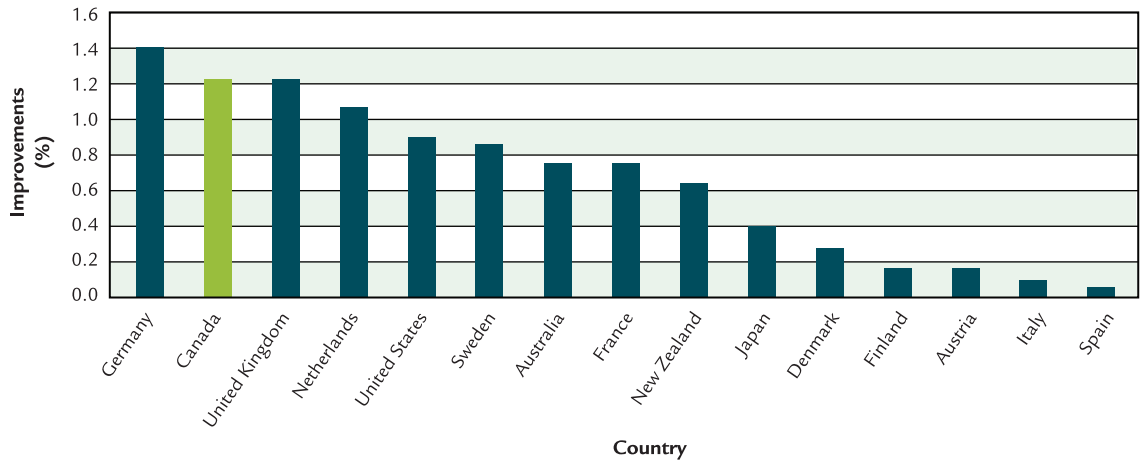
Energy efficiency is about getting the same levels of service, comfort and performance we need from our homes, cars, appliances and businesses while using less energy. Canada has been a leader in this field over the past 20 years with strong and positive results. Investing in energy efficiency reduces energy bills and saves money for consumers and businesses. Money not spent on energy bills can be more productively reinvested in the economy to drive jobs and growth.

Energy efficiency offers a proven pathway to generate substantial positive impacts: reduced fuel consumption, lower utility bills, less pollution and greenhouse gas (GHG), economic growth, improved air quality, more jobs, and enhanced competitiveness. The International Energy Agency *Energy Efficiency Market Report 2013* ranked Canada second out of 15 countries, tied with the United Kingdom, for its rate of energy efficiency improvement from 1990 to 2010. Over the same period, Canada's energy efficiency has improved by 25 percent. The report attributes this impressive result to the federal government's active role in developing and delivering programs and policies as well as its strong collaboration with provincial and territorial partners, utilities and the private sector.

Highlights in this present report show that Canada has made significant progress in all sectors to improve the efficiency of energy use:

- Canadian businesses and consumers saved $32 billion in 2010 because of energy efficiency improvements made since 1990.* This means, instead of spending $195 billion, Canadians spent only $163 billion on energy, thanks to energy efficiency.
- Because of energy efficiency improvements, Canadian industries were able to reduce their energy costs by $6.1 billion. These savings can now be invested in labour and capital to create more jobs and stronger economic growth.

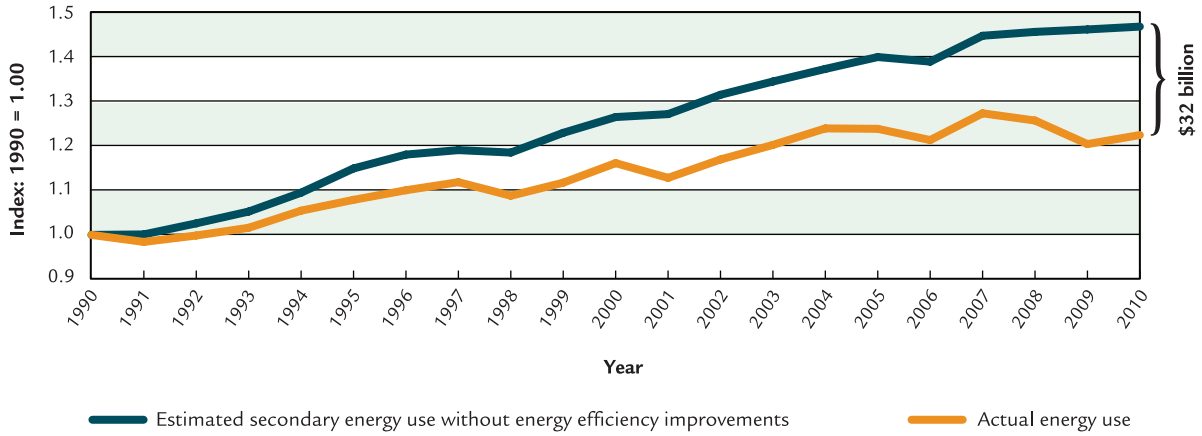
FIGURE EX-1 **Efficiency Improvement 1990 to 2010**



Source: Information provided by the IEA in the *Energy Efficiency Market Report 2013*

* Estimates indicate that, in 2011, Canadian consumers and businesses saved more than $34 billion in energy costs.

FIGURE EX-2 **Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010**



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

- Due to improvements to energy efficiency in Canada between 1990 and 2010, 93.3 megatonnes (Mt) of GHG emissions are not entering the atmosphere.
- Canada's freight industry saved $3.4 billion in 2010 as a result of energy efficiency improvements since 1990.
- Canada is a global leader in the production of renewable energy, with 18 percent of its primary energy supply coming from renewable sources in 2011.
- Two of Canada's small-scale Clean Energy Fund projects were identified by the accounting firm KPMG as among the top 100 most innovative and inspiring urban projects in the world.

This twentieth anniversary *Report to Parliament Under the* Energy Efficiency Act provides a snapshot of Canada's substantial progress and achievements in energy efficiency over the past two decades.

ENERGY EFFICIENCY SUCCESSES FOR BUSINESSES AND CONSUMERS

Housing – Canadian households saved, on average, $670 in 2010 as a result of energy efficiency improvements that have occurred since 1990. More than 640 000 homes (approximately 1 in 20) became more efficient with federal assistance since 2007. These Canadians are saving more than $400 million in energy costs each year.

Cars – In 2010, consumers saved $8.2 billion in passenger transportation costs as a result of improvements in energy efficiency since 1990. We equipped more than 200 000 students to save up to 10 million litres of fuel each year through the use of the Auto$mart Driver Education Kit. All provinces and territories, except one, are using the kit to educate young drivers about fuel efficiency.

DID YOU KNOW?

- ✔ Canadians who replace their 10-year-old washing machine with a new ENERGY STAR qualified one would save an estimated $700 on energy costs over a 10-year period.
- ✔ An average clothes washer consumed 75 percent less energy in 2011 than it did in 2000.

Industry – There were $6.1 billion in energy costs avoided in 2010 by Canadian industry because of energy efficiency – enough energy to heat more than 8 million Canadian households for one year.

Equipment – The familiar blue ENERGY STAR® label identifies the top energy performers for more than 65 products. It is marketed by more than 1 000 partners, used by over 70 percent of Canadians in making product purchases and identified as the first place Canadians look for energy efficiency information.

Buildings – Adoption of the 2011 *National Energy Code of Canada for Buildings* is currently underway across 12 jurisdictions. Code 2011 is 25 percent more stringent than the previous code and will result in $70 million in energy savings by 2015–2016.

Trucks – Currently more than 3 000 firms that share the goal of saving fuel and reducing GHG emissions are participating in the SmartWay Transport Partnership. Fleets are saving approximately 2 000 to 3 000 litres of fuel per truck per year.

REDUCING FUEL COSTS

One of Quebec's largest trucking companies reduced fuel use by 7.6 percent with the help of FleetSmart.

Helping Consumers

Helping Canadian families make smart, energy-efficient choices on electronics, appliances, cars and new homes is important to the Government of Canada. The EnerGuide label shows how much energy a product uses under normal conditions in one year, and the blue ENERGY STAR symbol identifies products that meet higher efficiency standards. Consumers rely on the Government's highly popular ENERGY STAR label to verify that they are buying the most energy-efficient product on the market.

SAVING CONSUMERS MONEY

Living in an R-2000 energy-efficient home and choosing ENERGY STAR appliances can save consumers more than $1,300 per year in energy costs. An R-2000 home is 68 percent more energy-efficient than a conventional home built in 1970.

Helping Businesses

Small and medium-sized business enterprises are benefiting from reduced costs in their day-to-day operations and improving their overall bottom line. This is done by ensuring that they have access to the best energy efficiency tools, standards and latest know-how on how to save energy and reduce their monthly energy bills. Organizations across Canada, including utilities, housing authorities, municipalities and efficiency organizations have used ENERGY STAR as a campaign driver to promote the use of efficient products.

SAVING SMALL BUSINESSES UP TO $1,900 EACH YEAR

A small business can save $1,900 per year by choosing ENERGY STAR for office equipment and using a building built to the 2011 energy code efficiency standards.

Helping Industry

Through concerted efforts, the Government of Canada is helping our industries cut their energy expenses so they can remain internationally competitive and is putting money back into the wallets of ordinary Canadians. Supporting these kinds of smart energy efficiency innovations keeps

HELPING A TORONTO CHOCOLATE FACTORY

Mondelez Canada (Cadbury) used cutting-edge energy efficiency to reduce its energy use in its Toronto factory. The result was savings of more than $500,000 on energy and water costs in 2010–2011 and for every year into the future. Mondelez Canada is an active member of the Canadian Industry Program for Energy Conservation – a voluntary industry-government partnership established to improve Canada's industrial energy efficiency.

ENERGY EFFICIENCY PROTECTS 300 JOBS IN THE FORESTRY SECTOR

Canada is able to help protect jobs and factories such as the pulp mill in Thurso, Quebec, which reopened thanks to energy efficiency actions under NRCan's Pulp and Paper Green Transformation Program. The mill was able to rehire 300 employees as a result of competitive energy input costs. When industries reduce energy use, real financial savings and benefits ensue.

our nation ahead of the curve in global markets and can lead to new jobs and economic prosperity while also protecting our land and water. The industrial sector alone spent $36.9 billion on energy in 2010, but our energy efficiency efforts are producing winning results to reduce input costs there too. Because of our efforts, this sector saved $6.1 billion in energy costs, which translates into 27.5 Mt of avoided GHG emissions.

Natural Resources Canada also invests in research, development and demonstration of new and emerging clean energy science and technology that produces economic and environmental benefits for Canadians. One big energy efficiency success is NRCan's Program of Energy Research and Development. It funded approximately 280 clean energy and energy efficiency research and development projects, including research in the environmental aspects of oil sands; clean electricity and renewables; bioenergy; smart grid and storage; pipelines and efficient end use in the buildings industry and the transportation sectors.

This work helps to create Canadian expertise, increase Canada's productivity, energy efficiency and competitiveness, as well as providing safe, reliable and affordable energy to Canadian consumers and industry.

One of the greatest sources of untapped energy is the energy we waste. Cutting back on energy waste makes common sense, improves productivity and brings real benefits for Canada's economy, environment and our society. The trends chapter of this report shows that Canadians spent $26.3 billion on household energy needs in 2010. However, this number would have been $9.0 billion higher without improvements in energy efficiency.

Introduction

This is the twentieth anniversary edition of the *Report to Parliament Under the* Energy Efficiency Act. In it you will learn about Natural Resources Canada (NRCan) and the benefits that continue to flow from both the historic and current investments Canada has made through its Office of Energy Efficiency (OEE) and other sectors to improve energy efficiency.

The OEE has empowered consumers and businesses to help them make better choices on the efficient use of energy, which in turn helps Canadians and our businesses to save money by decreasing energy bills. Investing in energy efficiency also stimulates the economy by creating local jobs and economic growth, while supporting the environment, reducing greenhouse gas (GHG) emissions and pollutants. All these actions lead to a greater quality of life for Canadians. This report highlights some of the many benefits and major achievements that have resulted over the past two decades.

The OEE operates as this country's centre of excellence for energy efficiency and information. It administers key programs that promote energy efficiency in the major energy-using sectors of the economy, collects and analyses energy efficiency data, and reveals important trends. These 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 economy, its environment, and security.

Informing key decision makers in government, industry and the international communities about Canada's energy efficiency efforts and successes is another of the OEE's major tasks. NRCan makes its publications and other documents on energy efficiency available to Canadians and others through a comprehensive Web site. The site provides details on programs and offers practical, up-to-date information and tips for all energy users. For more information, visit the Web site at nrcan.gc.ca/energy/efficiency.

Two other important federal partners are NRCan's CanmetENERGY and the Office of Energy Research and Development. These groups help deliver energy technology innovations and research to ensure that Canadians have the best-in-class and most up-to-date research, development and demonstration (R,D&D) of new and emerging clean energy science and technology. This work contributes to the energy efficiency actions that drive economic, social and environmental benefits for all.

NRCan 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 developing safety codes and standards, as well as technology roadmaps for transportation.

In 2012–2013, NRCan continued to help consumers save money and businesses remain competitive through the following programs and initiatives.

Energy Efficiency

- ecoENERGY Efficiency program (covering buildings, housing, equipment, standards and labelling, industry and vehicles)
- Federal Buildings Initiative

Alternative Transportation Fuels

- ecoENERGY for Alternative Fuels
- ecoENERGY for Biofuels

Science and Research and Development

- Program of Energy Research and Development
- ecoENERGY Technology Initiative
- Clean Energy Fund
- ecoENERGY Innovation Initiative

Renewable Energy

- Marine Renewable Energy Enabling Measures Program
- Investments in Forest Industry Transformation

POLICY INSTRUMENTS

The primary goal of NRCan's energy efficiency, alternative transportation fuels and renewable energy initiatives is to reduce energy consumption and to spur innovation to generate economic and environmental benefits. NRCan uses a variety of policy instruments in regard to energy supply and demand:

Building Codes

- The federal government collaborates with provincial and territorial governments to establish energy efficiency as a new and essential element within Canada's building codes, which helps consumers save on their energy bills. This work also reduces peak energy demand, improves the quality and comfort of a building's indoor environment, and helps reduce GHGs while improving the long-term sustainability of a home or building.

Information

- NRCan activities include labeling, training, workshops, webinars, publications, conferences, Web sites, building-design software and promotional products.

Voluntary Initiatives

- Voluntary programs increase the number of people and organizations that take advantage of existing opportunities to use energy more efficiently.

Regulations

- The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations that prescribe standards and labelling requirements for energy-using products and products that affect energy use that are imported to Canada or shipped across provincial borders for lease or sale. Energy performance regulations eliminate less efficient products from the market.

Leadership

- NRCan's Federal Buildings Initiative serves as an example in sustainable and environmental building practices for other Canadian business sectors.

Financial Incentives

- In 2012–2013, the department offered financial incentives for ethanol and biodiesel production, and the implementation of highly innovative technologies in the forest products sector.

Research, Development and Demonstration

- The department provides national leadership in energy science and technology by conducting research in its own research centres and supporting R,D&D activities with other private and public sector organizations.

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. R,D&D increases the opportunities for achieving higher levels of efficiency in a particular type of energy use.

HOW PROGRESS IS MEASURED

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 results
- market benefits

Program outputs are the products and actions that NRCan produces regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. Program outputs are designed to lead to **program results** – 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 results 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 results can directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable market benefits. **Market benefits** ultimately reflect the impacts of the department's programs on changes in energy efficiency, energy intensity, GHG emissions and the use of alternative energy. In this sense, achievement of a targeted market benefit or observable progress toward a market benefit, may be indicators of program effectiveness. Measuring progress toward an immediate market benefit can be difficult for R,D&D programs, which typically take many years to produce results that can be properly assessed.

An example of a program result leading to a market benefit is a householder's purchase of a more energy-efficient appliance, resulting in reduced use of electricity.

DATA COLLECTION AND ANALYSIS

In 1991 NRCan launched the National Energy Use Database initiative. Since that time, NRCan has helped Canada improve its knowledge of energy consumption and energy efficiency at the end-use level. The database is a crucial resource in supporting the department's analytical expertise and program activities. The initiative secures the development of a unique, reliable, Canada-wide information database on energy consumption at the end-use level for all energy-consuming sectors over longer time periods.

The 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.

The initiative also produces a comprehensive energy use database with accompanying publications to explain Canada's overall energy use and energy efficiency trends. These reports are available to the public, free of charge, online at oee.nrcan.gc.ca/corporate/statistics/neud/dpa/home.cfm.

CO-OPERATION

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

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 International Energy Agency, the International Partnership for Energy Efficiency Cooperation, the Asia-Pacific Economic Cooperation, and the Clean Energy Ministerial. Through these and bilateral partnerships such as the U.S.-Canada Clean Energy Dialogue, Canada is a major player on the global energy stage.

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.

Even with 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 $32 billion in 2010 compared to energy use patterns in 1990. In 2010, approximately $163 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 2010,[1] the amount of primary energy used in Canada was estimated at 11 960 petajoules[2] (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?

One petajoule (PJ) is equivalent to the energy required by more than 9 000 households (excluding transportation requirements) over one year.

Secondary energy use made up approximately 71 percent of primary energy use in 2010, or 8 479.1 PJ. It was also responsible for 70 percent (484.4 megatonnes [Mt]) of total greenhouse gas (GHG) emissions in Canada, including indirect emissions – those produced by electric utilities to meet end-use electrical demand.

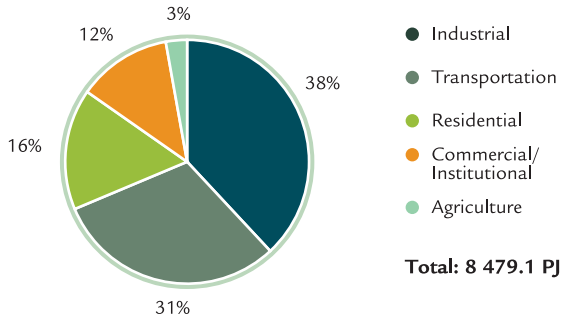
While secondary energy use increased by 22 percent from 1990 to 2010, Canada's population grew 23 percent and the gross domestic product (GDP) increased by 62 percent. Thus energy use grew much more slowly than the economy as a whole, indicating a marked improvement in the energy intensity of our economy per unit of output. In addition, total energy use grew slightly less rapidly than the population.

[1] Data in this chapter are presented for 1990–2010. Visit the Office of Energy Efficiency Web site to see data updates as they become available (oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/publications.cfm?attr=0).

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

The share of secondary energy used by each major economic sector does not vary much from year to year. For 2010, as demonstrated in Figure 1-1, the industrial sector was the largest energy user, accounting for 38 percent of total secondary energy use. The transportation sector was the second largest energy user at 31 percent, followed by the residential sector at 16 percent, the commercial/institutional sector at 12 percent and the agricultural sector at 3 percent.

FIGURE 1-1 Secondary Energy Use by Sector, 2010



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

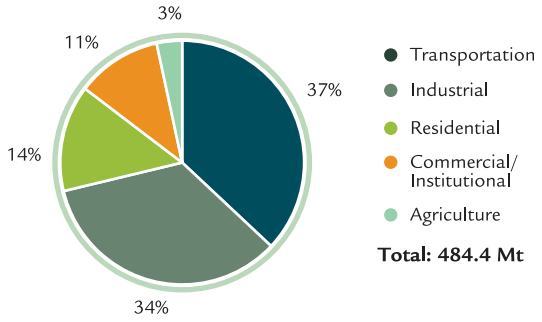
Figure 1-2 illustrates the distribution of GHG emissions[3] by sector. Carbon dioxide (CO_2) accounts for most of Canada's GHG emissions. In this chapter, CO_2 and GHG include emissions that are attributable directly to secondary energy use and emissions that are attributable indirectly to electricity generation, unless otherwise specified.

ENERGY INTENSITY AND ENERGY EFFICIENCY

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

[3] This report deals with energy-related GHG emissions, which comprise CO_2, methane and nitrous oxide.

FIGURE 1-2 Greenhouse Gas Emissions From Secondary Energy Use by Sector, 2010



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

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.

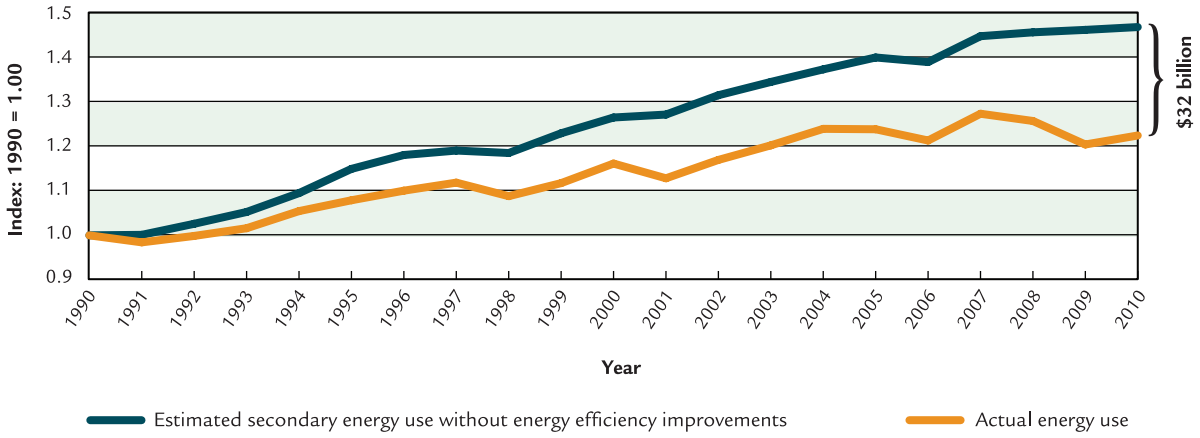
TRENDS IN ENERGY EFFICIENCY

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 25 percent[4] since 1990. Without significant improvements in energy efficiency in end-use sectors, energy use would have actually increased 47 percent. These improvements reduced energy use by 1 681 PJ, or the equivalent energy use of 32 million cars in 2010.

[4] based on the OEE index

FIGURE 1-3 **Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010**



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

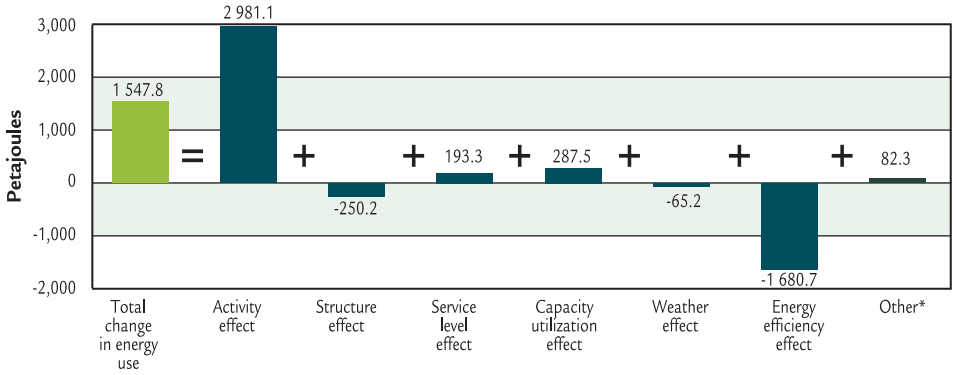
This is estimated to have reduced GHG emissions by 93.3 Mt and saved Canadians $32 billion in 2010. The change in energy use between 1990 and 2010, actual and without energy efficiency improvements is shown in Figure 1-3.

NRCan regularly publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use and GHG emissions and the contributions of the following key factors to these changes (see Figure 1-4):

- Increases in sector **activity** lead to increased energy use and GHG emissions. Activity is defined differently in each sector. For example, in the residential sector, it is defined as the number of households and the floor space of residences. In the industrial sector, it is defined as industrial GDP, gross output and physical industrial output, such as tonnes of steel.
- Fluctuations in **weather** lead to changes in space-heating and space-cooling requirements. A colder winter or a warmer summer can lead to increased energy use.
- A shift in the **structure** of activity toward more energy-intensive components of activity leads to increased energy use and emissions. For example, if the distribution of activity in the industrial sector shifts from forestry to the iron and steel industry, industrial energy use will increase because the former sector is less energy intensive than the latter.
- **Service level** refers to the penetration rate of electrical devices and equipment, for example, the use of auxiliary equipment in commercial/institutional buildings and appliances in homes or the amount of floor space cooled.
- **Capacity utilization rate** refers to the proportion of the installed production capacity that is in use. In 2010, sectors such as mining, transportation, equipment, and iron and steel showed a recovery from their 2009 lows.
- **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 light emiting diode lighting.

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

FIGURE 1-4 **Summary of factors influencing the change in energy use, 1990 to 2010**



* "Other" refers to street lighting, non-commercial airline aviation, off-road transportation and agriculture, which are included in the Total change in energy use column above but are excluded from the factorization analysis.

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

influence of capacity utilization was factored out. 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.

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 77 percent of the electricity we generate produces no GHG emissions. Canada is also positioned ninth in the world for the installed capacity of wind energy.

TRENDS IN RENEWABLE ENERGY

Canada is a leader in the production of renewable energy, with 18 percent of its primary energy supply coming from renewable energy sources in 2011. 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 2011, over 60 percent of Canada's electricity generation was provided by large and small hydroelectric plants, which generated 372 terawatt-hours (TWh) of electricity, up 7 percent from 348 TWh in 2010. Small hydro plants (i.e. less than 50 megawatts [MW]), representing an installed generating capacity of 3 503 MW, provided about 2.6 percent of the total installed generating capacity in Canada.

In 2011, 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 137 MW in 2000 to 5 265 MW in 2011 and to 6 201 MW in 2012.

With 1 654 MW of installed capacity in 2011, 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 2012. So far, 2012 has been the best year for solar photovoltaic, with 268 MW of new installations for a total solar photovoltaic installed capacity in Canada of 765 MW.

The Canadian active, solar thermal, installed capacity in 2012 was 1 249 162 square metres (m^2), which is approximately 862 megawatts thermal (MW_{th}). The domestic market increase has averaged over 20 percent annually since 1998. In 2012, the solar thermal collector market in Canada was approximately 100 354 m^2, approximately 14 percent fewer installations than in 2011 (114 944 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 1 045 MW_{th} of installed capacity and producing an estimated 1 420 gigawatt-hours equivalent annually.

TRENDS - RESIDENTIAL SECTOR

Energy Use

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.

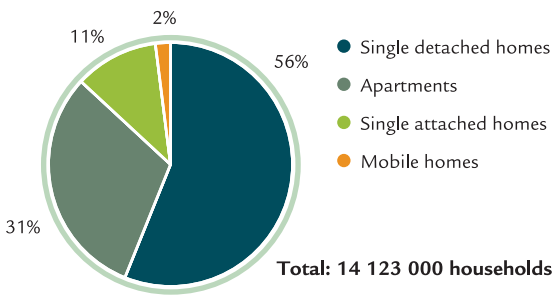
Canadians spent $26.3 billion on household energy needs in 2010. This sector accounted for 16 percent (1 360.7 PJ) of secondary energy use and 14 percent (68.4 Mt) of GHGs emitted in Canada.

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 2010 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.

Between 1990 and 2010, residential energy use increased by 6 percent, or 78.4 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 GHG-intensive fuels), the associated GHG emissions actually fell by 0.5 percent during the same period.

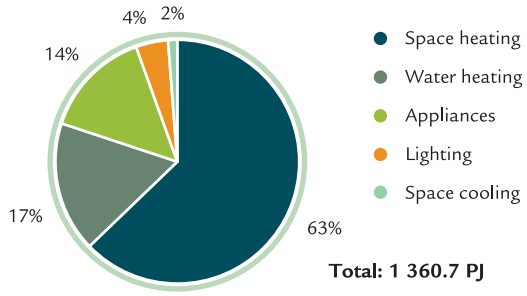
Energy intensity (gigajoules/household) decreased 21.5 percent despite the average household operating more appliances, becoming larger and increasing its use of space cooling. Space and water heating constituted 80 percent of residential energy use (which exhibited a small drop in space-heating energy use), followed by operating appliances, lighting and space cooling (see Figure 1-6).

FIGURE 1-5 Canadian Housing Stock by Building Type, 2010



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

FIGURE 1-6 Residential Energy Use by End Use, 2010



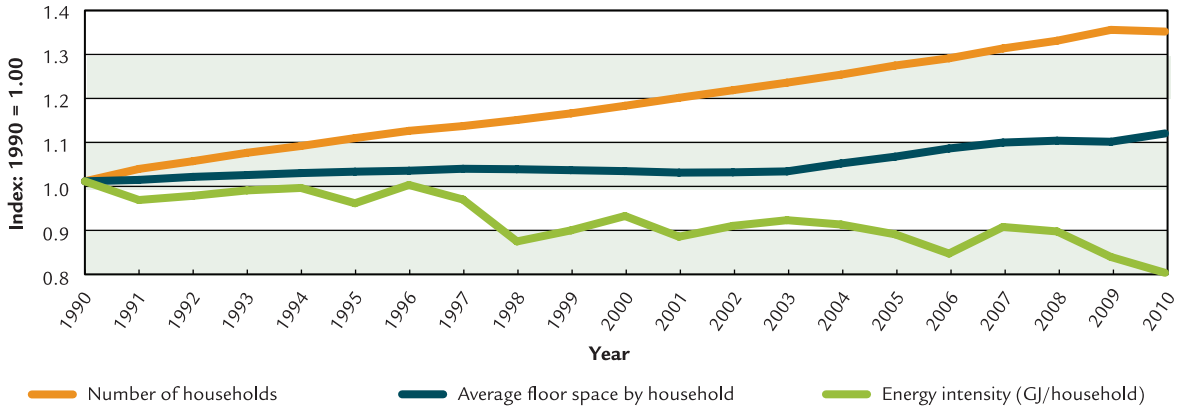
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Five main factors influenced residential energy use between 1990 and 2010 – activity, weather, structure, service level and energy efficiency effect:

- Activity – As measured by combining a mix of households and floor space, energy use increased 39.8 percent (510.6 PJ). Growth in activity was driven by a 50.4 percent increase in floor area and by a rise of 35.2 percent in the number of households.
- Weather – In 2010, the winter was warmer and summer was hotter than in 1990. The net result was an overall decrease in energy demand of 53.3 PJ.
- Structure – The increase in the relative share of single family houses resulted in the sector using an additional 9.9 PJ of energy.
- Service level – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 76.4 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 465.2 PJ of energy.

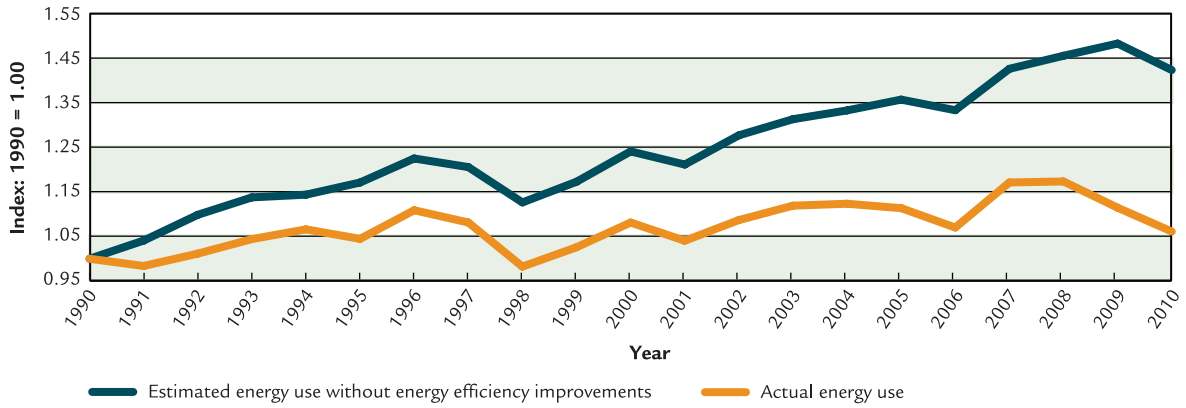
Growth in residential energy use was driven in large part by growth in activity. This growth in activity – specifically, growth in total floor space and number of households – was due to the increase in the average size of newly constructed houses, the rising population and the trend toward fewer individuals per household (see Figure 1-7).

FIGURE 1-7 Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2010



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 2010**



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2012

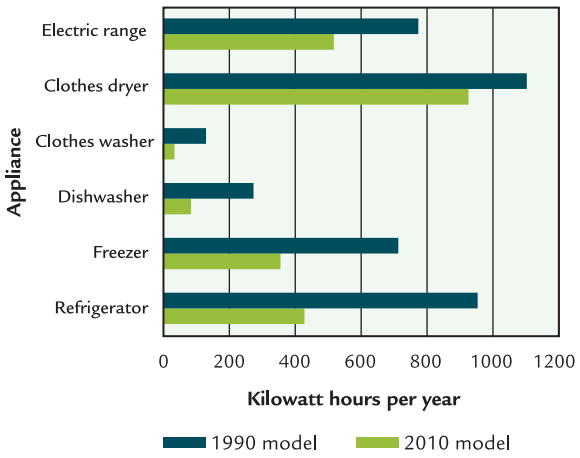
Energy Efficiency

The change in residential energy use between 1990 and 2010 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 36 percent improvement in energy efficiency between 1990 and 2010 translated into $9.0 billion (or 465.2 PJ) in energy savings in 2010.

Figure 1-9 shows how average energy consumption of new appliances has improved, by comparing 1990 and 2010 models.

FIGURE 1-9 **Average Energy Consumption of New Electric Appliances, 1990 and 2010 Models**



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

TRENDS - COMMERCIAL/ INSTITUTIONAL SECTOR

Energy Use

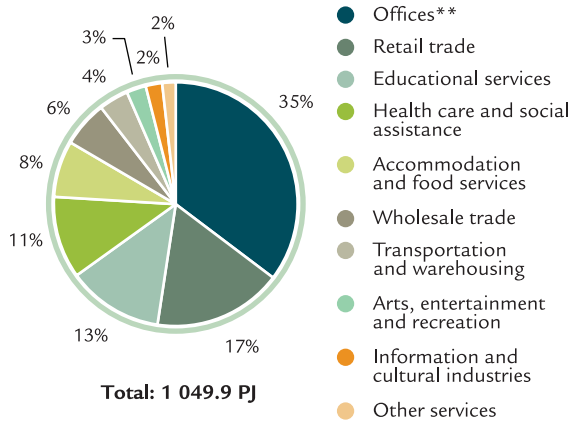
The commercial/institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services. This sector uses energy mainly for space and water heating, space cooling and lighting, as well as operating auxiliary equipment (such as computers, appliances, and medical equipment) and motors.

In 2010, commercial business owners and institutions spent $23 billion on energy to provide services to Canadians. This represented about 3 percent of the value of the GDP related to the sector. The sector also accounted for 12 percent of total energy use in Canada and produced 11 percent of associated GHG emissions.

Between 1990 and 2010, commercial/institutional energy use (including street lighting) increased by 22 percent, from 867.0 PJ to 1 057.3 PJ. GHG emissions from the sector, including electricity-related emissions, rose by 15 percent in the same period.

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 2010, offices accounted for 35 percent of the sector's energy demand. Retail trade (17 percent) and educational services (13 percent) were the next largest users.

FIGURE 1-10 Commercial/institutional Energy Use by Activity Type*, 2010



Total: 1 049.9 PJ

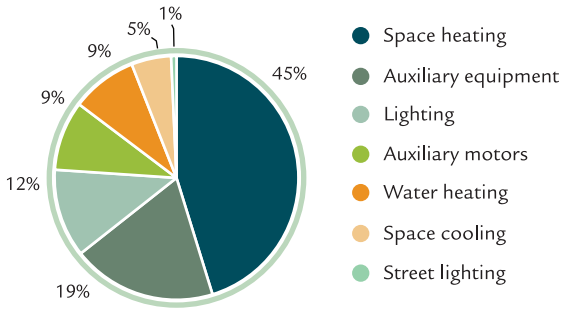
*Excludes street lighting

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

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

Energy is used for seven purposes in commercial/institutional activities. As illustrated in Figure 1-11, in 2010, the largest of these was space heating, which accounted for 45 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, 2010



Total: 1 057.3 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 2010 – activity, weather, structure, service level and energy efficiency effect:

- Activity – A 41 percent increase in floor space led to a 40 percent (343.6 PJ) growth in energy use and an increase of 17.8 Mt in GHG emissions.
- Structure – The effect of structure changes in the sector (the mix of activity types) was small and therefore changed GHG-related emissions only marginally.
- Weather – In 2010, the winter was warmer and summer was hotter than in 1990. The net result was an 11.9-PJ decrease in energy demand in the commercial/institutional sector, mainly for space heating, which had the effect of decreasing GHG emissions by 0.6 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 116.9-PJ increase in energy use and a 6.0-Mt increase in GHG emissions.

- Energy efficiency – Improvements in the energy efficiency of the commercial/institutional sector saved 256.1 PJ of energy and 13.2 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 51 percent. However, actual energy use increased by only 22 percent between 1990 and 2010, resulting in energy savings of $5.6 billion in 2010 (see Figure 1-12).

Between 1990 and 2010, the estimated energy efficiency improvements resulted in energy savings of 256 PJ for this sector.

TRENDS - INDUSTRIAL SECTOR

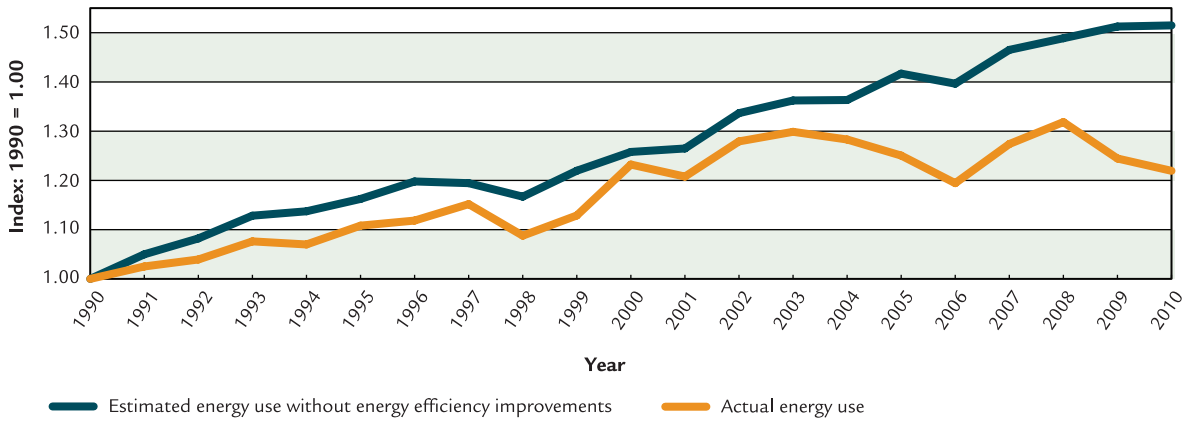
Energy Use

The industrial sector includes all manufacturing, mining (including oil and gas extraction), forestry and construction activities. However, it excludes electricity generation. This sector alone spent $36.9 billion on energy in 2010.

Overall, industrial energy demand in 2010 accounted for 38 percent (3 227.6 PJ) of secondary energy use and 34 percent (165.9 Mt) of GHG emissions (including electricity-related emissions). Between 1990 and 2010, actual industrial energy use increased by 19 percent, from 2 710.0 PJ to 3 227.6 PJ. The associated end-use GHGs increased 20 percent, from 138.1 Mt to 165.9 Mt.

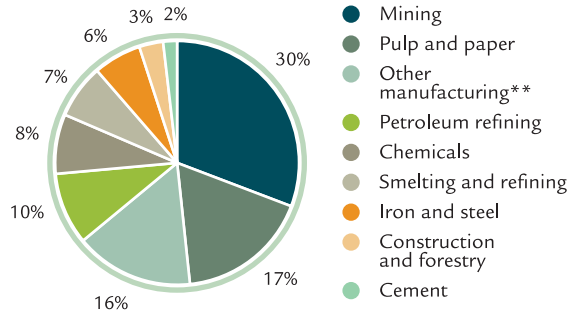
In the industrial sector, energy is used primarily to produce heat, generate steam or as a source of motive power. For example, coal is used by the cement industry to heat kilns. Numerous other industries use natural gas to fuel boilers for steam generation and electricity to power motors for pumps and fans. In 2010, energy was consumed primarily in mining, other manufacturing, pulp and paper production, and the petroleum refining industries. Mining alone accounted for 30.8 percent of total industrial energy demand (see Figure 1-13).

FIGURE 1-12 **Commercial/institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010**



Source: Natural Resources Canada, Commercial/Institutional End-Use Model, Ottawa, 2012.

FIGURE 1-13 Industrial Energy Use by Subsector – Including Electricity-related Emissions*, 2010

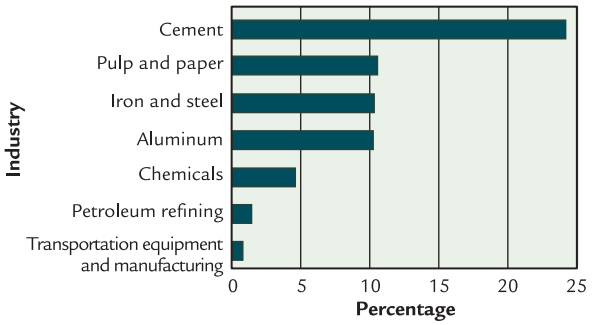


*The subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.

**Other manufacturing comprises more than 20 manufacturing industries.

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

FIGURE 1-14 Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2010



Source: Statistics Canada, CANSIM Table 301-0006

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 2010 (see Figure 1-14). For cement, in particular, the share was 24.2 percent.

As the Canadian economy evolves, so does the industrial make-up of GHG emissions. Increased production in the oil and gas industries has caused a larger share of direct GHG 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 49 percent decrease in GHG emissions and a smaller share of overall emissions.

Four main factors influenced industrial energy use between 1990 and 2010 – activity, structure, capacity utilization and energy efficiency effect:

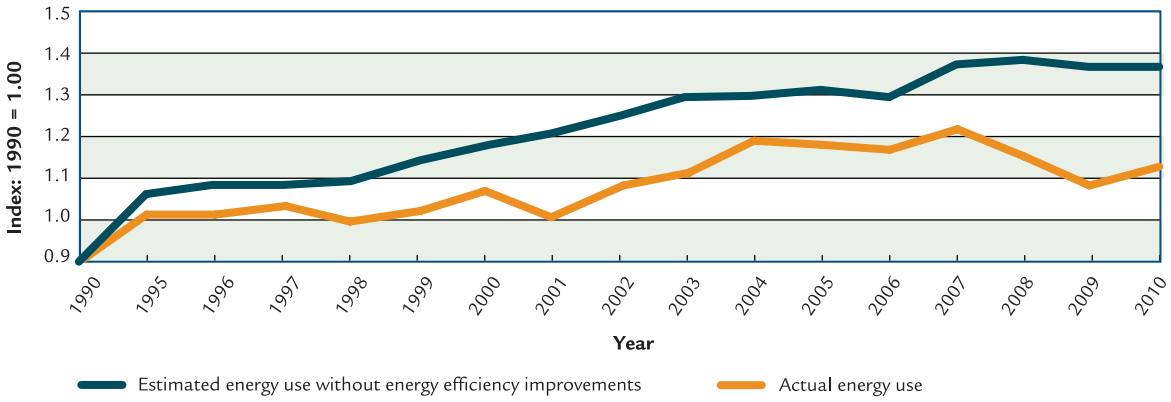
- Activity – The mix of GDP, gross output and production units (activity measures) increased energy use by 48 percent, or 1 287.9 PJ.
- Structure – The structural changes in the industrial sector, specifically a relative decrease in the activity share of energy-intensive industries, helped the sector to reduce its energy use by 522.3 PJ.
- Capacity utilization – The capacity utilization effect increased industrial energy use by 287.5 PJ.
- Energy efficiency – Improvements in the energy efficiency of the industrial sector avoided 535.3 PJ of energy use and 27.5 Mt of GHG emissions.

Energy Efficiency

In 2010, Canadian industry saved $6.1 billion in energy costs because of energy efficiency improvements, or 535.3 PJ of energy. This translates into 27.5 Mt of avoided GHG emissions. The change in energy use between 1990 and 2010 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 20 percent, largely because of improvements in energy intensity.

FIGURE 1-15 **Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010**



Note: 1991–1994 data are not available.

Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2012

TRENDS - TRANSPORTATION SECTOR

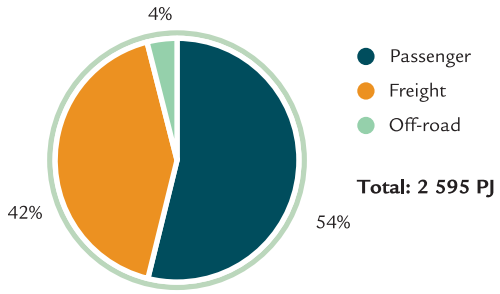
Energy Use

Canada's transportation sector is diverse and is responsible for moving people and goods over immense distances, varied geography and often intense weather conditions. Transportation has the largest energy bill of any sector in 2010. Although the sector (individuals and companies) spent $70.7 billion on energy (91 percent more than the second-place industrial sector), it actually uses only 30 percent of total energy in Canada (38 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 2 595.0 PJ of energy in 2010 (a 4 percent increase from 2009) and accounted for the largest portion of Canadian end-use GHG emissions at 37 percent (179.8 Mt).

The transportation sector consists of three subsectors: passenger, freight and off-road. In 2010, 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 1-16).

FIGURE 1-16 **Transportation Energy Use by Mode, 2010**



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 2010, total transportation energy use increased by 38 percent, from 1 877.9 PJ to 2 595.0 PJ, and the associated GHG emissions rose 36 percent, to 179.2 Mt from 131.4 Mt.

Within the transportation sector, freight was by far the fastest growing subsector, accounting for 63 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 18 percent

(211.3 PJ), while freight transportation energy use increased by 70 percent (455.1 PJ).

Three main factors influenced passenger transportation energy use between 1990 and 2010 – activity, structure and energy efficiency effect:

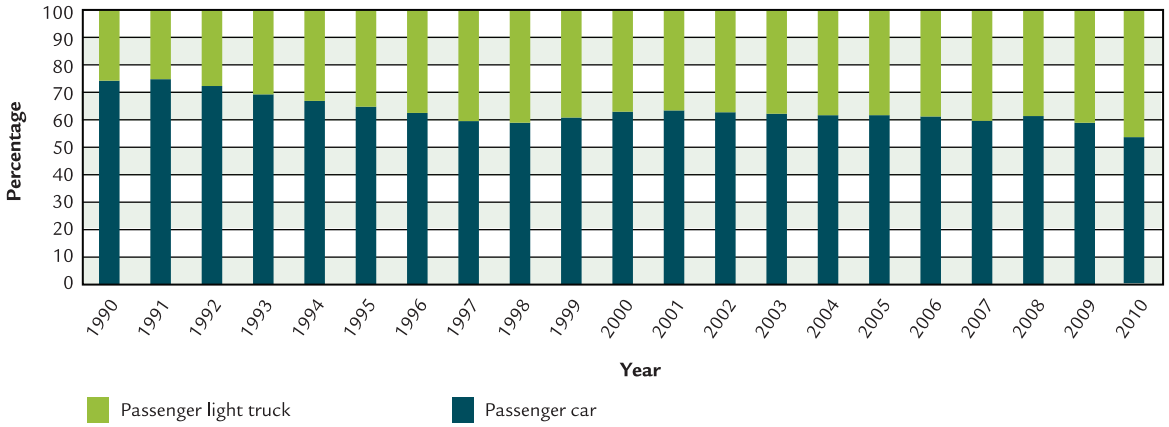
- Activity – The activity effect (i.e. passenger-kilometres travelled) increased energy use by 36 percent, or 483.9 PJ, with a corresponding 32.7-Mt increase in GHG emissions. Light-truck and air transportation led the growth in passenger-kilometres (and therefore, activity effect), with respective increases of 171 percent and 104 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 31.7-PJ increase in energy consumption and a 2.1-Mt increase in GHG emissions.
- Energy efficiency – Improvements in the energy efficiency of passenger transportation saved 293.0 PJ of energy and 19.8 Mt of energy-related GHG emissions. The light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation represented 68 percent of these energy savings.

Three main factors influenced freight transportation energy use between 1990 and 2010 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. tonne-kilometres moved) increased energy use 55 percent, or 355.1 PJ, and caused a corresponding 25.2-Mt increase in GHG emissions. This increase in the number of tonne-kilometres was mainly due to an increase of 190 percent in heavy-truck activity and an increase of 57 percent in medium-truck 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 231.2-PJ increase in energy use and an 16.4-Mt increase in GHG emissions.
- Energy efficiency – Improvements in the energy efficiency of freight transportation saved 131.2 PJ of energy and 9.3 Mt of GHG emissions. Improvements in freight trucks (light, medium and heavy trucks) were a large contributor, representing 73 percent of the savings.

Figure 1-17 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 had a significant effect on the increase in passenger energy use.

FIGURE 1-17 Market Shares of New Passenger Car and Light-truck Sales, 1990 to 2010

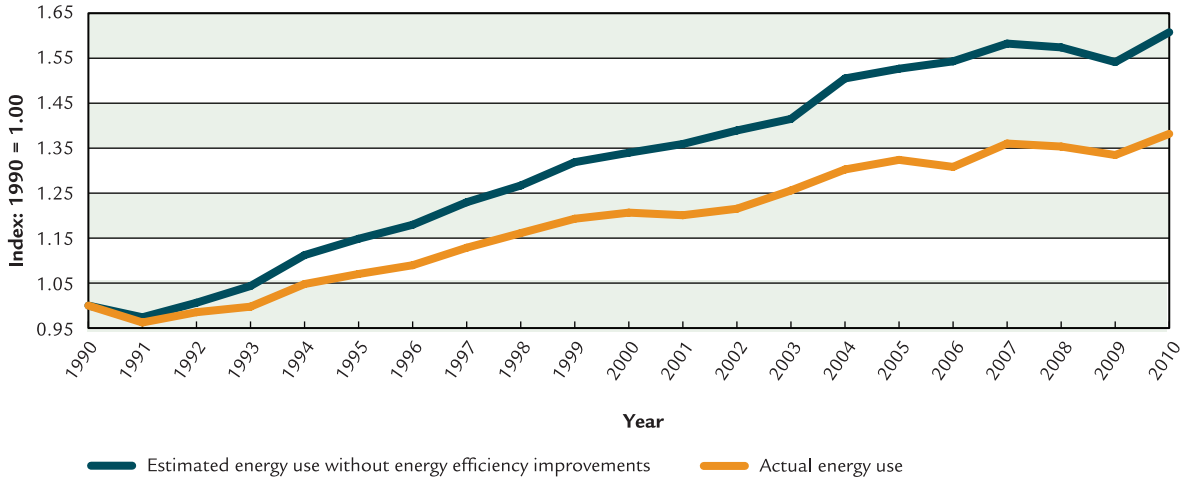


Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

Energy Efficiency

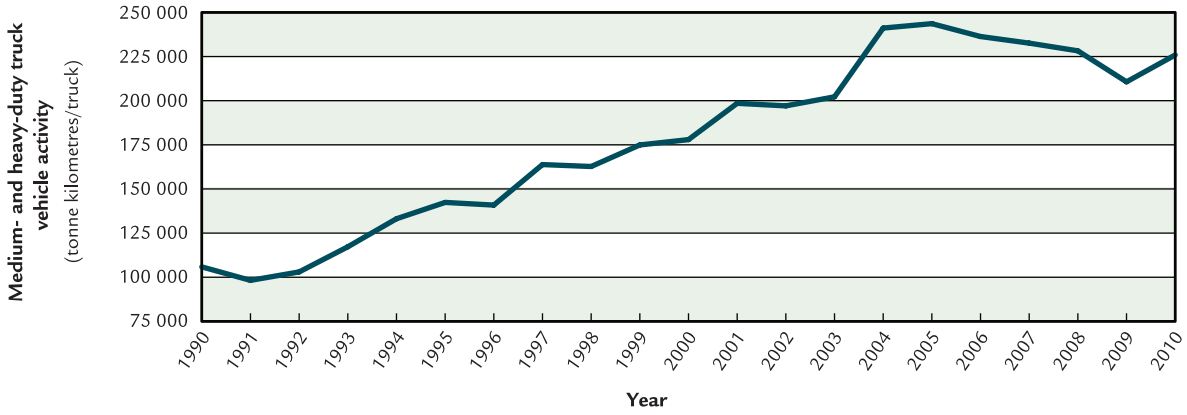
Between 1990 and 2010, energy efficiency in the transportation sector improved 24 percent, saving $11.6 billion or 424.2 PJ of energy. Without improvements in energy efficiency, increases attributable to activity and structure would have increased transportation energy use by 61 percent (see Figure 1-18). 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 1-18 Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010



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

FIGURE 1-19 **Average Activity per Truck, 1990 to 2010**



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

Figures 1-19 and 1-20 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2010. 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.

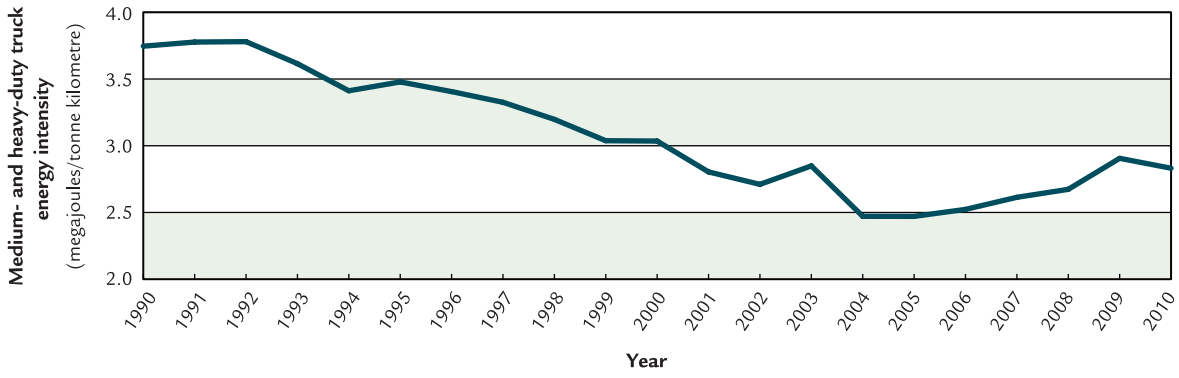
TRENDS - ALTERNATIVE AND RENEWABLE FUELS

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 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.

FIGURE 1-20 **Trucking Energy Intensity, 1990 to 2010**



Source: Natural Resources Canada, Transportation End-Use Model, Ottawa, 2012

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.

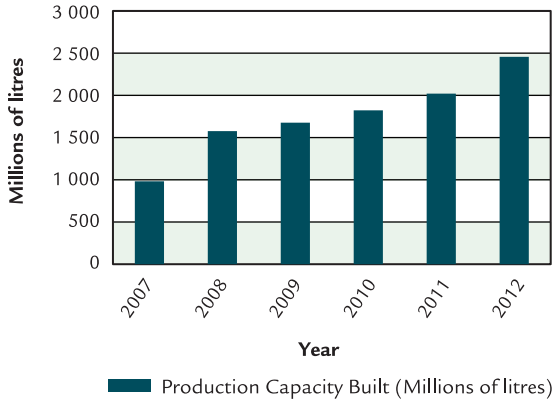
Renewable Fuels Production Capacity

Renewable fuels production capacity in Canada has risen significantly since the emergence of ethanol in Manitoba in the 1980s. Based on data compiled by NRCan's ecoENERGY for Biofuels program, ethanol production capacity rose from approximately 879 million litres (L) in 2007 to 1 881 million L at the end of 2012. In the case of biodiesel, production capacity rose from 103 million L to 575 million L over the same period.

Figure 1-21 shows the total biofuel production capacity that has been built from 2007 to 2012 based on the program's data.

On December 15, 2010, Environment Canada's *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.

FIGURE 1-21 Biofuels Production Capacity in Canada, 2007 to 2012



Source: Natural Resources Canada

Natural Gas Use in the Canadian Transportation Sector: Deployment Roadmap

Facilitated by NRCan, producing 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/energy/alternative-fuels/resources/3665.

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.

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 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.

When the market has achieved a higher level of efficiency, NRCan amends the Regulations to strengthen the minimum energy performance requirements for prescribed products. 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.

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

The Act and the Regulations require that a comparative EnerGuide label be displayed on major electrical household appliances and room air conditioners or, as in the case of the 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 ENERGY STAR® voluntary labeling 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.

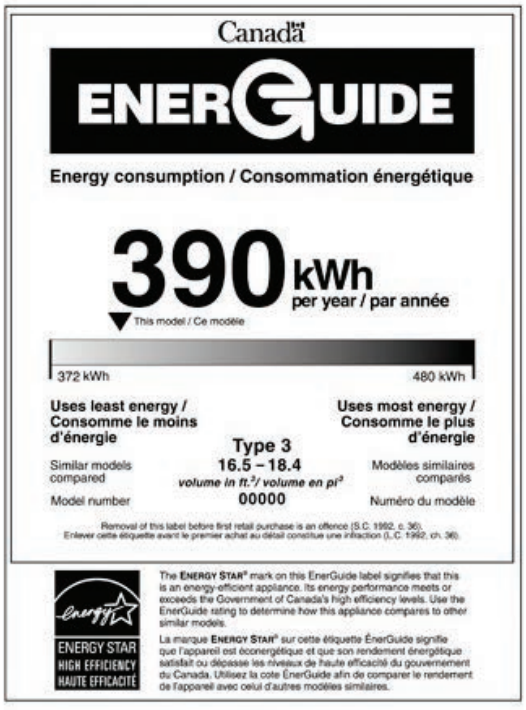
The ecoENERGY Efficiency program, launched in September 2011, includes support for the continuation of energy efficiency standards and labelling efforts. Further savings of 35 petajoules (PJ) of energy and 4 megatonnes (Mt) of emissions are expected to result in 2020 from additional standards and complimentary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

LABELLING AND PROMOTION

EnerGuide Label

Since 1978, the EnerGuide label has given Canadians the opportunity to compare the energy consumption of appliances (see Figure 2-1). 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.

FIGURE 2-1 EnerGuide Label



Online EnerGuide directories for all appliances and heating and cooling equipment are published on the Web site of the Office of Energy Efficiency (OEE) and updated regularly.

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 requirement in the Regulations to test, verify and report on fireplace efficiency. In 2013, at the manufacturers' request, domestic water heaters were added to the voluntarily EnerGuide labeling initiative. 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.

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 2-2). NRCan administers the ENERGY STAR program in Canada under a letter of agreement with the United States 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 initiative for Canada.

FIGURE 2-2 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, their availability in the marketplace, and their accessibility to consumers.

This is a voluntary initiative, however manufacturers must have their products tested and certified to demonstrate they meet the eligibility criteria and performance levels required to display the ENERGY STAR logo. 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.

The criteria for efficiency specifications ENERGY STAR qualification are set out by the Environmental Protection Agency, with the exception of fenestration products and heat recovery ventilators. ENERGY STAR qualified products can be found in the following product categories:

- major household appliances
- heating, cooling and ventilating equipment
- consumer electronics
- office equipment
- windows, doors and skylights
- lighting products – compact fluorescent lamps, fixtures, decorative light systems and solid-state lighting
- 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

DID YOU KNOW?

New since 2013 is an ENERGY STAR specification for pool pumps! Most pool owners don't realize how much energy their pool pump may be wasting. Pump speeds vary based on a pool's operation. Filtration, for example, only requires half the flow rate of running a pool cleaner. Conventional pool pumps, with only one speed, are set to run at the higher speeds required of the pool cleaner and waste energy during filtration operation by running faster than necessary. An ENERGY STAR certified pool pump can run at different speeds and be programmed to match the pool operation with its appropriate pool pump speed. The energy saved is considerable; reducing pump speed by one-half allows the pump to use just one-eighth as much energy.

ENERGY STAR certified pool pumps will do the following:

- ✔ save you more than $1,000 over their lifetime
- ✔ pay for themselves in five years
- ✔ run more quietly and prolong the life of your pool's filtering system

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 2012–2013, Hydro-Québec offered rebates for ENERGY STAR light emitting diodes , the Ontario Power Authority offered a consumer incentive for ENERGY STAR qualified heating and cooling equipment, SaskPower offered an ENERGY STAR lighting incentive program, and Manitoba Hydro ran incentive programs for ENERGY STAR qualified commercial kitchen equipment.

Organizations across Canada, including utilities, housing authorities, municipalities and efficiency organizations have used ENERGY STAR as a campaign driver to promote replacement with, or purchase of, higher efficiency products.

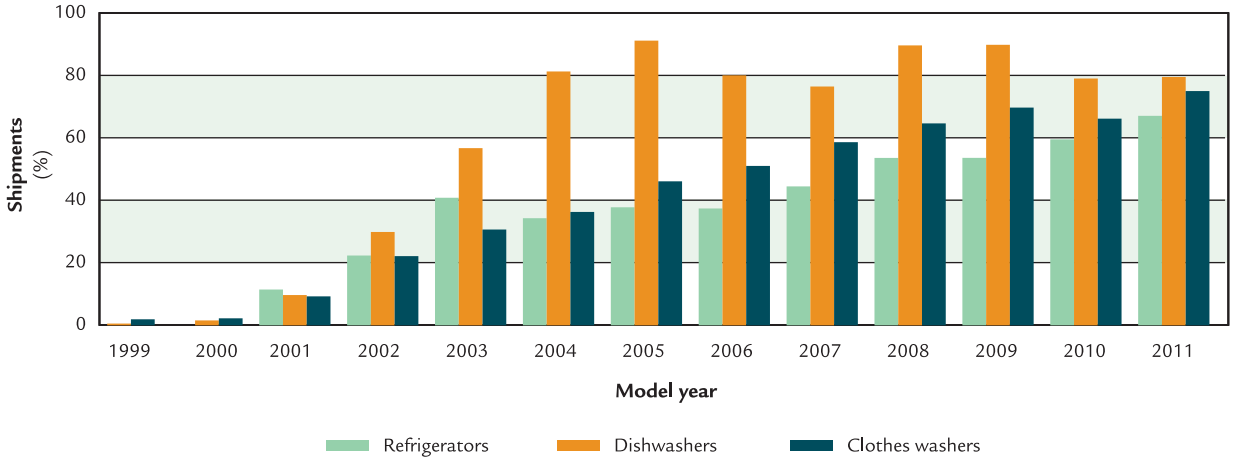
Continuous promotion of ENERGY STAR qualified appliances has paid off. Industry statistics for 2011 show an increase in market penetration from almost nil in 1999 to 67 percent for refrigerators, 75 percent for clothes washers and 79 percent for dishwashers (see Figure 2-3). The increase in market penetration 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 develop more efficient products and thus maintain the relevance and credibility of the brand. In addition, NRCan supports demonstration projects to validate the savings and other benefits of some of these products and to address barriers to their widespread acceptance.

ENERGY STAR is also well-known in the commercial sector, with criteria for products ranging from office and kitchen equipment to vending machines. These criteria are increasingly being adopted by large commercial and institutional organizations to help with bulk procurement decisions, and in 2012–2013, six hospitals joined the ENERGY STAR initiative to benefit from the savings afforded by this practice.

To this end, 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 GHG emissions associated with the purchase of ENERGY STAR qualified

FIGURE 2-3 **ENERGY STAR Qualified Appliances as a Percentage of Total Shipments in Canada, 1999 to 2011**



Source: *Energy Consumption of Major Household Appliances Shipped in Canada, Trends for 1999–2011*

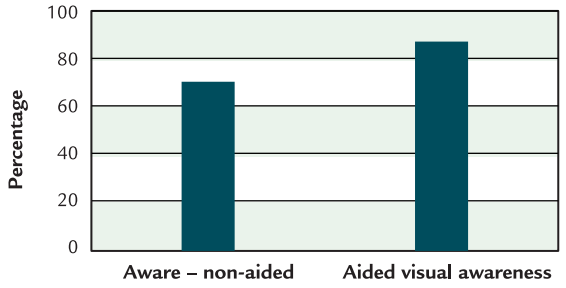
products. This information is needed to make a solid business case for investing in more efficient equipment in spite of the "first price tag" – which is often a barrier in bulk purchases of energy-using equipment.

The Government of Canada continues to lead by example in this area, with five national Master Standing Offers referencing mandatory ENERGY STAR criteria and an additional nine categories with optional ENERGY STAR criteria. NRCan maintains a close relationship with Public Works and Government Services Canada to include more ENERGY STAR product categories in federal procurement directives.

Canada also works 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 label, 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 1 product category added in 2012 and stringency increased for more than 12 others.

A 2010 study indicated that, even though they were not assisted, 71 percent of respondents indicated an awareness of the ENERGY STAR symbol. However, awareness levels grew to 89 percent when participants were shown the symbol (see Figure 2-4).

FIGURE 2-4 **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 a pilot 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. ENERGY STAR Most Efficient became a full-fledged offering in 2013, and as with the pilot initiative, NRCan participates fully in recognition of the specifications and eligible products, setting its own specification and product lists for windows.

Availability of the Most Efficient designation is advancing 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 GHG emissions.

FIGURE 2-5 **ENERGY STAR Most Efficient Logo**

The first *ENERGY STAR® in Canada Annual Report* was published in 2013. The report recognizes the industry-government achievements in transforming

the way Canadians use energy. In 2011 alone, the energy Canadians saved from using ENERGY STAR qualified products was equivalent to the energy used by 66 000 cars for the year – 3.4 PJ of energy. Further, it is recognized that the achievements of ENERGY STAR are durable, continuing year after year in a way that not only changes the Canadian marketplace but Canadian society. The complete report is available online at publications.gc.ca/site/eng/443627/publication.html

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 the same as, or 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 *Energy Efficiency Act* requires that:

- 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."

The 2010–2011 *Report to Parliament under the* Energy Efficiency Act demonstrated how our standards are as stringent as about 90 percent of those compared. Further reporting on this will be presented in the 2013–2014 report to Parliament.

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.

To monitor compliance with the Regulations, the department captures information from energy efficiency reports and import documents. 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 indicate 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 information that allows the department to confirm there is a matching energy efficiency report. The department can then confirm that all products entering Canada meet the required energy performance levels.

NRCan processed more than 3.15 million records (records from April 1, 2012 to March 31, 2013) relating to the importation of regulated energy-using products to Canada in 2012–2013.

More than 4.44 million new or revised model numbers were submitted to NRCan for entry into the department's equipment database (records from April 1, 2012 to March 31, 2013) 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*.

It is estimated that Canada's energy performance standards from 12 amendments have resulted in a reduction of 26.03 Mt in aggregate annual GHG emissions in 2010 (see Table 2-1).

TABLE 2-1 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	**184.77**	**336.47**	**26.03**	**44.75**

During 2012–2013, the department implemented the requirements of Amendment 11, the second amendment of the Clean Air Regulatory Agenda. This amendment came into force on April 12, 2012. NRCan finalized the analysis, consultation and drafting of Amendment 13, which completed our commitment in the Clean Air Regulatory Agenda. This amendment will increase the efficiency of the minimum energy performance standards for 15 currently regulated products; introduce performance standards for mercury vapor lamp ballasts; and update the scope, reporting and compliance requirements for several other products.

Amendment 13 also constitutes a comprehensive re-write of the entire *Energy Efficiency Regulations* to remove outdated requirements and to make the Regulations easier to read and use. In response to the Cabinet Directive on Regulatory Reform, the department conducted analysis of the administrative cost burden of Amendment 13 to conform with the "One-for-One" rule. Finally, analysis and recommendations were developed to support final implementation of the light bulb standard.

The final 2020 projected energy efficiency impacts of the published and soon-to-be pre-published amendments (Amendments 10 to 13) are savings of 105.01 PJ of energy and 11.14 Mt of GHG emissions.

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 initiatives under the suite of ecoENERGY programs, including the following:

- 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
- Federal Buildings Initiative
- ecoENERGY for Alternative Fuels
- ecoENERGY for Biofuels

For more information:

nrcan.gc.ca/energy/offices-labs/office-energy-efficiency/5691

This chapter describes the objective of each of the aforementioned programs and outlines key achievements for fiscal year 2012–2013.

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 make the housing, building and equipment stock more energy-efficient, energy performance more visible, and industry and vehicle operations more efficient.

Improving energy efficiency contributes to a cleaner environment and reduces greenhouse gas (GHG) 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 follow.

ecoENERGY EFFICIENCY FOR BUILDINGS

Objective

ecoENERGY Efficiency for Buildings 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 is improving the efficiency of new and existing buildings in Canada's commercial and institutional sector. Activities include the following:

- providing technical, policy and financial support to the National Research Council of Canada, the federal organization responsible for code development, to update the 2011 National Energy Code of Canada for Buildings, resulting in publication of the 2015 edition of the energy code. Code 2015 will include new equipment standards and regulations. Beyond 2015, updates to the code will include energy performance

improvements that maintain our collective progress to net-zero energy buildings. In addition, information, tools, training and best practices are 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 (3 000 to 4 000 buildings). The benchmarking tool provides 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 and face-to-face and Web-enabled events. Collaborative arrangements are undertaken to foster capacity building, transfer knowledge and support the implementation of energy management projects and practices.

Key 2012–2013 Achievements

- More than 2 300 building sector participants were trained in Dollars to $ense workshops.
- Four provinces adopted or have taken significant steps toward adopting the 2011 *National Energy Code of Canada for Buildings* or an equivalent code. Ontario adopted an equivalent building energy code in 2011, and three provinces undertook consultations on the code in 2012–2013.
- More than 20 benchmarking awareness sessions were held.

DID YOU KNOW?

Strong building codes are affordable and effective tools for increasing the long-term energy efficiency of our buildings. Economic analysis indicates that every dollar spent on energy code compliance and enforcement initiatives yields $4 to $8 in energy savings. Implementing energy codes will help improve the efficiency of our building stock, save Canadians millions of dollars annually and help reduce both our carbon emissions and the need to build new power stations to meet growing energy demands.

ecoENERGY EFFICIENCY FOR HOUSING

Objective

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

Description

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

- 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 some regional incentive 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 20 percent 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[5] 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 50 percent 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.

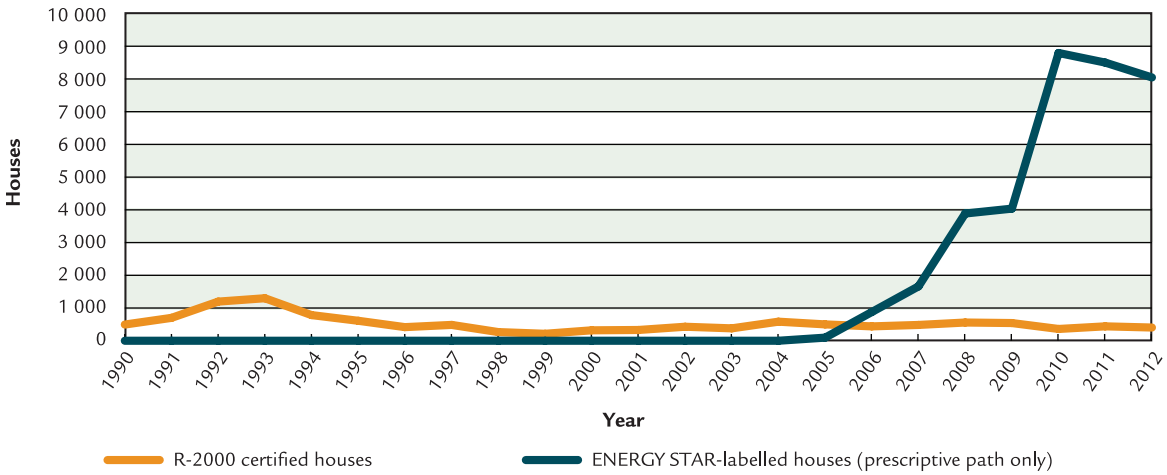
DID YOU KNOW?

For the first time in Canada, new home buyers will know that their dwellings have been built with energy efficiency in mind. The current edition of the *National Building Code of Canada* includes energy efficiency requirements for houses and small buildings that cover thermal performance of walls and windows, heating systems, ventilation, air-conditioning and hot water heating.

Figure 3-1 shows the number of R-2000 certified houses and ENERGY STAR labelled houses built from 1990 to 2012.

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

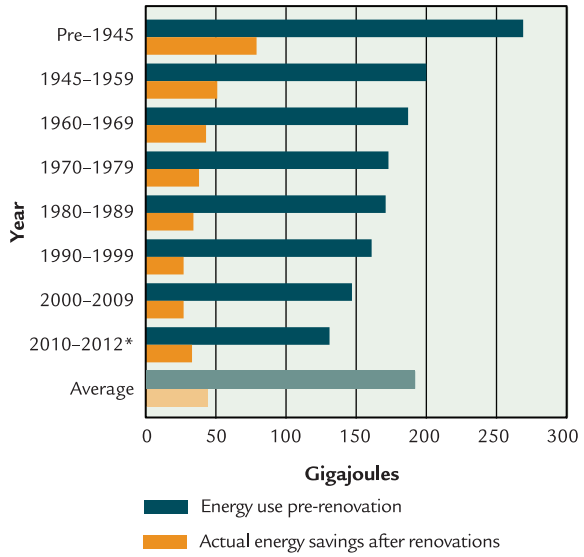
FIGURE 3-1 Number of R-2000 House Certifications and ENERGY STAR Prescriptive-labelled Houses, 1990 to 2012



Source: NRCan national housing database and internal data

Figure 3-2 illustrates the energy use and savings gained per household before and after renovations.

FIGURE 3-2 Residential Energy Use and Energy Savings per Household, Pre-1945 to 2010–2012



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

Key 2012–2013 Achievements

- NRCan-developed housing standards and systems were used in 26 provincial, territorial and utility programs in 2012–2013. Two other non-governmental programs also used the standards and systems.
- Minimum energy performance requirements were added to the housing and small buildings section of the *National Building Code of Canada*.
- New ENERGY STAR for New Homes and R-2000 building standards were implemented.
- More than 16 000 new housing energy labels were issued.

ecoENERGY EFFICIENCY FOR EQUIPMENT STANDARDS AND LABELLING

Objective

The objective of ecoENERGY Efficiency for Equipment Standards and Labelling is to eliminate the worst energy performers and accelerate the introduction of more energy-efficient products in Canada's equipment stock. NRCan is introducing new and more stringent regulated minimum energy efficiency performance standards and deploying 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 GHG emissions. Activities include the following:

- continuing to implement regulated minimum energy efficiency standards through amendments to the *Energy Efficiency Regulations*. These standards will eliminate least efficient 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
  - high-intensity discharge 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 includes ongoing support for 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 the following:
  - the official implementation of the ENERGY STAR Most Efficient designation, which identifies the best performers of ENERGY STAR qualified products. Products that meet ENERGY STAR Most Efficient specifications are up to 50 percent more efficient than standards specified in the regulations.
  - the implementation of a new voluntary EnerGuide label for domestic water heaters. They will provide energy consumption information for consumers to make informed purchase decisions.

  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. This will be done by providing support for product showcases, deployment and monitoring.

Key 2012–2013 Achievements

- Sixteen market assessments were completed for consumer and commercial products to be regulated. Nine technology assessments were also undertaken.
- Three national test standards were developed.
- One new ENERGY STAR product category was introduced, and more than 12 product specifications were revised.

DID YOU KNOW?

The ISO 50001 Energy Management System standard was developed by 43 major countries representing 60 percent of the world's energy use. Canada was the first country in the world to adopt it.

ecoENERGY EFFICIENCY FOR INDUSTRY

Objective

ecoENERGY Efficiency for Industry 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 the following:

- supporting the Canadian Industry Program for Energy Conservation (CIPEC). CIPEC 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. These help industrial companies reduce energy use by improving energy management practices.
- providing newsletters, reports, guides, manuals and publications. These increase awareness of industrial energy efficiency.

Key 2012–2013 Achievements

- More than 1 000 participants were trained in Dollars to $ense training workshops and CIPEC webinars.
- Twelve collaborative agreements were signed.
- Four technical publications and tools were produced, and 19 e-newsletters were issued.

ecoENERGY EFFICIENCY FOR VEHICLES

Objective

ecoENERGY Efficiency for Vehicles aims to raise awareness about 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 the following:

- helping Canadians understand the links between their driving behaviour and fuel consumption through fuel-efficient driver training and other tools:
  - Auto$mart targets novice drivers of light-duty vehicles.
  - SmartDriver targets drivers in the commercial and institutional fleet sector.
  - Commercial and institutional fleets also have access to additional practical advice, tools and strategies offered through FleetSmart.
- providing consumers with the information they need to make decisions about purchasing energy-efficient vehicles and equipment. This includes the following:
  - the *Fuel Consumption Guide* and on-line consumer fuel efficiency information
  - introducing updated energy efficiency labels for light-duty on-road vehicles
  - developing a new consumer awareness initiative that provides Canadians with information about fuel-efficient tires for light-duty vehicles
- introducing a Canadian version of the SMARTWAY Transport Partnership, a successful program launched by the U.S. Environmental Protection Agency:
  - SMARTWAY connects freight shippers with an interest in greening their operations to a list of endorsed energy-efficient freight carriers.
  - Based on the data that they submit, participants' energy use and activity information are used to benchmark their emissions performance.
  - The SMARTWAY Transport Partnership continues to expand in scope.

Key 2012–2013 Achievements

- In 2012–2013, NRCan improved the information programs it provides on fuel-efficient driving. For example, a new Auto$mart curriculum for personal vehicle drivers that includes new multimedia components was launched. It is now available for adoption by provinces and territories, and uptake has been very positive.

The curricula for highway truck drivers and fleet owners were also updated.

- More than 216 000 drivers were trained.
- Fleets comprised of more than 3 000 highway trucks registered for the SmartWay Transport Partnership program in Canada.

DID YOU KNOW?

Operating a vehicle with its tires underinflated by 8 pounds per square inch (56 kilopascals) can reduce the life of the tires by 10 000 kilometres and increase the vehicle's fuel consumption by 4 percent. You can find the recommended tire pressure for your vehicle on the tire-information placard – on the edge of the driver's door or doorpost – or in your owner's manual. Learn more about tire maintenance at www.betiresmart.ca.

FEDERAL BUILDINGS INITIATIVE

Objective

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

Description

The Federal Buildings Initiative facilitates the implementation of energy saving projects in Canadian federal organizations (departments, agencies and Crown corporations). The initiative provides tools, training, a Community of Practice, 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.

DID YOU KNOW?

Since the inception of the Federal Buildings Initiative in 1991, there have been more than 80 retrofit projects, attracting $312 million in private sector investments and generating more than $43 million in annual energy cost savings. These Federal Buildings Initiative projects have demonstrated on average a 15 to 20 percent energy savings and have also helped reduce the impact of operations on the environment.

The Federal Buildings Initiative's services include the following:

- support for recommissioning of building systems
- support and building awareness for the adoption of the energy benchmarking system Portfolio Manager
- customized training from the Dollars to $ense workshop series
- a Community of Practice networking group that brings together real property and environmental managers from federal facilities to share knowledge about energy efficiency strategies, products and tactics

Key 2012–2013 Achievements

- NRCan helped the following departments undertake opportunity assessments toward the development of energy performance projects: Environment Canada, the National Research Council and the Canada Border Services Agency.
- Two energy performance contracts were signed with NRCan and the Department of National Defence (Valcartier).
- Twelve new federal clients used the services of the Federal Buildings Initiative in 2012–2013, bringing the total to 38 clients since 2011.
- Five community of practice meetings were held.

ecoENERGY FOR ALTERNATIVE FUELS

Objective

ecoENERGY for Alternative Fuels is a five-year, $3.0-million program to help advance the deployment of natural gas vehicles in transportation by supporting education and outreach efforts as well as much needed codes and standards work.

Description

The ecoENERGY for Alternative Fuels program activities represent the federal government's contribution to implementing recommendations from the *Natural Gas Use in the Canadian Transportation Sector: Deployment Roadmap*. These activities address key areas that facilitate the deployment of medium- and heavy-duty natural gas vehicles in Canada.

Education and outreach activities include establishing up to three local support networks. The hubs – which are modeled after the United States Clean Cities Program – 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) by providing "on-the-ground" resources to end-users who want information about options for fuelling their vehicles with natural gas.

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

Codes and standards work within the ecoENERGY for Alternative Fuels program is focused on accelerating the harmonization of codes and standards for compressed natural gas vehicles and infrastructure between the United States and provinces to reduce barriers to implementation and deployment of vehicles. This work also involves developing new codes and standards for liquefied natural gas vehicles and infrastructure that align with those in the United States.

DID YOU KNOW?

New heavy-duty vehicle standards that come into effect in Canada and the United States for model year 2016 vehicles will, for the first time, regulate GHG emissions. Natural gas trucks and buses will comply with these standards and can help position fleets for longer term compliance due to the lower GHG emission profile of natural gas as a transportation fuel.

Key 2012–2013 Achievements

- In 2012–2013, the ecoENERGY for Alternative Fuels program supported technical committees that revised two existing codes for compressed natural gas vehicles and refueling infrastructure. A third code was amended to include refueling infrastructure for liquefied natural gas vehicles, which addressed a priority area highlighted in the roadmap.
- The Go with Natural Gas Web site was launched in 2012 as a resource for Canadian fleets wanting to know more about natural gas vehicles (oee.nrcan.gc.ca/transportation/alternative-fuels/fuel-facts/natural-gas/18320).
- Tools were developed for outreach and national training and education that had been identified as needed by industry stakeholders.

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.

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 and has the following aims:

- reduce the GHG 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?

Advanced technologies are now able to transform municipal, commercial and agricultural biomass waste into ethanol fuel.

Key 2012–2013 Achievements

- The ecoENERGY for Biofuels program signed agreements with producers that represent a production capacity of 1 881 million litres per year (L/year) of renewable alternatives to gasoline (ethanol) and 575 million L/year of renewable alternatives to diesel (biodiesel).
- Environmental assessments were completed for the 27 facilities that have a contribution agreement with the program.

CHAPTER 4

Clean Energy Science and Technology

INTRODUCTION

Natural Resources Canada (NRCan) invests in research, development and demonstration (R,D&D) of new and emerging clean energy science and technology that produces economic and environmental benefits for Canadians. NRCan's Innovation and Energy Technology sector leads the federal government's energy science and technology initiatives. Energy efficiency is an integral component of the energy R,D&D portfolio.

Within the Innovation and Energy Technology Sector, 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. CanmetENERGY provides science and technology expertise in support of NRCan's activities and programs.

These programs are delivered in partnership with other government departments and agencies and the private sector. Collectively more than $120 million was invested in 2012–2013 which in turn leveraged significant private industry and public sector funding, usually 1 or 2 times more than the initial NRCan investment.

The programs help find new, long-term, cleaner and more efficient solutions to reducing environmental emissions by developing and disseminating new knowledge and new technologies through R,D&D initiatives. The work also helps to create Canadian expertise, increase Canada's productivity and competitiveness, as well as provide safe, reliable and affordable energy to Canadian consumers and industry.

This chapter describes in detail the programs, activities and 2012–2013 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/energy/offices-labs/oerd/5711
nrcan.gc.ca/energy/offices-labs/canmet/5715

PROGRAM OF ENERGY RESEARCH AND DEVELOPMENT

Objective

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

Description

The Program of Energy Research and Development is a federal, interdepartmental program operated by NRCan. The program funds R&D 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 an ongoing or opportunity basis in the program:

- Aboriginal Affairs and Northern Development Canada
- Agriculture and Agri-Food Canada
- Atomic Energy of Canada Limited
- Canada Mortgage and Housing Corporation
- Environment Canada
- Fisheries and Oceans Canada

- Health 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 following groups:

- 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 2012–2013 fiscal year was approximately $45 million. Of that amount, $12 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 $33 million was allocated to energy R&D programs managed and performed in NRCan, a portion of which contributed to improved energy efficiency and the integration of renewable energy sources in Canada.

Key 2012–2013 Achievements

In 2012–2013, the Program of Energy Research and Development funded approximately 280 clean energy and energy efficiency R&D projects, including research in the environmental aspects of oil sands, clean electricity and renewables, bioenergy, smart grid and storage, pipelines and efficient end use (in the buildings industry and the transportation sectors). Such energy efficiency projects include the following:

- DABO, a software tool developed by CanmetENERGY for continuous optimization of building operations, was licensed to a Canadian software company. Benefits of using the tool include significantly decreased overall operating costs (25 percent) through energy savings while maintaining occupant comfort level.
- CanmetENERGY developed a strategy for reducing residential summer peak electrical loads by 50 percent. The work included analysis to improve energy-efficient performance, partnering with a manufacturer to develop an innovative zoned air handling product, working with utilities to develop an alternative Smart Grid approach for controlling zoned systems, and partnering with universities to examine the business case and carry out local monitoring of systems installed in Canadian homes.
- A computer simulation-optimisation tool was developed to assess fuel cogeneration (combined heat and power) scenarios with different hypotheses for the fuel costs, process steam demand and boiler characteristics. In a case study at an Ontario pulp mill, energy savings of 5 megawatts (MW) and water use reduction of 800 000 cubic metres per year were identified. A review of the waste heat recovery strategies identified in the study will be used to develop specific performance indicators that will help guide an investment strategy roadmap for the pulp and paper sector.

For more information:

nrcan.gc.ca/energy/funding/current-funding-programs/perd/4993

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 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 $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. Government of Canada funding ended in 2012, but some projects are ongoing.

Key 2012–2013 Achievements

- Of the 10 small-scale carbon capture and storage projects under the ecoENERGY Technology Initiative, 7 are completed. Two others will be completed in 2013–2014, and the completion of the last project is planned for 2014–2015.
- A key deliverable of the International Energy Agency Greenhouse Gas Weyburn-Midale CO_2 Monitoring and Storage Project is a comprehensive *Best Practices Manual*. This is a practical "how to" guide for the design, implementation, monitoring and verification of carbon dioxide (CO_2) geological storage, especially in the context of enhanced oil recovery. A national carbon capture and storage Web site (www.CCS101.ca) was created to realize the project's aims to influence the development of effective public consultation and outreach processes.

For more information:

nrcan.gc.ca/energy/science/1335

CLEAN ENERGY FUND

Objective

To fund the R,D&D of technologies, including large-scale carbon capture and storage projects and renewable energy and clean energy systems projects to reduce greenhouse gas (GHG) emissions and increase the percentage of electricity produced from clean sources.

Description

The Clean Energy Fund, a component of Canada's Economic Action Plan announced in 2009, provides funding for the R,D&D of promising technologies to support the Government of Canada's commitments to reducing GHG emissions. Approximately 37 percent of the Clean Energy Fund is 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 2012–2013 fiscal year were approximately $32 million. Of that amount, approximately $10.2 million was allocated to large-scale demonstration projects and approximately $16.6 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.

Key 2012–2013 Achievements

- The Clean Energy Fund continues to show progress on 19 announced or committed small- and large-scale projects. Two Clean Energy Fund wind projects were in the process of commissioning their turbines in 2012–2013. These projects will add 10.8 MW of clean electricity generation at the Wind Energy Institute's research site in Prince Edward Island and at a First Nation in Saskatchewan.
- Two small-scale projects supported by the Clean Energy Fund have been identified by KPMG as some of the 100 most innovative and inspiring urban infrastructure projects in the world (Infrastructure 100: World Cities Edition, 2012). The two projects are the University of British Columbia's Bioenergy Research and Demonstration Facility (Vancouver, British Columbia), which will be the world's first biomass-fueled, heat-and-power generation system that operates on a scale suitable for communities and Harvest Power's Energy Garden

(Richmond, British Columbia) which is Canada's first high-efficiency system for producing renewable energy from food scraps and yard trimmings.

- In addition, more than $253 million was leveraged from proponents and collaborators of two large-scale carbon capture and storage demonstration projects (Shell Quest and Enhance Energy's Alberta Carbon Trunk Line) in 2012–2013. The construction of both projects is progressing as planned. It is expected that about 3 megatonnes of CO_2 will be captured annually, starting in 2015. These projects will help demonstrate the feasibility of integrated carbon capture and storage schemes in Canada and translate into tangible reduction of CO_2 emitted from large industrial point sources, such as oil sands operations and fertilizer plants.

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

Available funding totals $268 million over five years. The initiative supports energy technology innovation to produce and use energy in a cleaner and more efficient way through R&D projects and demonstrations in five key strategic areas: energy efficiency; clean electricity and renewables; bioenergy; electrification of transportation; and unconventional oil and gas.

The ecoENERGY Innovation expenditures for the 2012–2013 fiscal year were $42.8 million. Of that amount, approximately $17.9 million was allocated to internal federal government R&D, $6.1 million to external R&D and $9.8 million to demonstration projects.

Key 2012–2013 Achievements

In 2012–2013, the ecoENERGY Innovation Initiative undertook 123 R,D&D projects. Two of these projects are highlighted below:

- The ecoENERGY Innovation Initiative supported research conducted by Environment Canada to characterize the emissions from, and fuel efficiency of medium-duty trucks. Emissions characterization covered nitrogen oxides, particulate matter, carbon monoxide, hydrocarbons and GHGs. This information supports Environment Canada with its on-going development of GHG regulations for heavy-duty vehicles. Specifically, the results of this program will be used to support validation of a certification tool called the Greenhouse Gas Emission Model.
- Another highlight under the ecoENERGY Innovation Initiative is the signing of a contribution agreement with CO_2 Solutions Inc. The company will develop an enzyme-based approach for low-cost CO_2 capture from industrial effluent emissions in the Alberta oil sands and elsewhere. CO_2 Solutions and its partners will optimize and validate the technology at large bench- and pilot-scale facilities with a view to capturing 90 percent of CO_2 from oil sands in situ production and upgrading operations. This is expected to garner cost savings of at least 25 percent compared to conventional carbon capture technology.

For more information:

ecoenergyinnovation.nrcan.gc.ca

The following areas were funded by the ecoENERGY Innovation Initiative, Clean Energy Fund, Program of Energy Research and Development and/or A-Base and provide a more technology-specific view of activities and achievements that occurred during 2012–2013.

BUILDINGS AND COMMUNITIES

Objective

To support the department's goals to introduce more energy-efficient equipment, processes and technologies to the market through R,D&D in its own science and technology laboratories and in collaborations with industry, academia, and other governments domestically and around the world.

The following research areas are included:

- advanced heating, cooling and refrigeration equipment including integration of renewables and energy storage
- smart buildings through innovation in building controls and energy management
- high performance building and housing design including net zero energy solutions
- high efficiency mechanical and renewable energy systems for the built environment
- integrated energy community systems including municipal level smart energy (electricity and thermal) networks

DID YOU KNOW?

Drake Landing Solar Community: A Sustainable Energy Home Heating System

Canada has demonstrated the technical feasibility of community seasonal solar storage capable of meeting 98 percent of its space-heating needs (a world record) through the use of solar thermal collectors and seasonal ground energy storage. The system charges a borehole thermal energy storage field in the summer, extracting this energy in winter to heat the homes. GHG emissions have been reduced by more than 5 tonnes per home per year. Feasibility studies are underway in Whitehorse, Edmonton and China to replicate this concept using Canadian-led engineering services.

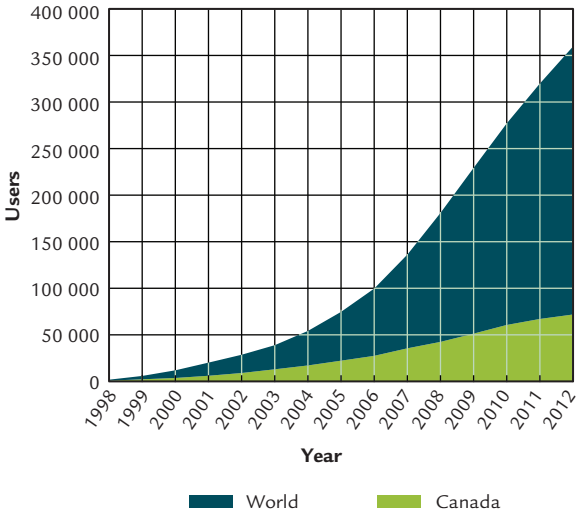
Description

Work ranges from the development of innovative technologies such as integrated systems for housing, buildings and communities to the development of energy modeling analytical tools and software, making it possible to achieve greater energy efficiency to be implemented at minimal incremental costs.

Key 2012–2013 Achievements

- The number of users of RETScreen®[6] Clean Energy Project Analysis Software increased to more than 359 000 throughout the world (see Figure 4-1). In addition, more than 500 colleges and universities globally are now using RETScreen for teaching and research.
- In co-operation with the NASA Langley Research Center and the Austria-based Renewable Energy and Energy Efficiency Partnership, a major upgrade to the RETScreen software was launched, called RETScreen Suite. The RETScreen Suite includes a new Benchmark Analysis Tool and Clean Energy Policy Toolkit.
- The RETScreen Training Institute was established and delivered four courses in collaboration with York University (Toronto).

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



Source: NRCan/RETScreen Customer Database.

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

- NRCan and SNC Lavalin are working together to improve energy efficiency in building operations such as heating, cooling, lighting and ventilation. With funding from NRCan's Low Carbon Initiative, a pilot project is underway to assess the implementation of the ISO 50001 Energy Management System standard in a federal government facility. ISO 50001 is a new international standard that establishes a framework for integrating energy efficiency into management practices. Initial savings are a 17 percent reduction in electrical energy use ($30,000 annually) with a projected 10 percent reduction in building heating requirements.
- A novel technology assessment approach was developed that uses a new simulation engine that was developed by CanmetENERGY. This optimization software simulation engine is coupled with cloud computing to provide a platform to identify more optimal net zero energy solutions from thousands of possible options. Preliminary analysis of a Toronto model home suggests that using a net zero energy solution instead of current methods will save $30,000 to $40,000 in capital costs.
- Experimental plans and testing procedures were developed to demonstrate the potential of generating both heat and electricity with photovoltaics by using CanmetENERGY's unique Outdoor Photovoltaic and Thermal Testing Facility. Preliminary results show that a building-integrated photovoltaic roof that has heat recovery can produce as much as 45 percent more equivalent-thermal energy than conventional stand-alone photovoltaic and solar thermal systems.
- CanmetENERGY erected a "mini-camp" to showcase innovative technologies that can reduce fuel consumption for military operations in northern conditions for Defence Research and Development Canada. To sustain those operations, the Department of National Defence depends heavily on a long logistics line of communications to supply diesel fuel as the main supply of power and energy. The technologies demonstrated focused on thermal energy recovery, thermal energy storage and distribution to points of consumption within the camp, as well as heat pumps, variable capacity generators and electrical energy storage for the Arctic. Their adoption could lead to up to a 50 percent reduction in diesel use.
- In Canada, more photovoltaic systems are being installed to reduce GHG emissions. However, environmental factors, electrical failures and defective components cause significant losses of photovoltaic power generation. CanmetENERGY developed a Web-based fault detection and diagnostic system that identifies electricity production losses caused by system faults. Operators can take appropriate actions to correct the faults and maintain expected energy production levels.
- NRCan, working with an industrial partner, tested a new, centrally ducted, zoned forced air system in Ontario. The new system consumed 7 percent less natural gas and 15 percent less electricity. Most importantly, summertime peak electrical demand was reduced by over 50 percent, while maintaining comfort in occupied zones. This system could provide an affordable option for meeting the goals of electric utilities to reduce demand and load shift during summer peak electricity periods.
- CanmetENERGY demonstrated that we can reduce the amount of energy that a household uses for space heating and/or air conditioning by up to 60 percent by using strategic zoned heating and cooling. For example, a non-centralized system can heat individual rooms to different temperatures (±2°C) to reduce energy consumption.

For more information:

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

CLEAN ENERGY PRODUCTION

Objective

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

Description

NRCan's work on clean electric power generation focuses on developing renewable energy technologies and reducing emissions from existing fossil fuel power plants.

Clean power production includes a wide variety of power generation technologies, such as bioenergy, wind, solar photovoltaics, marine (including tidal current, river current and wave energy) as well as 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 generation. Bioenergy activities include the following:

- combustion – converting forestry, agricultural and municipal residues into heat and power
- 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 new and used vegetable oils, tallow and yellow grease into bio-diesel
- anaerobic digestion – converting manures, food-processing and municipal wastes into methane-rich biogas

DID YOU KNOW?

Canadian tax law makes alternative energy sources, such as solar, wind, marine and biofuels more fiscally attractive for industry. Under Classes 43.1 and 43.2 in the *Income Tax Regulations*, certain capital expenditures on systems that produce electric power renewable energy sources are eligible for accelerated capital cost write-offs, at 30 and 50 percent. Without these accelerated write-offs, many of these assets would be depreciated at the much lower annual rates of 4 to 20 percent.

Key 2012–2013 Achievements

- NRCan's work with New Energy Corporation in developing the EnCurrent Power Generation systems (Vertical Axis Hydrokinetic Turbines systems) led to the first Canadian marine renewable energy technology that is commercially available. New Energy Corp sells the EnCurrent turbine technology nationally and internationally in various sizes and is working on scaling their technology. The success of New Energy Corporation has led to river current technologies being included in the development of international standards for marine energy and a new ecoENERGY Innovation Initiative project to establish a Canadian hydrokinetic turbine test centre that is dedicated to river current technologies.
- High Pressure Oxy-fired Combustion (HiPrOx) for power generation has been identified as a carbon capture and storage technology that is competitive, next generation, less costly and more efficient than current technologies. Pilot-scale testing of HiPrOx used a Canadian lignite coal. Stable combustion was achieved with approximately 95 percent removal of sulphur oxides and 85 percent removal of nitrous oxides. This was accomplished by condensing the water in the flue gas to produce a highly concentrated CO_2 stream.

- CanmetENERGY and its partners completed a Canada-United States study to evaluate the potential to store CO_2 in the Basal Aquifer formation of western Canada and the northeastern United States. This study determined the Canadian storage capacity as 86 gigatonnes over 459 000 square kilometres. Such capacity will facilitate the current and future large-scale developments of carbon capture and storage in the region. The research project is a joint Canada-United States effort involving industry, academia and government research partners. The Basal Aquifer is in the Prairie region of Canada and the northern Great Plains region of the United States and underlies the source of nearly half of Canada's CO_2 emissions.
- CanmetENERGY established a remote community research advisory committee that represents governments, industry and utilities in five regions of Canada. The research focuses on the integration of renewable energy and the application of smart controls in targeted remote community microgrids to reduce diesel fuel consumption by 25 to 50 percent compared to current practice. A Remote Smart Microgrid workshop was organized by CanmetENERGY to strengthen collaboration among research organizations and industry that are members of the Canadian Smart Microgrid Research Network.
- CanmetENERGY, in collaboration with the Standard Council of Canada, facilitates a dialogue about the future of smart grid technology in Canada through its work on standards technical committees. This work supports the implementation of the recommendations published in *The Canadian Smart Grid Standards Roadmap: A strategic planning document* in 2012. This activity is encouraging the adoption of harmonized standards at a time when large investments are required to modernize the electricity power system.
- CanmetENERGY chairs the Canadian national committee for the development of international solar photovoltaic standards. It is reviewing the standards and codes to remove the barriers to the interconnection to the electricity grid in Canada. In 2012, Canada adopted the amendments to the International Electrotechnical Commission standards on solar photovoltaic module safety (IEC 61730).
- NRCan support for Nexterra, a gasification company in British Columbia, was the basis for the installation of a heat and power facility at the University of British Columbia. Nexterra designed and built a gasifier that converts waste forestry materials to a high quality fuel gas that replaces natural gas.

For more information:

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

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

INDUSTRIAL PROCESSES

Objective

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

Description

NRCan works with industry to 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 activities 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.

Activities also include the development and testing of semi-pilot-scale plants, pilot plants, prototypes and full-scale field trials including evaluating 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.

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, specialty ceramic manufacturing as well as gas and electric utilities, equipment manufacturers and other levels of government.

DID YOU KNOW?

The signing of a five-year Science and Technology Cooperation Agreement between CanmetENERGY and FPInnovations enables developing cutting-edge solutions to support market transformation in the Canadian forest sector. This cooperation focuses on energy efficiency, process integration, combined heat and power applied to the pulp and paper industry, forest biorefineries and the conversion of forest biomass into bioenergy and bioproducts as well as the recovery and upgrading of waste heat. The objective is to create new bio-economy based on forest operations that will provide benefits for industry and communities across Canada by identifying and commercializing novel products, and technologies.

Key 2012–2013 Achievements

- CanmetENERGY organized two round tables with the *Association Québecoise pour la Maîtrise de l'Énergie* Industrial Committee on waste heat. More than 40 people from the Quebec industrial sector met to discuss the major opportunity that industrial waste heat recovery represents. Participants included representatives from the pulp and paper, chemical, petrochemical, metallurgy, cement, and food and drink processing industrial sectors, as well as utilities, associations and other energy experts. CanmetENERGY plays a key role in the waste heat area thanks to its unique expertise in process integration as well as in various technologies for heat recovery and upgrading.
- An innovative visualization technique for mapping the steam consumption and waste heat sources in industrial plants has been developed. The mapping technique considers all the steam consumption points in relation to corresponding process energy demands. Such a technique was applied at the Kruger mills in Wayagamack, Quebec, and Corner Brook, Newfoundland and Labrador, and the Resolute Forest Products mill in Thunder Bay, Ontario. These applications identified several steam savings projects that saved 10 to 25 percent, depending on the mill configuration.
- A simulation-optimization tool in the general algebraic modeling system, a high-level modeling system for mathematical programming problems, was developed. The tool has the flexibility to incorporate new cogeneration scenarios with different values for fuel costs, process steam demand, turbine condensate preheating options and boiler characteristics. Following this development, energy savings of 15 MW of steam were realized at the Resolute mill in Thunder Bay. FPInnovations and the Canadian Forest Service performed this case study.
- In parallel, a novel software (*I-BIOREF*) was developed for energy, economic and environmental assessment of biorefinery technologies that are used in existing pulp and paper mills. This software was applied and validated for a lignin-based biorefinery at the Kruger Wayagamack mill.

- CanmetENERGY expertise in heat pump systems and industrial process integration enabled the identification of 4 million kilowatt-hours of potential energy savings associated with the integration of heat pumps in a milk processing plant in Quebec, which was 10 percent of the energy use at the plant. The same results can be expected at other Canadian milk processing plants.
- CanmetENERGY was solicited by the Bureau de l'efficacité et de l'innovation énergétiques of Quebec to define the criteria of a provincial initiative to increase the penetration rate of refrigeration systems that have a lower carbon footprint in the Quebec food processing industry. CanmetENERGY estimated that GHG emissions could be reduced by 600 000 tonnes CO_2 equivalent per year in the food processing industry. The same results could be realized across the Canadian food processing industry.

For more information:

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

FOSSIL FUELS

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 GHG 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

NRCan 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.

NRCan 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, GHG and other air emissions challenges in the oil and gas sector. Major improvements need to be made in the entire process chain of oil sands and heavy oil development, from the initial extraction to the production of petroleum products.

Key 2012–2013 Achievements

- As technical experts in the field of oil sands dilbit composition, CanmetENERGY became one of the members of the Interdepartmental Committee on Dilbit Transport. This committee focuses on Canada's marine response regime and what enhancements are needed to handle the associated risk of the expected increase of oil transport in pipelines. CanmetENERGY's role on this committee is to provide information on dilbit characterization and how this relates to the corrosivity of pipelines.
- NRCan, in collaboration with Alberta Innovates – Energy and Environmental Solutions and other government, industry and academia groups, contributed to the development of *The Oil Sands Tailings Technology Roadmap and Action Plan: Introduction and Key Recommendations*. The final report provides an extensive scan of the current state of oil sands tailings technologies. As a result of these objective evaluations, technology gaps and research opportunities can be more easily identified, allowing for more informed decisions about the future direction of tailings research.
- CanmetENERGY participated in the first Alberta-Canada Collaboratory on Cleaner Oil Sands Development workshop. This workshop brought together experts from the Government of Alberta energy sector, NRCan and from various universities and research organizations. They discussed collaborative research initiatives

in cleaner energy technology applications in oil sands and heavy oil; tailing and water management; advanced fuels characterization and testing; corrosion of oil sands and heavy oil operations, and pipelines. Action plans were drafted to identify future collaborative research initiatives.

- CanmetENERGY has collaborated with JGC Corporation and the state-run Japan Oil, Gas and Metals National Corporation for several years. In 2012–2013, a new Super Critical Water Process pilot plant facility in Devon, Alberta, was commissioned and initial operations performed to test a Supercritical Water Cracking Technology. If commercialized, this technology is expected to reduce GHG emissions by avoiding the energy requirement for transporting diluent to and from in situ field production sites.
- CanmetENERGY has been identified as technical experts for reviewing environmental impact assessments for proposed oil sands production projects. CanmetENERGY was asked to provide technical expertise and witness the evaluation of several oil sands project proposals including the Shell Jackpine Mine Expansion, Shell Pierre River Mine and the Teck Frontier Mine projects and the Enbridge Northern Gateway Project approval hearing. As a federal research organization, CanmetENERGY has a responsibility to provide information and advice to support the review of environmental assessments of proposed projects by the responsible authorities.

For more information:

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

TRANSPORTATION

Objective

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

Description

NRCan 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.

Hybrid and electric vehicle technologies offer energy-saving advantages over current vehicle technologies that run solely on conventional fuels, such as gasoline or diesel. NRCan is supporting R&D 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.

R&D 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 worldwide. NRCan 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.

Key 2012–2013 Achievements

- Emissions Characterization, Well-to-Wheels Energy Efficiency and Emissions Analyses for Transit Buses – Data from this project are influencing decisions about bus usage and procurement to optimize energy efficiencies; contributing to developing an emissions database for GHG regulations for heavy-duty vehicles; and supporting the Renewable Fuels Strategy.
- In collaboration with the Canadian Standards Association, the *Canadian Electrical Code* was updated to include standards for charging

stations for electric vehicles in concert with United States and Mexico to reduce trade barriers within North America and abroad.

- In collaboration with Transport Canada and the Standards Council of Canada, NRCan participated in modifying the Electric Vehicle Training Package for First Responders that is produced by the United States National Fire Protection Association.
- Canada hosted the joint Canada/United States Transportation Technologies and Fuels Forum in 2013. More than 130 participants took part in this two-day event that is helping to advance clean transportation technologies and policies in the two countries. The results were several recommendations including a Canada/United States workshop to identify and address R&D priorities for natural gas vehicles and associated infrastructure.

For more information:

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

CHAPTER 5

Renewable Energy

RENEWABLE ENERGY USE

In 2011, renewable sources accounted for 18 percent of Canada's total primary energy supply and over 63 percent of Canadian electricity generation and almost 62 percent of the total electricity-generating capacity (see Table 5-1). Estimates indicate that, in 2012, renewable sources accounted for 18.1 percent of the total primary energy supply, 64.5 percent of electricity generation and 62.2 percent total electricity-generating capacity.

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
2011	81 967	61.7	1.3

Source: Statistics Canada, *Electric Power Generating Stations*

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 5-2 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
In-stream 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 60 percent of the electricity generated in 2011. Canada's hydro supply is dominated by large-scale projects developed by electric utilities.

Of the 75 573 megawatts (MW) of installed hydro capacity, 3 503 MW come from small hydro sites (capacity less than 50 MW), representing 2.6 percent of Canada's total installed electricity capacity. Significant potential remains for additional large and small run-of-river hydroelectric development in most provinces and territories.

Biomass

Biomass provides a renewable source of energy derived from the conversion of matter from living organisms or metabolic by-products. Canada has an abundant supply of many types of biomass, which is important for the production of energy, biofuels, materials and chemicals. The two largest sources of biomass supply in Canada are 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 4.8 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 2011, 734 MW of biomass generating capacity came from spent pulping liquor used in the pulp and paper industry. This amount represents approximately 44 percent of the total biomass generating capacity, while 46 percent of the capacity (760 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 2011, the biomass installed generating capacity was 1 654 MW, of which 9.7 percent was from landfill gas plants (126 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

Because the sun heats the surface of the planet and the earth itself has insulating qualities, 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 1 045 megawatts of thermal energy (MW_{th}) of installed capacity and producing an estimated 1 420 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, 2012, 6 201 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 1 298 MW of new wind power generating capacity installed across the country, representing a 33 percent increase from the 2010 level (3 967 MW) (see Figure 5-1). In fact, Canada ranked 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.

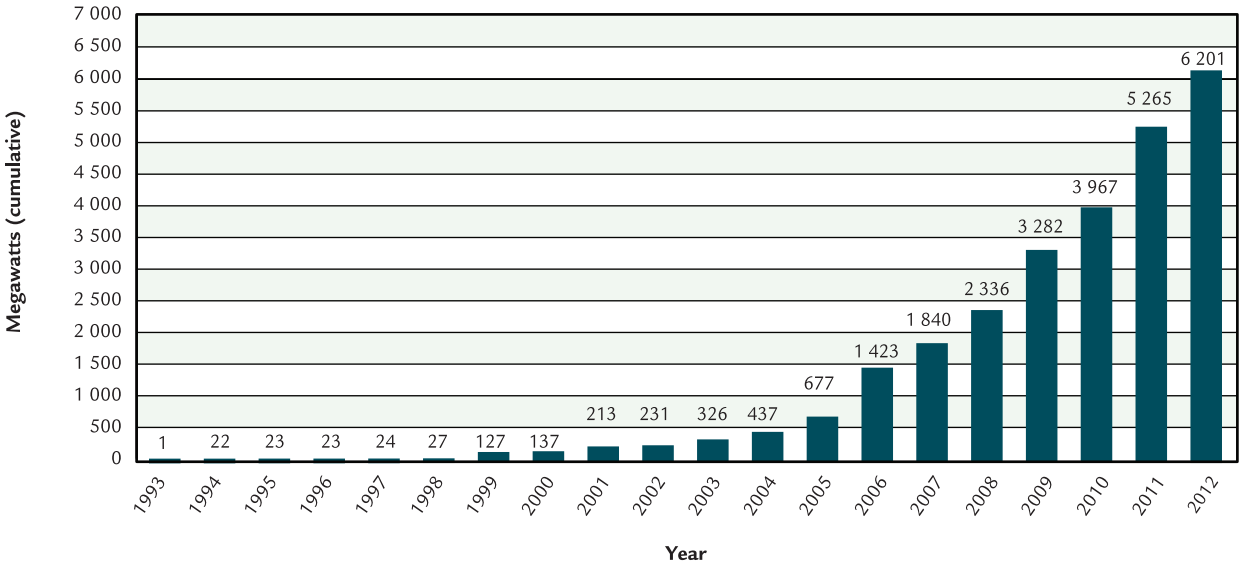
Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairie provinces. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses.

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 2012 - 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 2012 was 1 249 162 m^2, which represents approximately 862 MW_{th}. The domestic market increase has averaged over 20 percent annually since 1998. In 2012, the solar thermal collector market in Canada was approximately 100 354 m^2, approximately 14 percent fewer installations than in 2011 (114 944 m^2).

Solar photovoltaic energy also experienced high rates of capacity growth – about 40 percent average growth rate annually between 1992 and 2012 – even though it started from a low baseline. So far, 2012 has been the best year for solar photovoltaic energy, with an estimated total installed capacity of 765 MW, representing an increase of 268 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 this program is to develop, by 2015–2016, policy framework recommendations and options on the administration of marine renewable energy activity in the federal offshore.

Description

The purpose of the Marine Renewable Energy Enabling Measures program is to address critical knowledge gaps on the future administration of marine renewable energy in the federal offshore.

The program will address these gaps in two phases. The first phase will involve research and analysis of Canada's policy instruments, including relevant legislation and regulations, consultations with stakeholders, and the examination of international marine renewable energy management regimes. These activities will lead to the development of a policy paper, which will incorporate knowledge gained from these activities and highlight issues that need to be addressed to develop an efficient and effective policy framework for the administration of marine renewable energy development in the federal offshore.

The second phase of the program will involve further consultations with stakeholders on the policy paper, followed by the development of a policy framework for administering marine renewable energy in the federal offshore.

Key 2012–2013 Achievements

As of the end of 2012–2013, the Marine Renewable Energy Enabling Measures program has accomplished the following:

- completed a report on regulatory approaches to offshore renewable energy activities in other countries
- engaged national authorities about their countries' regulatory regimes and experiences
- initiated informal consultations within Natural Resources Canada and with the Department of Fisheries and Oceans, Aboriginal Affairs and Northern Development Canada and Transport Canada
- analyzed legal and policy considerations for potential governance models

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 up to $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 2012–2013 Achievements

- Budget 2010 allocated up to $100 million for the Investments in Forest Industry Transformation Program to support Canada's forest sector in becoming more economically competitive and environmentally sustainable through targeted investments in innovative technologies.
- To date, $46 million has been invested to catalyze 12 world-first or Canadian-first technologies that will lead to non-traditional, high-value forest products and increased renewable energy production.

For more information:

forest-transformation.nrcan.gc.ca

DID YOU KNOW?

The Investments in Forest Industry Transformation program contributed $6.75 million to Millar Western Forest Products in Whitecourt, Alberta, to generate green energy from pulp mill effluent by using innovative anaerobic hybrid digester technology. This waste-to-energy technology will enhance mill environmental performance by reducing fossil-fuel use, greenhouse gas emissions, and water contaminant release. Implemented for the first time in Canada's forest products sector, this project has strong potential for replication at other mills across Canada.

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 text box) 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.

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. 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.

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 advisory council's recommendations. As of March 31, 2013, the federation committed $668 million to support 986 green initiatives in 477 communities 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 2012–2013* at fcm.ca/home/about-us/green-municipal-fund-council/annual-reports.htm.

NATURAL GAS ROADMAP IMPLEMENTATION COMMITTEE

In January 2011, NRCan released a deployment roadmap for natural gas use in the Canadian transportation sector. 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.

Following the release of the roadmap, NRCan established the Natural Gas Roadmap Implementation Committee to address the recommendations and provide guidance to key stakeholders. The committee is composed of federal and provincial governments, utilities, industry associations, vehicle and equipment manufacturers, end-users and other related stakeholders.

The committee assesses progress against key milestones and 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 working groups on outreach and education, emerging markets and technological advances. The working groups have the following functions:

- to facilitate the development and launch of a natural gas industry Web site for Canadian fleets and support the establishment of up to three local support networks that will deliver education and outreach materials to fleets and other stakeholders
- to 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 update the codes and standards, to harmonize and align with the United States
- to continue analytical work with respect to the use of natural gas in other modes of transportation, with a focus on emerging modes such as light-duty vehicles, marine, and rail

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 help 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. The result has been significant collaboration on energy efficiency activities across all jurisdictions.

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.

Underscoring this progress, the 2012 Energy and Mines Ministers' Conference endorsed *Moving Forward on Energy Efficiency in Canada: Achieving Results to 2020 and Beyond*. The report highlights that the continuation of current federal, provincial and territorial measures could save Canadians more than $2 billion in energy costs in 2020. The report is available at nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/files/pdf/EMC_Report_e.pdf.

The report focuses on the progress made across six key areas of collaboration:

- continuous improvement in energy codes for buildings

- next generation EnerGuide Rating System to support home energy labeling, codes and incentives
- SmartWay Canada – advancing the energy efficiency of freight transportation in Canada
- improving industrial energy performance by adopting the ISO 50001 Energy Management Systems standard
- innovative financing in the built environment
- standards and labelling programs for energy-using products

Together, federal, provincial and territorial collaborative efforts like these will continue to have a significant impact on the future energy and environmental performance of the Canadian economy.

Federal-Provincial-Territorial Electricity Working Group

The 2012 Energy and Mines Ministers' Conference committed to further work in the areas of regulatory reform, labour markets, markets and international trade, energy efficiency and innovation.

To ensure the reliability of the Canadian electricity grid, as well as to maintain access to United States markets for Canada's electricity, federal, provincial and territorial governments, together with the United States Federal Energy Regulatory Commission, developed and endorsed cross-border data sharing principles. This will help facilitate data and information sharing to expedite investigations following major power outages and represents a key milestone in the collaborative efforts between jurisdictions in Canada and with the United States in maintaining a reliable North American bulk power system.

The Federal-Provincial-Territorial Electricity Working Group has established a monitoring and enforcement subgroup, composed of Canadian electricity regulators and enforcement organizations, to report to the Federal-Provincial-Territorial Electricity Working Group on enforcement issues and best practices for the enforcement of North American electric reliability standards in Canada.

BUILDING ENERGY CODES COLLABORATIVE

The Building Energy Codes Collaborative supports the Energy and Mines Minister's Conference. It is comprised of representatives from provincial/territorial government entities, as well as NRCan and the Canadian Codes Centre.

In 2007, the Canadian Commission on Building and Fire Codes approved the plan submitted by NRCan and the Collaborative for updating the *1997 Model National Energy Code for Buildings*. With $4 million and technical expertise from NRCan, the revision took four years and resulted in the publication of the *National Energy Code of Canada for Buildings* in 2011, complementing the objective-based model national construction codes issued in 2010. Adoption of Code 2011 is currently underway across 12 jurisdictions, with enforcement to follow within 12 to 24 months.

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, it provides the OEE with a broad range of opinions on all energy efficiency matters, connecting the OEE to the latest innovation and thinking in the field. The Council provides advice to the OEE on the following issues:

- the strategic approach in meeting federal policy objectives
- its planning and programs
- performance measures and progress reports and other long-term issues

Since its establishment, the council has provided an important forum for the OEE to solicit expert advice on energy efficiency and alternative fuels policy and programs from a national, multisector group. Council membership is drawn from across Canada, including representatives from academia, economic sectors, energy utilities and government and non-governmental organizations. The council meets twice during the fiscal year to advise and guide the OEE on the most effective way to achieve its mission.

USE OF FEDERAL PROGRAM TOOLS BY UTILITIES, PROVINCES AND TERRITORIES

The following federal tools are available for use:

- Building on the momentum established by the ecoENERGY - Retrofit Homes program, homeowners in six provinces have access to 11 provincial/territorial or utility-led energy efficiency programs using NRCan's EnerGuide Rating System. This system provides an infrastructure on which these programs can operate, leading to significant cost savings for regional program delivery and provides homeowners with a nationally recognized label and custom upgrade recommendations by a certified energy advisor.
- 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.
- NRCan's R-2000 standard is used by utility and government-led programs in Alberta, Saskatchewan and Quebec as a qualifying criterion for incentives and rebates designed to encourage the construction of energy-efficient new homes.
- All the provincial and territorial government bodies responsible for driver education, except Nunavut, are using fuel efficiency messaging based on the Auto$mart Driver Education Kit, developed by the OEE, to educate young drivers on fuel efficiency. Also, many provinces display the OEE's publications in their motor vehicle licensing bureaus.
- ecoENERGY Efficiency for Vehicles (FleetSmart) has negotiated the addition of 5 hours of OEE-developed SmartDriver for Highway Trucking training into the tractor-trailer driver training programs offered by the Ontario Ministry of Training Colleges and Universities. In addition, FleetSmart has enhanced the provision of energy efficiency education and outreach in collaboration with six provinces and two territories, integrating SmartDriver for Highway Trucking content into their commercial vehicle operator's licensing processes. This will continue to help improve professional truck driving practices and road safety while simultaneously reducing fleet fuel consumption and related greenhouse gas (GHG) emissions.

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 electricity through requests for proposals, standard offer and feed-in tariff programs.

CO-OPERATION AGREEMENTS

NRCan promotes energy efficiency and renewable energy with the provinces and territories. Examples include working with the following organizations:

- Ontario Power Authority, to facilitate the delivery of Dollars to $ense workshops in Ontario
- Efficiency New Brunswick, Efficiency Nova Scotia, Climate Action Secretariat, industry associations and utilities, to provide energy management training to companies across Canada through Dollars to $ense workshops
- OEE, which is collaborating with CANMET Varennes, le Bureau de l'efficacité et de l'innovation énergétiques, Efficiency New Brunswick, Union Gas and C3 to build capacity in process integration by developing, translating and delivering intensive three-day workshops to technical professionals across Canada

NRCan has also funded projects related to energy efficiency with the Yukon Energy Solutions Centre in Whitehorse. The centre provides technical services and programs for the Yukon population and undertakes outreach and public education activities.

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 by Sustainable Development Technology Canada.

The NextGen Biofuels Fund™ facilitates establishment of 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 2012–2013, Sustainable Development Technology Canada approved funding for the front-end development phase of two more projects in addition to the one approved in 2011–2012. Together, these three projects represent a potential contribution of $192.5 million should they be approved for full investment.

Sustainable Development Technology Canada – SD Tech Fund

Sustainable Development Technology Canada also manages the SD Tech Fund™ to stimulate the development and demonstration of Canadian technologies that address climate change, clean air, clean water and clean soil.

As of March 2013, the SD Tech Fund had allocated $592 million to 245 projects. An additional $1.5 billion has been leveraged from other partners for a total of $2.1 billion in portfolio value. Funded projects are active in all major Canadian economic sectors, including energy exploration and production, power generation, energy utilization, transportation, agriculture, forestry and wood products, and waste management.

In 2012, the foundation spent $78 million. Sustainable Development Technology Canada funded projects are expected to generate positive impacts on climate change, clean air, clean water and clean soil, with 90 percent of projects generating multiple environmental benefits. Of the 84 projects completed since the fund's inception, 74 projects reported emission reductions of approximately 1.1 megatonnes in 2012.

Atlantic Energy Gateway

The Atlantic Energy Gateway initiative was a joint initiative of NRCan and the Atlantic Canada Opportunities Agency to facilitate cooperative development of the region's clean energy resources.

Eight collaborative research studies were commissioned in 2011–2012 and released in Charlottetown on September 10, 2012, at the Energy and Mines Ministers' Conference. The studies provide insight into the challenges and opportunities required to maximize the development of clean energy in the region.

INTERNATIONAL CO-OPERATION

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

Canada benefits from international co-operation in the following ways:

- learning about improved ways of designing and delivering energy efficiency, alternative transportation fuels and renewable energy programs to meet policy objectives, and best practices to inform policy development
- supporting innovation and accelerating technology deployment through joint research, development (R&D) and deployment initiatives
- 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 support global environmental and energy security goals

DID YOU KNOW?

CanmetENERGY has been recognized as a global leader in the area of GHG monitoring and mitigation strategies for the oil and gas sector and was selected to lead the design and management of projects for Nationally Appropriate Mitigation Actions in the Colombian and Mexican oil and natural gas production sector. In 2012–2013, CanmetENERGY successfully implemented an emission monitoring system at an oil and gas facility in Mexico to provide accurate real time emission data on a secure Web-based site. From this data, mitigation strategies using cost-effective emission reduction opportunities will be identified.

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. 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. Its activities include the following:

- 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 energy efficiency work. The OEE represents Canada on the working party. In 2011, the agency released a report that recognized Canada as one of the top five member countries that has fully or partially implemented the agency's best-practice recommendations on energy efficiency policy.

Canada's international energy technology R&D objectives are mainly advanced through the agency's working parties, implementing agreements and experts groups that are overseen by the Committee for Energy Research and Technology. Work is focused in four main areas: energy security, economic development, environmental awareness and engagement worldwide. NRCan contributed $616,000 to agency implementing agreements in 2012–2013.

Co-operation accelerates technology development and sets the stage for technology deployment in

Canada, generating benefits that far outweigh the direct costs of collaboration. For example, work undertaken as part of the Hybrid and Electric Vehicle Technologies and Programs Implementing Agreement produces objective information for decision makers on hybrid and electric vehicle technology, projects and programs and their effects on energy efficiency and the environment. The Agreement allows for the dissemination of this information, collaboration on pre-commercialization research projects, investigation of the need for further research in promising areas, and it acts as a platform for reliable information on hybrid and electric vehicles.

CanmetENERGY was named the operating agent of Annex 54, Integration of Micro-generation and other Energy Related Technologies in Buildings. The research program will focus on improved models of poly-generation and/or hybrid-type micro-generation systems. The purpose is to better assess the application of these systems, to identify the impact on energy use and GHG emissions and to investigate the competitiveness of these micro-generation systems in relation to other technologies. Participants are from 14 countries in Europe, Asia, Japan and North America and represent 36 research organizations, academia and private companies.

Canada participates in the Implementing Agreement on Heat Pumping Technologies (end-use technologies). CanmetENERGY is chairing the Heat Pump Program, which includes 14 countries. 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 GHG emissions. Program activities include an information service performed by the Heat Pump Centre in Sweden, international collaborative projects (annexes) in R&D, 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.

In early 2012, NRCan and the Korea Institute of Energy Research reinstated a memorandum of understanding between the two organizations. Under this, CanmetENERGY developed two joint, multi-year projects with the institute and the Korean Ministry of Trade, Industry, and Energy (formally known as the Korean Ministry of Knowledge Economy). These 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 Korea Institute of Energy Research intends to demonstrate the systems developed under these projects during the 2018 Olympic Winter Games, hosted by Korea in the "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 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 grids. Formed under the Clean Energy Ministerial in 2010, Canada is participating in three Annexes. CanmetENERGY is providing a leadership role on the steering committee for these annexes with the following outputs and activities:

- Annex 1 published a report on *Smart Grid Drivers and Technologies by Country, Economies, and Continent*. This annex is building a smart grid inventory of projects across all participating countries.

- Annex 2 produced case studies exploring the results and lessons learned of smart grid demonstrations, pilots and deployments. Under this annex, CanmetENERGY served as lead author and editor for an international case book on *advanced metering infrastructure* for release at the 4th Clean Energy Ministerial in 2013.
- Annex 4 hosted an international webinar through the Clean Energy Solutions Center on unlocking markets for smart grids. Led by the Ontario Ministry of Energy, this webinar was delivered in partnership with CanmetENERGY, India Smart Grid Forum and Siemens Canada. This annex continues to produce insights for decision makers on smart grid policy, programs and stakeholder engagement.

All publications are available on the International Smart Grid Action Network Web site at www.iea-isgan.org.

International Partnership for Energy Efficiency Co-operation

Canada is a founding member of the International Partnership for Energy Efficiency Co-operation. The membership's 15 developed and emerging economies collectively account for over 75 percent of global gross domestic product and energy use. The partnership provides a high-level dialogue for policy makers to share best practices on actions that yield high energy efficiency gains. Canada was elected as chair of the governing Policy Committee for 2012–2014.

A key component of the partnership 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.

The Global Superior Energy Performance Partnership seeks opportunities for continuous improvements in the energy performance of industrial facilities and commercial buildings, including through the implementation of energy management systems.

The activities of the Super-efficient Equipment and Appliance Deployment partners include the following:

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

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 by 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 updating information on Canadian equipment standards, labelling and new initiatives.

The OEE also provides 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 allows for transparency in the implementation of the region's aggregate goal to reduce energy intensity by 45 percent between 2005 and 2035, as agreed to by leaders at their 2011 summit in Hawaii.

Clean Energy Ministerial

The Clean Energy Ministerial forum was launched by the United States in July 2010 to share best practices that facilitate the transition to a global clean energy economy. Its goals are advanced through three pillars: high-level dialogue at Ministerial meetings; technical cooperation in 13 clean energy initiatives; and engagement with the private sector. Twenty-three governments representing 80 percent of global GHG emissions and 90 percent of global clean energy investment participate.

Initiatives cover three categories: those that improve energy efficiency; those that work to expand clean energy supply; and crosscutting initiatives that address key issues in clean energy policy, leadership and 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, with participation led by NRCan:

- Global Superior Energy Performance Partnership (also a task group under the International Partnership for Energy Efficiency Co-operation, see p. 64)
- Super-efficient Equipment and Appliance Deployment (also a task group under the International Partnership for Energy Efficiency Co-operation, see p. 64)
- International Smart Grid Action Network (also an International Energy Agency implementing agreement)
- Carbon Capture, Use and Storage Action Group

U.S.-Canada Clean Energy Dialogue

The Clean Energy Dialogue was launched by Prime Minister Harper and President Obama in February 2009 to enhance collaboration on the development of clean energy technologies aimed at reducing GHG emissions and addressing climate change.

Following the completion of the first Action Plan under the Clean Energy Dialogue in June 2012, the Canadian Minister of the Environment and the United States Secretary of Energy released Action Plan II. The second action plan supports continued collaboration by three joint working groups, with an added emphasis on collaboration in the area of energy efficiency. Three working groups are included:

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

Clean Energy Research and Development and Energy Efficiency Working Group

R&D drives technological discovery and innovation, which are key ingredients in developing the low-carbon energy system of the future. Strengthening collaboration in these areas through joint R&D and deployment will help reduce GHG emissions while strengthening both countries' economies and creating new jobs.

In 2012–2013, the Clean Energy Research and Development and Energy Efficiency Working Group coordinated joint action on the following priority themes:

- Energy Efficiency
  - introducing the U.S. ENERGY STAR® Most Efficient initiative into Canada. As of

January 1, 2013, ENERGY STAR Most Efficient specifications are promoted in Canada for nine products. The specifications and listings are fully integrated with those of the Environmental Protection Agency, with the exception of windows, where Canada has a unique ENERGY STAR specification for climatic reasons.

- adapting the U.S. Portfolio Manager Building Benchmarking Tool for the Canadian market to comparatively benchmark energy use in commercial/institutional buildings and help encourage building improvements. The Canadian version of the tool was launched in August 2013. The tool will include an automated data exchange service through which utilities and other energy service providers can automatically send energy billing data directly into Portfolio Manager.
- accelerating industry adoption of the ISO 50001 Energy Management Systems standard by undertaking pilots to support ISO 50001 certification. In 2012–2013, five firms will further implement ISO 50001 through the certification audit process to achieve full registration status under the standard.

- Advanced Biofuels – Collaboration between CanmetENERGY, U.S. Pacific Northwest National Laboratory and National Renewable Energy Laboratory continued on fast pyrolysis of forest residue feedstocks. An assessment of pre-treatment requirements for bio-oil from target feedstocks was conducted, with the aim of maximizing energy efficiency in producing and using bio-oil in stationary applications such as industrial heat and power.
- Advanced Transportation – Given North America's growing natural gas supply, Canada and the United States are collaborating to facilitate the deployment of natural gas vehicles.

  The Transportation Technologies and Fuels Forum was hosted by NRCan and the United States Department of Energy from February 5 to 6, 2013, to further discuss the policies, programs and technical implementation challenges related to end use, engine performance and emissions, and fuel supply. A half-day of the forum was dedicated to natural gas opportunities and challenges and led by NRCan. Discussion panels on R&D, deployment initiatives, and codes and standards were very effective in engaging participants to discuss common challenges and to identify key action items of mutual interest to both countries.
- Advanced Buildings and Communities – NRCan worked with the United States to advance simulation tools for the design of energy-efficient buildings and communities. This will allow for a consistent approach to building energy analysis through a common platform of shared resources, methodologies and standards. As a result, joint building energy R&D projects can be accelerated so that emerging building technologies can be readily evaluated and prioritized for the Canadian context.

Electricity Grid Working Group

The Electricity Grid Working Group facilitates the long-term transition to a modernized electricity system based on clean and renewable generation. In 2012–2013, Canada and the United States initiated an offshore renewable energy dialogue, aimed at sharing experiences and best practices in the development and administration of offshore renewable energy regulatory frameworks.

The working group also established the Canadian Smart Grid Repository to serve as an information clearinghouse for information on Canadian smart grid projects and companies. The working group also commissioned a study on utility best practices for engaging consumers on smart grid-related initiatives. Further work is being done to support the development of standards for the smart grid.

Also, the working group co-organized a conference in 2012 to examine the state of advancement of energy storage technologies and barriers facing their deployment. An additional study was initiated late in 2012–2013 to examine case studies on a regional or cross-border basis that have facilitated the integration of renewable generation.

Carbon Capture and Storage Working Group

Under Action Plan II, the Carbon Capture and Storage Working Group is undertaking six initiatives that advanced carbon capture and storage technology research, development and demonstration; facilitated dialogue on carbon capture and storage policies and practices; and improved public and stakeholder engagement practices. Four of these projects evolved from work that began under the *Action Plan I* framework. Projects have shown how the Clean Energy Dialogue strengthens the dialogue between Canada and the United States in areas that are vital to the development and deployment of carbon capture and storage projects and technologies. Through binational conferences and workshops that bring together researchers, project developers, policy makers and regulators, the working group has shared experiences, best practices and lessons learned on carbon dioxide storage, monitoring and verification; current research underway in Canada and the United States; methodologies for long-term risk assessment; and next generation carbon capture technologies.

Other United States Bilateral Activity

In addition to collaborating through the Clean Energy Dialogue, Canada-United States energy issues are formally discussed by senior staff of the energy and foreign affairs departments of both countries through the bilateral Energy Consultative Mechanism. Established in 1979, the Energy Consultative Mechanism is a day-long meeting, usually held annually. Both countries review and address the main issues affecting the bilateral energy relationship to enhance the level of collaboration. Officials highlight various energy efficiency initiatives implemented across all sectors of the economy including housing, buildings and equipment, industry, and transportation.

Finally, under a 2005 memorandum of understanding, NRCan's OEE and the U.S. Environmental Protection Agency continue to work toward the common goal of achieving greater energy efficiency and reducing GHG emissions in the freight transportation sector through the voluntary programs: FleetSmart and the SmartWay® Transport Partnership. These two programs use a voluntary approach with the on-road freight sector to increase energy efficiency. A renewed memorandum will further harmonize efforts under the SmartWay Transport Partnership in Canada and the United States.

Canada-Israel

In 2012, NRCan announced the Canada-Israel Energy Science and Technology Fund to help promote collaboration between leading researchers to spur the development of innovative energy technologies and processes that enable the responsible development of unconventional oil and gas resources, including applications to address environmental challenges. NRCan is providing $5 million over three years, using ecoENERGY Innovation Initiative funds, to the Canada-Israel Industrial Research and Development Foundation. The Government of Israel will provide matching funds on a project-by-project basis.

APPENDIX 1

Natural Resources Canada's Energy Efficiency, Alternative Transportation Fuels and Renewable Energy Initiatives and Expenditures, 2012–2013

(millions of dollars)

Energy Efficiency and Alternative Transportation Fuels[1]	**$184.2**
ecoENERGY Efficiency for Buildings	
ecoENERGY Efficiency for Housing	
ecoENERGY Efficiency for Equipment Standards and Labelling	
ecoENERGY Efficiency for Industry	
ecoENERGY Efficiency Vehicles	
ecoENERGY for Alternative Fuels	
ecoENERGY for Biofuels	
Federal Buildings Initiative	
National Energy Use Database	

(millions of dollars)

Energy Efficiency – Energy Science and Technology[2]	**$66.7**
Buildings and Communities	
Clean Energy Production	
Industrial Processes	
Fossil Fuels	
Transportation	

Alternative Energy – Renewable Energy Sources	**$182.4**
Investments in Forest Industry Transformation	
Marine Renewable Energy Enabling Measures Program	
Wind Power Production Incentive[3]	
ecoENERGY for Renewable Power[4]	

Total	**$433.3**

[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 61.

[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 the incentive is being paid out to recipients until 2016–2017.

[4] The ecoENERGY for Renewable Power program is fully committed but the incentive is being paid out to recipients until 2020–2021.

APPENDIX 2

Data Presented in the Report

The aggregate energy use data presented in Chapter 1 are based on the revised Statistics Canada's *Report on Energy Supply and Demand in Canada, 1995–2010 (RESD)*. This is explained in the Preface of the *Energy Efficiency Trends in Canada, 1990–2010*. Also, 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 2010*. The differences that exist between this report and Canada's Energy Outlook relate to the sector allocations of energy-use data from the RESD.

It is a common practice in energy end-use analysis to allocate greenhouse gas emissions associated with electricity production to the sector that uses that electricity. This allocation is done by multiplying the amount of electricity used by a national average emission factor that reflects the average mix of fuels used to generate electricity in Canada.

Figure 1-1: Secondary Energy Use by Sector, 2010

Sector	Industrial	Transportation	Residential	Commerical/ institutional	Agriculture	Total
Energy use (PJ)	3 227.6	2 595.0	1 360.7	1 057.3	238.5	8 479.1
Percentage	38.1	30.6	16.0	12.5	2.8	100.0

Figure 1-2: Greenhouse Gas Emissions From Secondary Energy Use by Sector, 2010

Sector	Transportation	Industrial	Residential	Commerical/ institutional	Agriculture	Total
GHG emissions (Mt)	179.2	165.9	68.4	54.6	16.3	484.0
Percentage	37.0	34.2	14.1	11.3	3.4	100.0

Figure 1-3: Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Estimated secondary energy use without energy efficiency improvements	1.00	1.00	1.03	1.05	1.09	1.15	1.18	1.19	1.18	1.23	1.29	1.27	1.31	1.34	1.39	1.41	1.39	1.45	1.45	1.46	1.47
Actual energy use	1.00	0.98	1.00	1.02	1.05	1.08	1.10	1.12	1.09	1.12	1.16	1.13	1.17	1.20	1.24	1.24	1.21	1.27	1.26	1.20	1.22

Figure 1-4: Summary of Factors Influencing the Change in Energy Use, 1990 to 2010

Factor influencing the change	Change in energy use (PJ)
Activity effect	2 981.1
Structure effect	-250.2
Service level effect	193.3
Capacity utilization effect	287.5
Weather effect	-65.2
Energy efficiency effect	-1 680.7
Other*	82.3
Total change in energy use	**1 547.81**

* "Other" refers to street lighting, non-commercial airline aviation, off-road transportation and agriculture, which are included in the "Total change in energy use" row above but are excluded from the factorization analysis.

Figure 1-5: Canadian Housing Stock by Building Type, 2010

Dwelling type	Housing stock by building type (thousands)	Percentage
Single detached homes	7 902	56
Apartments	4 355	31
Single attached homes	1 586	11
Mobile homes	279	2
Total	**14 123**	**100**

Figure 1-6: Residential Energy Use by End Use, 2010

Activity	Energy use (PJ)	Percentage
Space heating	851.5	63
Water heating	237.9	17
Appliances	190.0	14
Lighting	54.8	4
Space cooling	26.5	2
Total	**1 360.7**	**100**

Figure 1-7: Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2010

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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	1.35
Average floor space by household	1.00	1.00	1.01	1.01	1.02	1.02	1.02	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	1.11
Energy intensity (GJ/ household)	1.00	0.96	0.97	0.98	0.98	0.95	0.99	0.96	0.86	0.88	0.92	0.87	0.90	0.91	0.90	0.88	0.83	0.89	0.88	0.82	0.78

Figure 1-8: Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Estimated energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.23	1.21	1.13	1.17	1.24	1.21	1.28	1.31	1.33	1.36	1.33	1.43	1.46	1.48	1.42
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.04	1.11	1.08	0.98	1.03	1.08	1.04	1.09	1.12	1.12	1.11	1.07	1.17	1.17	1.11	1.06

Figure 1-9: Average Energy Consumption of New Electric Appliances, 1990 and 2010 Models

Appliance	1990 model (KWh/yr)	2010 model (KWh/yr)
Refrigerator	956	425
Freezer	714	365
Dishwasher	277	84
Clothes washer	134	35
Clothes dryer	1 103	928
Electric ranges	772	522

Figure 1-10: Commercial/institutional Energy Use by Activity Type,* 2010

Activity type	Energy use (PJ)	Percentage
Offices**	370.2	35
Retail trade	178.9	17
Educational services	132.5	13
Health care and social assistance	114.7	11
Accommodation and food services	80.0	8
Wholesale trade	63.5	6
Transportation and warehousing	40.9	4
Arts, entertainment and recreation	27.5	3
Information and cultural industries	23.1	2
Other services	18.6	2
Total	**1 049.9**	**100**

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

Figure 1-11: Commercial/institutional Energy Use by Purpose, 2010

Purpose	Energy use (PJ)	Percentage
Space heating	478.2	45
Auxiliary equipment	202.4	19
Lighting	123.7	12
Auxiliary motors	97.6	9
Water heating	92.2	9
Space cooling	55.7	5
Street lighting	7.5	1
Total	**1 057.3**	**100**

Figure 1-12: Commercial/institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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	1.36	1.42	1.40	1.47	1.49	1.51	1.51
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.12	1.15	1.09	1.13	1.23	1.21	1.28	1.30	1.28	1.25	1.19	1.27	1.32	1.24	1.22

Figure 1-13: Industrial Energy Use by Subsector – Including Electricity-related Emissions,* 2010

Subsector	Energy use (PJ)	Industrial energy use (%)
Mining	993.5	30.8
Pulp and paper	565.9	17.5
Other manufacturing**	506.5	15.7
Petroleum refining	308.3	9.6
Chemicals	254.7	7.9
Smelting and refining	231.5	7.2
Iron and steel	205.4	6.4
Construction and Forestry	102.5	3.2
Cement	59.3	1.8
Total	**3 227.6**	**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, 2010

Industry	Energy cost of total production cost (%)
Cement	24.2
Pulp and paper	10.5
Iron and steel	10.3
Aluminum	10.2
Chemicals	4.6
Petroleum refining	1.4
Transportation equipment and manufacturing	0.7

Figure 1-15: Industrial Energy Use, With and Without Energy Efficiency Improvements, 1990 to 2010

Index (1990 = 1.00)	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Estimated energy use without energy efficiency improvements	1.00	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	1.39
Actual energy use	1.00	1.09	1.10	1.11	1.08	1.10	1.14	1.09	1.15	1.18	1.24	1.24	1.22	1.26	1.21	1.15	1.19

Figure 1-16: Transportation Energy Use by Mode, 2010

Mode	Energy use (PJ)	Percentage
Cars	625.2	
Passenger light trucks	479.5	
Motorcycles	5.8	
School buses	13.4	
Urban transit	33.1	
Intercity buses	4.7	
Passenger air	225.5	
Passenger rail	2.9	
Passenger total	**1 390.3**	**53.6**
Freight light trucks	192.6	
Medium trucks	156.9	
Heavy trucks	547.3	
Freight air	5.3	
Freight rail	80.7	
Marine	117.9	
Freight total	**1 100.7**	**42.4**
Off-road total	**104.1**	**4.0**
Total transportation energy use	**2 595.0**	**100.0**

Figure 1-17: Market Shares of New Passenger Car and Light-truck Sales, 1990 to 2010 (percentage)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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	53.5
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	46.5

Figure 1-18: Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2010

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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	1.32	1.34	1.36	1.39	1.42	1.51	1.53	1.54	1.58	1.57	1.54	1.61
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.16	1.19	1.21	1.20	1.22	1.26	1.30	1.32	1.31	1.36	1.35	1.33	1.38

Figure 1-19: Average Activity per Truck, 1990 to 2010 (tonne kilometres/truck)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total medium- and heavy-duty truck vehicle activity	105 857	98 224	103 004	117 235	133 122	142 375	140 856	163 809	162 714	174 929	177 942	198 501	197 055	202 188	241 129	243 631	236 343	232 601	228 235	210 667	225 883

Figure 1-20: Trucking Energy Intensity, 1990 to 2010 (megajoules/tonne kilometre)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total medium- and heavy-duty trucks energy intensity	3.75	3.78	3.78	3.62	3.41	3.48	3.41	3.33	3.20	3.04	3.04	2.80	2.71	2.85	2.47	2.47	2.52	2.61	2.67	2.91	2.80

Figure 1-21: Biofuels Production Capacity in Canada 2007 to 2012

Year	Production Capacity Built (million litres)
2007	982.0
2008	1 576.4
2009	1 676.4
2010	1 822.5
2011	2 020.5
2012	2 456.4

Figure 2-3: ENERGY STAR Qualified Appliances as a Percentage of Total Shipments in Canada, 1999 to 2011

Appliance	1999 (%)	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)	2010 (%)	2011 (%)
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	79.2
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	74.7
Refrigerators	..	..	11.4	22.3	40.7	34.2	37.6	37.3	44.3	53.4	53.4	59.3	66.8

Figure 2-4: ENERGY STAR Awareness Levels in Canada, 2010

	Percentage
Aware – non-aided	71
Aided visual awareness	89

Figure 3-1: Number of R-2000 Housing Certifications and ENERGY STAR Prescriptive-labelled Houses, 1990 to 2012

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
R-2000 certified houses	495	699	1 196	1 299	784	610	416	484	265	213	319	329	428	379	583	500	439	483	557	541	360	440	404
ENERGY STAR labelled houses (prescriptive path only)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	878	1 662	3 888	4 037	8 794	8 500	8 046

Figure 3-2: 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	132	192
Actual energy savings after renovations (GJ)	79	51	43	38	34	27	27	36	44

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

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

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Canada	778	2 265	3 684	6 050	9 017	13 001	17 130	22 262	27 456	35 529	42 447	51 323	60 621	67 074	71 853
World total	**1 841**	**5 864**	**11 903**	**20 164**	**29 616**	**38 882**	**54 189**	**74 657**	**99 663**	**135 119**	**180 870**	**229 299**	**277 099**	**319 871**	**359 647**

Figure 5-1: Canadian Wind Power Capacity, 1993 to 2012 – Cumulative

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Wind power capacity (MW, cumulative)	1	22	23	23	24	27	127	137	213	231	326	437	677	1 423	1 840	2 336	3 282	3 967	5 265	6 201