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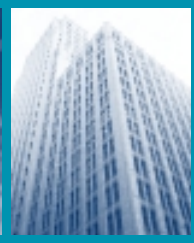
Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act*








2002–2003

Improving Energy Performance in Canada – Report to Parliament Under the *Energy Efficiency Act* 2002–2003

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Her Excellency the Right Honourable Adrienne Clarkson,
C.C., C.M.M., C.D.
Governor General of Canada and Commander-in-Chief

Your Excellency,

I have the honour to present the *Report to Parliament Under the* Energy Efficiency Act for the fiscal year ending March 31, 2003, in accordance with Section 36 of the Act.

Respectfully submitted,

The Honourable R. John Efford, P.C., M.P.
Minister of Natural Resources Canada

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Minister's Foreword

This tenth report under the *Energy Efficiency Act* describes what the Government of Canada, through Natural Resources Canada (NRCan), accomplished in 2002–2003 to advance our country's energy efficiency and use of renewable energy.

The Government of Canada continues in its work to improve energy efficiency. Specifically, for a number of years, NRCan has been helping governments, industry and individual Canadians reduce energy use and save money through voluntary initiatives, programs and regulations. NRCan also supports innovative research and development, leading to new technologies that have made Canada a world leader in energy efficiency and renewable energy.

Reducing greenhouse gas (GHG) emissions is essential to addressing the global challenge of climate change. We all need to take action — governments at all levels, companies of all sizes and individuals. That is why we are encouraging all Canadians to take the One-Tonne Challenge and reduce personal GHG emissions by 20 percent. Making the right choices in our daily lives will bring us closer to this goal.

By promoting the responsible use of our energy resources and the sustainable development of our natural resources, NRCan supports the Government of Canada's agenda of strong social foundations, a strong economy for the 21st century and ensuring Canada's role of pride and influence in the world.

The Honourable R. John Efford, P.C., M.P.

Minister of Natural Resources Canada

Executive Summary

With the ratification of the Kyoto Protocol in 2002, Canada formally committed to a specific target for reducing its greenhouse gas (GHG) emissions to address the global issue of climate change. Canada's industrialized economy, based largely on natural resources, makes decreasing GHG emissions a particular challenge.

In 2002–2003, Canadians spent almost $114 billion on energy to heat and cool homes and offices, to fuel vehicles and to operate appliances and industrial processes. Several factors contribute to Canadian energy demand: a vast geography, a northern climate with extreme seasonal variations in temperature and an economy founded on an abundance of natural resources.

Types of Energy Use

There are two general types of energy use: primary and secondary. Primary use comprises Canada's total consumption, including energy required to transform one form to another – such as coal to electricity – and to deliver energy to consumers. Secondary use comprises energy consumed for residential, agricultural, commercial/institutional, industrial and transportation purposes.

Between 1990 and 2001, the latest year for which figures are available, primary energy use increased by 16.5 percent, from 9714 to 11 316 petajoules (1 petajoule = 10^{15} joules). This increase, however, would have been much greater if not for the efficiency improvements made to buildings and equipment and the changes in the behaviour of energy users during the past several decades.

In 2001, secondary use accounted for 70.2 percent of primary energy use and produced 65.7 percent (473 megatonnes) of Canada's total GHG emissions. This last figure includes emissions produced by utilities in meeting the demand for electricity.

The industrial sector consumes the most energy, accounting for 38.5 percent of total secondary energy use in 2001. Transportation is second (28.6 percent), followed by residential (16.8 percent), commercial/institutional (13.3 percent) and agriculture (2.7 percent).

Four key factors contribute to changes in energy use:

- Activity – variations in levels of activity within sectors;
- Structure – shifts toward more or less energy-intensive activities;
- Weather – annual fluctuations; and
- Energy efficiency – changes in the level of energy consumption of products and equipment.

Promoting Energy Efficiency

For the past decade, Natural Resources Canada (NRCan) has promoted energy efficiency and the use of alternative energy as means to reduce GHG emissions and save money. NRCan exercises a broad range of policy instruments, including leadership, information, voluntary actions, financial incentives, research and development (R&D) and regulation.

Evidence of Change

As explained in this report, recent growth in energy use is primarily due to increased activity in various sectors. This growth, however, would have been far greater without improvements in energy efficiency. As reported in Chapter 2, energy efficiency improvements between 1990 and 2001 reduced GHG emissions by more than 44 megatonnes and decreased energy expenditures by $10.7 billion in 2001 alone.

During this period, the residential sector recorded an 18.7 percent increase in energy efficiency. The figures for transportation (10.2 percent), industry (7.8 percent) and the commercial/institutional (3.6 percent) sectors demonstrate that energy efficiency improvements are being made throughout the economy.

NRCan's efficiency and alternative energy (EAE) initiatives strive to improve energy efficiency by

- increasing the energy efficiency of new and existing buildings, equipment, systems and vehicles;
- persuading individuals and organizations to choose buildings, equipment, systems and vehicles that are more energy efficient;
- ensuring that energy-consuming equipment is used in the most energy-efficient way possible;

- influencing the energy-use practices of individuals and organizations; and
- developing technologies that provide consumers, industry and communities with new opportunities to improve energy efficiency.

NRCan's EAE initiatives strive to increase the use of alternative energy by

- encouraging investment in renewable energy systems and purchases of electricity generated from renewable sources;
- encouraging the expansion of the infrastructure for the sale of alternative transportation fuels;
- supporting R&D to reduce the costs, improve the performance and increase the scope of renewable energy technologies; and
- supporting R&D to develop safety and performance standards for renewable energy technologies.

Through improvements in energy efficiency, Canadians can reduce the size of their energy bills and achieve important environmental goals. In the short term, changes to less GHG-intensive fuels (e.g. from coal to natural gas) can help reduce GHG emissions. Over the long term, however, reducing GHG emissions to 1990 levels will require more widespread use of alternative energy.

In recent years, the production of energy derived from alternative sources has increased significantly. Between 1990 and 2001, the amount of electricity generated from the sun, the wind and biomass increased by 203 percent.

Measuring Progress

The goal of EAE initiatives is to improve energy use by altering energy-consumption practices and patterns in Canada. Measuring the effectiveness of the initiatives is of paramount importance to the success and viability of EAE.

NRCan regularly measures three aspects of EAE programs. **Program outputs** are items produced on a regular basis, such as marketing and informational materials, demonstration projects, financial incentives and regulations. These items are designed to deliver **program outcomes**, such as changes in behaviour. These alterations lead to **market outcomes**, such as observable differences in the amount and type of energy consumed.

Engaging Canadians

To maximize the effectiveness of its initiatives, NRCan engages a growing number of partners from the private and public sectors. Dozens of cooperative agreements are in place with a broad range of businesses, community groups and other levels of government.

These initiatives engage Canadian society, along with every sector of the economy, in new and more efficient approaches to secondary energy use and in the development and deployment of renewable energy sources.

This report provides an overview of the work being done in each sector, highlights NRCan's EAE programs and lists their key achievements for 2002–2003. All programs are described in the corresponding sector chapter. Program entries for market transformation programs also include quantitative performance indicators in graph or table format. A list of NRCan's EAE initiatives and expenditures appears in Appendix 1.

Housing

The residential sector accounts for 16.8 percent of total secondary energy use and 15.7 percent of Canada's annual GHG emissions. Between 1990 and 2001, residential energy use increased by 3.7 percent, while GHG emissions increased by 6.8 percent. The growth in energy use was largely due to increased activity; the relatively greater rise in GHG emissions was principally due to an increase in the carbon intensity of generated electricity.

Improvements in energy efficiency, through superior construction of new homes and reduced energy use by occupants, moderated that increase. Without these improvements, which were supported by NRCan programs, total residential energy consumption would have been 18.7 percent higher.

NRCan programs in the housing sector focus on three areas: new houses, existing houses and residential equipment, including energy-performance regulations and labelling. The majority of dwellings in Canada are detached and semi-detached houses, so most NRCan programs in this sector focus on these types of homes.

New Houses

Houses built in Canada today are more energy efficient than ever. A house constructed in 2002 consumes

33 percent less energy than a house built in 1970. Air-leakage rates have also improved dramatically. Data recorded during audits performed under EnerGuide for Houses (EGH) demonstrate that the average number of air changes per hour for homes built between 1985 and 1987 was 5.3; the number for homes built between 2000 and 2002 was 3.5.

NRCan's R-2000 Standard encourages the construction and purchase of new houses that consume less energy, produce fewer pollutants and are healthier to live in than standard houses. A house built to the R-2000 Standard undergoes only 1.1 air changes per hour and consumes 64 percent less energy than the average house constructed in 1970. During 2002–2003, a revised R-2000 standard was introduced. All previously trained professionals updated their skills, and eight new builders were trained to the new standard.

NRCan's Super E™ program supports the export of energy-efficient and environmentally friendly housing technology to foreign builders. Thanks to this program, the R-2000 concept has been adapted to several international markets. Last year marked the opening of the first Super E™ home in Scotland. Since the program began in 1978, 70 houses have been built in Japan, and 20 houses have been completed in the United Kingdom. Contracts are already confirmed for another 60 houses in the United Kingdom. Also, new Super E™ projects in Ireland and China will begin next year.

Existing Houses

NRCan programs for existing houses encourage Canadians to improve the energy efficiency of their homes. EGH provides homeowners with expert advice on how to improve the energy performance of their homes, particularly when undertaking renovation and maintenance projects. Homeowners who completed retrofit activities experienced an average annual energy savings of 19 percent.

In 2002–2003, more than 17 000 houses underwent energy evaluations through EGH. The overall client-satisfaction rate with EGH services was above 90 percent; 76 percent of EGH clients described the service as "exceeding expectations."

On average, houses built before 1946 and evaluated under EGH had potential energy savings of 111 gigajoules per year – meaning homeowners could reduce their energy use by nearly 40 percent. For those who implemented some of the suggested modifications, the actual average energy savings were closer to 23 percent.

Residential Equipment

NRCan develops regulations and sets standards for the energy performance of residential equipment, such as appliances and furnaces. The regulations now cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial/institutional sector.

Through labelling and promotional activities, NRCan also encourages the manufacture and purchase of more energy-efficient equipment.

Between 1990 and 2001, the energy efficiency of new household appliances increased substantially. An average 2001-model freezer, for instance, consumes 46 percent less energy than a similar 1990 model. The 2001-model refrigerators and dishwashers consume, on average, 42 percent and 38 percent less energy, respectively.

From 1990 to 2000, the EnerGuide labelling program is estimated to have resulted in a total energy savings of 531 gigawatt hours and a reduction of 287 kilotonnes of GHG emissions.

Buildings

Retail and office space accounts for more than half of the building sector's energy demands. Schools, health-care facilities, hotels and restaurants account for a further 26 percent.

Between 1990 and 2000, commercial and institutional energy use increased by 21.5 percent. In 2001, the commercial/institutional sector accounted for 13.3 percent of total secondary energy use and 13.0 percent of GHG emissions. However, improvements in energy efficiency worked to decrease total energy use by 3.6 percent.

NRCan programs address all building types with measures that target new buildings, existing buildings and equipment.

New Buildings

NRCan provides financial incentives to builders and developers who incorporate energy-efficient features into new construction projects. During 2002–2003,

79 contributions worth a total of $3.9 million were made to construction projects involving commercial, institutional and multi-unit residential buildings. The energy efficiency of these buildings increased by an average of 34.4 percent.

NRCan also provides assistance to builders and developers of industrial structures. In 2002–2003, nine contribution agreements were signed. Moreover, 28 architects and engineers received training on energy-efficient industrial building design.

Existing Buildings

NRCan provides businesses and institutions with access to tools and financial assistance to improve the energy efficiency of their existing buildings. More than 700 organizations have made formal commitments to reduce GHG emissions and improve energy efficiency.

Between 2001 and 2003, federal contributions to renovation and retrofitting projects totalled $12.7 million, and client investment equalled $207 million. Actual energy savings achieved through these projects was worth $33.5 million.

Equipment

Through a range of equipment programs, NRCan establishes standards and regulations for energy efficiency and supports the development, testing, deployment and promotion of new technologies.

In 2002–2003, NRCan increased the minimum-performance standards for ballasts and room air conditioners and established new standards for dry-type transformers and incandescent reflector lamps. Products that consume 50 percent of the energy used in the commercial/institutional sector must now meet standards for energy efficiency.

NRCan also develops and distributes building-simulation software tools to support advancements in building technology. Architects and engineers use these tools to optimize energy performance. To date, the software has been used to simulate the energy performance of more than 45 000 houses for NRCan's R-2000 and EGH and more than 800 buildings for the Commercial Building Incentive Program.

NRCan collaborates with associations, governments and businesses to develop specialized solutions to reduce energy consumption and GHG emissions in a cost-effective manner. In 2002–2003, NRCan attracted more than 80 participants from across Canada to a national workshop on supermarket refrigeration systems. NRCan also started an innovative demonstration project that integrates supermarket refrigeration, heating and ventilation systems to save energy.

Industry

The industrial sector – forestry, construction, mining and manufacturing – accounts for 38.5 percent of secondary energy use and 33.6 percent of GHG emissions.

Between 1995 and 2001, industrial energy use rose by 3 percent in Canada, while GHG emissions grew by 10.6 percent. However, during the same period, industrial activity increased by 22.4 percent. Improvements in energy efficiency helped reduce total energy use by 8 percent.

Within this sector, NRCan's energy efficiency initiatives focus on industrial processes and technologies, and equipment.

Industrial Processes and Technologies

NRCan works with companies and associations to encourage and support efforts to invest in, develop and employ more energy-efficient methods and to reduce GHG emissions. During 2002–2003, the number of registrants to the Industrial Energy Innovators program grew to 77 from 24 the year before.

At the sector level, organizations that participated in NRCan's Canadian Industry Program for Energy Conservation (CIPEC) realized significant savings. The mean five-year increase in energy consumption was 2.2 percent for CIPEC participants and 5.2 for non-participants.

NRCan also helps industry develop cleaner, more energy-efficient combustion processes. Current research focuses on optimizing the performance of stationary combustion equipment and developing and evaluating new products, fuels and retrofit activities.

In 2002–2003, NRCan tested and optimized a Canadian technology to remove sulphuric- and nitric-oxide pollutants from the flue gases of coal-fired boilers, producing fertilizer as a by-product.

NRCan helped finance a pilot installation at a coal-fired power plant in Ontario that could reduce emissions of

nitrogen oxides by up to 35 percent. The process, known as Fuel Lean Gas Reburn™, relies on natural gas to improve combustion.

Equipment

Through regulation, standards setting, labelling and research support, NRCan programs work to improve the energy efficiency of equipment used in industry.

Canada's *Energy Efficiency Regulations* set out minimum performance standards through the *Energy Efficiency Act* to eliminate the less energy-efficient models of energy-using equipment from the market. EnerGuide for Equipment promotes and encourages the manufacture, purchase and use of more energy-efficient industrial equipment.

Transportation

The transportation sector accounts for more than 28.0 percent of secondary energy use and 34.4 percent of GHG emissions. This sector is divided into three sub-sectors: passenger, which comprised 57.8 percent of total energy use in 2001; freight, 38.5 percent; and off-road, 3.6 percent.

Between 1990 and 2001, transportation energy use grew by 21.3 percent. Two main factors were responsible for the rise: an increase in activity and a shift toward larger vehicles. While the fuel efficiency of new vehicles has improved markedly, average fuel economy has been stable, because new cars and trucks are increasingly heavier and feature more powerful engines.

Between 1990 and 2001, improvements in energy efficiency reduced energy use in this sector by 10.2 percent from what it would have been in the absence of such improvements.

In 2001, road transport, at 77.8 percent, was the largest user of energy in the sector. Passenger energy use accounted for 48 percent of that total, and freight, 30 percent. In this sector, NRCan focuses its energy-use programs on road transportation, dividing them into four areas: personal vehicles, fleet vehicles, R&D and alternative fuels.

Personal Vehicles

NRCan programs encourage manufacturers to meet standards for fuel consumption and to improve fuel efficiency by adopting advances in technology. NRCan also encourages private motorists to purchase energy-efficient vehicles. Under a voluntary agreement, manufacturers attach EnerGuide fuel-consumption labels to their cars so that purchasers can make informed buying decisions.

The Auto$mart Student Driving Kit helps instructors teach fuel-efficient driving techniques to novice drivers. During 2002–2003, 150 new instructors were recruited into the program. As of March 2003, more than 800 000 novice drivers had been exposed to these fuel-efficiency techniques.

Fleet Vehicles

In partnership with fleet and industry associations and other levels of government, NRCan delivers information materials, workshops, demonstrations and training to fleet operators to help improve fuel efficiency and encourage the use of alternative fuels in commercial and municipal fleets.

During 2002–2003, the SmartDriver Initiative trained more than 149 000 novice and experienced drivers in fuel-efficient driving techniques. To date, the Fleet Vehicles initiative has registered more than 2800 members, representing more than 400 000 fleet vehicles.

Transportation Technology Research and Development

NRCan supports research into transportation technologies that improve the energy efficiency of vehicles and reduce GHG emissions.

During 2002–2003, a pilot process was developed that could lead to greater use of lightweight materials in vehicle manufacturing and increased fuel efficiency. The process involves seam-welding aluminum tubes for hydroforming.

In the mining industry, NRCan plays a lead role in a consortium that is developing a mining vehicle powered by fuel cells. A test vehicle underwent extensive surface testing during 2002–2003.

Alternative Transportation Fuels

NRCan promotes the use and development of alternative fuels, such as ethanol, natural gas and fuel cells, to minimize environmental impacts.

During 2002–2003, two provinces announced plans to introduce legislation requiring ethanol in government vehicles. Additionally, the first public E-85 (85 percent ethanol) fuelling station opened in Canada.

Renewable Energy

Renewable energy includes the well-established hydroelectric industry, which generates about 60 percent of all electricity in Canada. Small-scale projects, defined as those with a capacity of 20 or fewer megawatts, now provide about 4 percent of Canada's total capacity and offer excellent potential for increased production.

Several other renewable energy sources and technologies, such as wind power, also hold much promise. National wind power capacity has increased substantially in recent years, reaching 230 megawatts in 2002 with SaskPower's construction of a second wind farm.

NRCan delivers several initiatives to encourage the development and use of renewable energy. These initiatives support education and promotion programs, develop standards and research, and provide financial incentives for capacity building.

Renewable Energy Programs

During 2002–2003, the Government of Canada purchased more than 45 gigawatt hours of electricity from renewable source projects in Saskatchewan and Prince Edward Island. This resulted in a 40-kilotonne reduction of GHG emissions. The governments of Alberta and Ontario have also committed to purchasing electricity from renewable sources.

More than $900,000 in federal incentives were distributed to 50 projects under the Renewable Energy Deployment Initiative. Valued at $5 million, these projects have led to an annual reduction of approximately 5.8 megatonnes of GHG emissions.

In 2002–2003, the Renewable Energy Capacity-Building Program developed a new Web site that offers software to help decision-makers analyse the feasibility of renewable energy projects. Software that features a baseline model is under development.

Canada's first solar-powered car wash opened in Markham, Ontario, thanks to a partnership with Suncor Energy Products Inc.

NRCan's Wind Power Production Incentive (WPPI) aims to support the installation of 1000 megawatts of new wind energy capacity by 2007. By displacing other sources, wind power capacity installed under the WPPI is projected to reduce annual GHG emissions by three megatonnes by 2010. In 2002–2003, five projects were completed or under construction, for a total new capacity of approximately 93 megawatts.

Federal House in Order

As the country's largest single enterprise, the Government of Canada is getting its own energy-use house in order. The government has established a target of a 31 percent reduction in GHG emissions by 2010.

The Government of Canada has already achieved a 24 percent reduction since 1990 through a series of measures, including building retrofits, improvements in fleet management, downsizing of operations and purchases of green power. In 1990, emissions were 3837 kilotonnes; in 2001, emissions were down to 2987 kilotonnes. The Government of Canada plans a further reduction of 12 percent by 2010.

Key departments and agencies that are responsible for 95 percent of federal GHG emissions have been assigned specific targets under a three-year action plan and must report annually on their programs. NRCan provides services and support to federal departments and agencies to help them achieve their energy efficiency targets.

Federal Initiatives

The Federal House in Order initiative includes such activities as GHG inventory and tracking, purchases of green power (emerging sources of renewable electricity) and efforts to reduce outside emissions.

Under the Federal Buildings Initiative, NRCan helps organizations implement energy efficiency improvements through private-public partnerships. During 2002–2003, about $1 million worth of incremental energy savings were achieved through this program. In addition, energy intensity improved by 20 percent and GHG emissions were reduced by 15 to 20 percent.

The Federal Industrial Boiler Program (FIBP) provides technical and project-management services to federal departments and agencies that are implementing energy efficiency projects. Since its inception in 1991, the FIBP has worked with Agriculture and Agri-Food Canada, the Department of National Defence, Environment Canada and the Department of Foreign Affairs and International Trade, among others. These partnerships have reduced GHG emissions by an average of 4.7 kilotonnes per year.

Through the Federal Vehicles Initiative, NRCan helps other departments and agencies improve the efficiency of their fleets and switch to cleaner-burning fuels. During 2002–2003, the number of federal vehicles using E-85 fuel, (85 percent ethanol) doubled to more than 200. In addition, the federal fleet now includes more than 130 hybrid gasoline-electric vehicles. Another promising trend is the continued rise in the percentage of newly acquired vehicles that can operate on alternative fuels: from 3 percent of the federal fleet in 2001–2002 to more than 10 percent in 2002–2003.

Introduction

Greenhouse Gases and Climate Change

Climate change is a global challenge arising from the continuing buildup in levels of anthropogenic (human-produced) greenhouse gases (GHGs) in the atmosphere, in addition to naturally occurring emissions. GHGs are constituted by a number of gases, but the main source of anthropogenic emissions is carbon dioxide (CO_2) from the combustion of fossil fuels. Substantially reducing GHG emissions is a challenge, particularly given Canada's highly industrialized and resource-based economy. Solutions require a multi-faceted, coordinated domestic response and a high level of cooperation among all nations.

In December 1997, Canada and more than 160 other countries met in Kyoto, Japan, and agreed to targets to reduce GHG emissions. Canada's target is to reduce its GHG emissions to 6 percent below 1990 levels by the first commitment period (2008 to 2012). After signing the Kyoto Protocol, Canada established a National Climate Change process with provinces, territories, stakeholders and the Canadian public to examine the potential impacts, costs and benefits of the protocol and possible options for its implementation.

The Government of Canada ratified the Kyoto Protocol and notified the United Nations of its decision on December 17, 2002. Earlier, in November 2002, the Government of Canada had released the Climate Change Plan for Canada, which provides a framework for the way forward on climate change, while allowing for continuous adjustment. It also proposed a further range of initiatives for reducing GHG emissions.

Natural Resources Canada's Efficiency and Alternative Energy Program

Over the past decade, Natural Resources Canada (NRCan) has emphasized the promotion of energy efficiency and the use of alternative energy (i.e. alternative transportation fuels and renewable energy) as a means to reduce GHG emissions, particularly in relation to the Kyoto Protocol. A complete listing of NRCan's energy efficiency and alternative energy (EAE) initiatives in 2002–2003 is provided in Appendix 1. These initiatives engage Canadian society and all major sectors of the economy in new and more advanced approaches to secondary energy use – i.e. the consumption of energy in the residential, commercial and institutional, industrial and transportation sectors.

NRCan's EAE initiatives are managed by

- the Office of Energy Efficiency (OEE), which delivers market transformation initiatives to improve energy efficiency and the use of alternative transportation fuels;
- the CANMET Energy Technology Centre and the Mineral Technology Branch, which deliver EAE research and development (R&D) initiatives;
- the Electricity Resources Branch, which delivers market transformation initiatives for renewable energy; and
- the Science Branch of the Canadian Forest Service, which undertakes R&D in the use of forest biomass for energy.

[1] CANMET is the Canada Centre for Mineral and Energy Technology.

In its efforts to reduce GHG emissions, NRCan emphasizes partnership and cooperation with stakeholders, such as other levels of government, the private sector and non-governmental organizations. Using this approach, the demand side of the energy market moves toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels. On the supply side, Canada participates in developing technology for tapping renewable energy resources and alternative transportation fuels as well as increasing the energy efficiency of production.

In This Report

This tenth annual Report to Parliament focuses principally on EAE initiatives that address secondary energy use. Chapter 1 provides the policy context and strategic overview. Trends in energy use and GHG emissions in Canada are discussed in Chapter 2. Chapter 3 summarizes work undertaken during the reporting period to improve the quality and coverage of performance indicators for the initiatives described in Chapters 4 through 9. Chapters 4 to 7 review individual EAE initiatives to improve energy use in housing, buildings, industry and transportation, highlighting their achievements and progress indicators. Chapter 8 deals with renewable energy sources and use. Chapter 9 describes the Government of Canada's actions to improve its own use of energy. The final chapter describes intergovernmental cooperation in EAE.

Chapter 1: Policy Context and Legislation

Federal Policy and Measures on Energy Efficiency and Alternative Energy

Energy use has been a policy concern since the 1970s when governments responded to the oil crises of 1973 and 1979 by promoting energy conservation and renewable energy sources. By the mid-1980s, world oil supply had become sufficiently abundant that governments deregulated energy prices and markets and phased out most energy conservation and renewable energy programs.

Toward the end of the 1980s, individuals, organizations and governments around the world became concerned that greenhouse gas (GHG) emissions produced by burning fossil fuels – such as coal, oil and natural gas – could contribute to climate change. In 1990, Canada's concern about its GHG emissions (which result mostly from energy use) spurred an expansion of the federal program to improve energy efficiency and increase the use of alternative energy sources. These measures encouraged investment in corporate and consumer energy efficiency and alternative energy (EAE) opportunities and sought the engagement of all sectors of the economy and Canadian society in rethinking and improving energy use. Since 1991, a number of major developments have affected Natural Resources Canada's (NRCan's) EAE policies and programs.

In 1992, Canada signed and ratified the *United Nations Framework Convention on Climate Change* (UNFCCC). Under this convention, Canada and other countries agreed to work to stabilize GHG emissions at 1990 levels by 2000. In 1995, federal and provincial ministers of energy and the environment approved the National Action Program on Climate Change, which included as a key strategic element the promotion of energy efficiency in all sectors of the economy. At the same time, they established the Climate Change Voluntary Challenge and Registry (VCR). Later, in October 1997, it was incorporated as a non-governmental, not-for-profit organization. Canada's Climate Change Voluntary Challenge and Registry Inc. (VCR Inc.) invites Canadian companies and organizations to develop action plans to limit their net GHG emissions and to file these, as well as progress reports and achievements, on its public registry.

The federal budget of February 1997 provided $60 million over three years for new initiatives to improve energy efficiency in new commercial buildings; encourage commercial building retrofits; provide for energy performance assessments of houses; and stimulate demand for cost-effective, commercially available renewable energy systems for space and water heating and cooling. This funding was renewed in the February 2000 federal budget and further extended to March 2006 in the budget of February 2003.

In December 1997, at the third Conference of the Parties to the UN Framework Convention on Climate Change in Kyoto, Japan, the participating countries agreed to reduce GHG emissions from 1990 levels within 2008 to 2012. Canada pledged to reduce its emissions by 6 percent. The protocol will enter into force when at least 55 parties to the Framework Convention, representing 55 percent of industrialized countries' GHG emissions, have ratified it.

In February 1998, the federal budget provided $150 million over three years for a Climate Change Action Fund (CCAF) to help Canada develop its response to the Kyoto Protocol. This funding was renewed in the February 2000 federal budget. The fund had four components:

- *Public Education and Outreach* to build public awareness and understanding of climate change and encourage action to reduce GHG emissions;
- *Technology Early Action Measures* (TEAM) to share with the private sector the risk of demonstrating cost-effective technology projects that will lead to reductions in GHG emissions;
- *Science, Impacts and Adaptation* to support research to advance our knowledge of the magnitude, rate and regional distribution of the impacts of climate

change on Canada and to support the development of adaptation strategies; and

- *Foundation Analysis* to support the National Climate Change Process and the analysis of options for reducing Canada's GHG emissions.

The federal, provincial and territorial governments established the National Climate Change Process in 1998 to examine the impact, costs and benefits of the Kyoto Protocol and the implementation options open to Canada. From spring 1998 to winter 1999–2000, the process engaged more than 450 experts from across Canada, and their recommendations were provided to governments in fall 2000. In May 2002, the Government of Canada released the *Discussion Paper on Canada's Contribution to Addressing Climate Change* to continue consultations with stakeholders. NRCan officials have provided a great deal of support, analysis, advice and guidance to the National Climate Change Process.

In addition to the previously noted renewal of funding for four EAE initiatives and the CCAF, the federal 2000 budget also provided funds for the Green Municipal Enabling Fund (GMEF) and the Green Municipal Investment Fund (GMIF). The federal budget of December 2001 doubled the initial endowment. The Federation of Canadian Municipalities manages the two funds under agreements with NRCan and Environment Canada. The GMEF is a $50-million endowment, available for five years, to contribute to feasibility studies of energy and environmental projects in municipal operations. The GMIF is a permanent, $200-million endowment to provide loans and loan guarantees to eligible recipients to carry out energy and environmental projects. It also provides grants and long-term loans for pilot projects that demonstrate innovative technologies and processes.

Building on a successful initial purchase of green power in Alberta, the February 2000 federal budget expanded the pilot initiative to permit the procurement of $15 million in renewable energy over the next 10 years for federal facilities in Saskatchewan and Prince Edward Island.

In October 2000, the Government of Canada announced its *Action Plan 2000 on Climate Change*, representing its contribution to *Canada's First National Climate Change Business Plan* developed with the provinces and territories. Funding of $500 million over five years was provided in the budget update of October 2000 for a broad range of measures that commenced operation in 2001–2002.

In November 2002, the Government of Canada released the *Climate Change Plan for Canada*, outlining how Canada can meet its GHG reduction target. The Plan sets out a three-step approach: the first step is the measures implemented under Action Plan 2000; the second, a set of new initiatives; and the third, options for attaining the target by the end of the first commitment period in 2012. The federal budget of February 2003 provided new funding of $2 billion over five years commencing with fiscal year 2003–2004 to support the climate change initiatives identified in the Plan. This is in addition to the $1.7 billion in climate change investments announced by the Government of Canada since 1997. The next edition of this Report to Parliament will describe the measures implemented with this new funding.

Responsibility

In April 1998, NRCan's Office of Energy Efficiency (OEE) was established, with a mandate to strengthen and expand Canada's commitment to energy efficiency, in particular to help address the challenges of climate change. The OEE's initiatives target all final energy consumers and emphasize partnerships and economic investment. Its program objectives are to overcome the market barriers posed by inadequate information and knowledge about energy efficiency and alternative transportation fuels, and to address institutional deterrents in energy-use markets and economic constraints that energy users face. The OEE is also responsible for identifying opportunities for new and heightened energy efficiency measures. The National Advisory Council on Energy Efficiency assists the OEE by providing advice and guidance. The council comprises energy efficiency experts and leaders from all sectors of the economy.

NRCan's Office of Energy Research and Development (OERD) coordinates and funds non-nuclear, energy-related research and development (R&D) for the Government of Canada in partnership with 12 federal departments and agencies through the Program of Energy Research and Development (PERD). Seventy-seven percent of PERD's current programs contribute to finding technology solutions to help

Canada address its climate change challenges. PERD promotes the development of energy-efficient, renewable and alternative energy sources and technologies and the development and use of Canada's oil and gas resources in a clean and safe manner.

NRCan's CANMET Energy Technology Centre (CETC) focuses on technology development and deployment. Technology development activities are performed on a cost-shared basis either through in-house R&D work at its laboratories or by providing funding support to its technology partners. CETC – Ottawa, in Ontario, works in partnership with a range of stakeholders to develop and disseminate innovative, cleaner energy technologies. These include energy-efficient technologies for homes, businesses and industry; renewable energy; alternative transportation fuels; district heating and cooling systems; advanced low-emissions combustion technologies; and energy-efficient metallurgical fuel products and technologies. CETC – Varennes, in Quebec, develops technologies that use energy wisely and help Canadians stay competitive in the marketplace. These include advanced drying technologies, heat transfer and storage systems, photovoltaics, renewable energy for remote communities and related software tools, such as RETScreen® International.

The Electricity Resources Branch (ERB) is the fourth organization within NRCan's Energy Sector reporting on programs in this document. Within the ERB, the Renewable and Electrical Energy Division promotes the development of a sustainable renewable energy industry in Canada. It promotes investments in renewable energy systems for heating and cooling and provides information on renewable energy technologies. By strengthening markets for the renewable energy industry, its programs contribute to GHG reductions, job creation and export sales.

Outside of the Energy Sector, two other sectors within NRCan report on programs related to energy efficiency and alternative energy in this document. They are the Canadian Forest Service and the Minerals and Metals Sector.

Energy Efficiency Strategy

Most of NRCan's EAE initiatives deal solely with energy efficiency. Their goal is to improve energy efficiency by

- increasing the energy efficiency of new and existing buildings, equipment, systems and vehicles;
- persuading individuals and organizations to purchase buildings, equipment, systems and vehicles that are more energy efficient;
- ensuring that energy-consuming equipment is used in the most energy-efficient way;
- influencing the energy-use practices of individuals and organizations; and
- developing technologies to give consumers, industry and communities new opportunities to improve energy efficiency.

These measures help the demand side of the energy market move toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels.

Alternative Energy Strategy

In the short term, energy efficiency improvements can contribute significantly to energy savings and environmental objectives. In the long term, however, reducing GHG emissions will require greater use of alternative energy sources.

Alternative energy includes renewable sources other than large hydro-electric facilities, new applications of conventional sources and new fuels, such as hydrogen for fuel cells. (Large hydro is not considered an alternative energy source because it is already a successful, well-established mode of energy production, supplying more than 60 percent of the electricity in Canada.) Some technologies, such as those related to the use of propane as a vehicle fuel and to forestry biomass, are already commercially available and accepted. Some have found applications in specialized markets, such as remote communities. Others are still in the early stages of development.

Federal initiatives are helping to expand the infrastructure (e.g. fuelling stations) for the sale of alternative transportation fuels, especially in urban areas where the provision of infrastructure is more economic. R&D focuses on ways to improve options in the use of these fuels.

NRCan supports R&D to reduce costs, improve performance, develop safety and performance standards and increase the scope of renewable energy technologies. The department also provides incentives for investments in renewable energy systems and purchases of electricity generated from renewable sources, disseminates information to consumers, and assesses economic and environmental aspects of renewable sources of energy.

Policy Instruments

NRCan's key policy instruments are as follows:

- leadership;
- information;
- voluntary initiatives;
- financial incentives;
- regulation; and
- research and development.

Leadership

Leadership means setting an example for other levels of government and for the private sector by increasing energy efficiency and the use of alternative energy in the Government of Canada's operations.

Information

NRCan disseminates information to consumers, using methods that range from broad distribution to individual consultations with clients, to increase awareness of the environmental impact of energy use and to encourage consumers to become more energy efficient and to make greater use of alternative energy sources. Activities include publications, exhibits, advertising, toll-free lines, conferences, Web sites, workshops, training, building-design software and promotional products.

Voluntary Initiatives

Companies and institutions work with NRCan on a voluntary basis to establish and achieve energy efficiency objectives. NRCan's voluntary EAE initiatives target large consumers of energy in the commercial, institutional and industrial sectors and organizations whose products are important determinants of energy use. The initiatives involve industry-government agreements and, for groups of large industrial energy users, energy efficiency target setting. NRCan provides a variety of support services to assist and stimulate action by companies and institutions on energy efficiency, including developing standards and training.

Financial Incentives

NRCan uses financial incentives to encourage final users of energy to employ energy efficiency and renewable energy technologies and practices when they acquire, design or build new buildings or retrofit existing ones. NRCan also offers financial incentives for wind energy and for natural gas vehicles and refuelling infrastructure.

Regulation

The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations concerning EAE, primarily performance and labelling requirements for energy-using products (as well as doors and windows) that are imported or shipped from province to province. Regulation also involves working with provincial governments to improve the energy efficiency provisions in Canadian building codes.

Research and Development

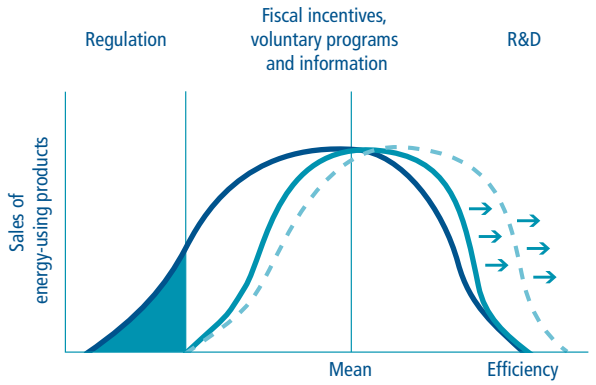
NRCan's EAE initiatives support the development and dissemination of more energy-efficient equipment, processes and technologies and alternative energy technologies. R&D also provides the scientific knowledge needed to develop the technologies, codes, standards and regulations required for the sustainable use of energy.

NRCan provides national leadership in energy science and technology (S&T) by undertaking in-house research in its own laboratories, by contracting out research activities to other organizations and through the federal PERD. PERD and TEAM are the only federal interdepartmental S&T investment funds that focus on the energy sector and its economic and environmental effects.

Figure 1-1 shows how these policy tools work together to increase energy efficiency, i.e. how they help to reduce the amount of energy needed to obtain a certain level of service. R&D increases the opportunities for achieving greater levels of efficiency in a particular type of energy use. Non-R&D measures increase the take-up of existing opportunities to use energy more efficiently. Regulations also eliminate less-efficient products from the market.

FIGURE 1-1

Moving the Market



Chapter 2: Trends in Energy Use

Introduction

Canadians enjoy an abundance of energy from a variety of sources. This comparative advantage in the supply of energy has helped Canadians deal with the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. It also has favoured the development of industries that have a particularly strong energy demand. As a result, Canada consumes more energy per capita than most countries.

Canadians spend almost $114 billion per year on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes. This represents 10.4 percent of the country's gross domestic product.

Energy Use and Greenhouse Gas Emissions

There are two general types of energy use: primary and secondary. Primary energy use encompasses the total requirements for all users of energy, the energy required to transform one energy form to another (e.g. coal to electricity) and the energy used to bring energy supplies to the consumer. Secondary energy use is energy used by final consumers for residential, agricultural, commercial, industrial and transportation purposes.

Primary energy use in Canada today reflects changes over several decades in energy-consuming equipment and buildings and in the behaviour of energy users. Primary energy use increased by 16.5 percent between 1990 and 2001, from 9714 petajoules to 11 316 petajoules.

Secondary energy use (7949 petajoules) accounted for 70.2 percent of primary energy use in 2001. It was responsible for 65.7 percent (473 megatonnes) of total greenhouse gas (GHG) emissions in Canada, if indirect emissions – namely, those produced by electric utilities to meet end-use electrical demand – are included.

This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane and nitrous oxide. CO_2 represents the majority of Canada's GHG emissions. All subsequent references in this report to CO_2 and GHGs include emissions that are attributable directly to secondary energy use and indirect emissions attributable to electricity generation, unless otherwise specified.

From 1990 to 2001, secondary energy use increased by 13.8 percent. GHG emissions attributable to secondary energy use increased by 16.1 percent because of a 2.3 percent increase in the GHG intensity of energy users. This reflects changes in the fuel mix used to generate electricity. The GHG intensity of electricity increased by 15.3 percent over the period. The industrial sector is the largest energy user, accounting for 38.5 percent of total secondary energy use in 2001. The transportation sector is the second largest energy user at 28.6 percent, followed by the residential sector at 16.8 percent, the commercial and institutional sector at 13.3 percent and the agriculture sector at 2.7 percent.

Energy Efficiency

Natural Resources Canada (NRCan) annually publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use (and GHG emissions) and the contribution of the following key factors to these changes:

- increases in sector *activity* lead to increased energy use and emissions. In the residential sector, for example, an increase in the number of households has the effect of increasing 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;
- fluctuations in *weather* lead to changes in space-heating and cooling requirements. A colder winter or a warmer summer can lead to increased energy use; and
- *energy efficiency* – how effectively energy is being used, for example, how long an appliance can be operated with a given amount of energy.

In this report, changes in energy efficiency are the net result after allowing for the changes in energy use due to changes in activity, structure and weather. To the extent that other factors that affect energy use have not been captured, this measure of energy efficiency improvement might overstate or understate the "actual" change. For example, in the industrial sector, there may have been changes in energy use due to shifts in the mix of products, but this is not captured.

Secondary energy use increased by 13.8 percent between 1990 and 2001 (from 6988 to 7949 petajoules). Due to data limitations in the industrial sector as Statistics Canada converts to a new industrial classification system, the analysis of factors affecting energy use could not be done for 1990–2001. However, the energy savings for this period have been estimated by coupling the 1990–1995 data from the 2000 database with the 1995–2001 data from the 2001 database and re-basing them to 1990. Using this methodology, it can be estimated that if only activity, structure and weather had been in effect, secondary energy use would have increased by 24.7 percent. However, improvements in energy efficiency worked to decrease energy use by 9.6 percent (764 petajoules).

TABLE 2-1

Explanation of Changes in Secondary Energy Use, 1990 to 2001 (in petajoules) *

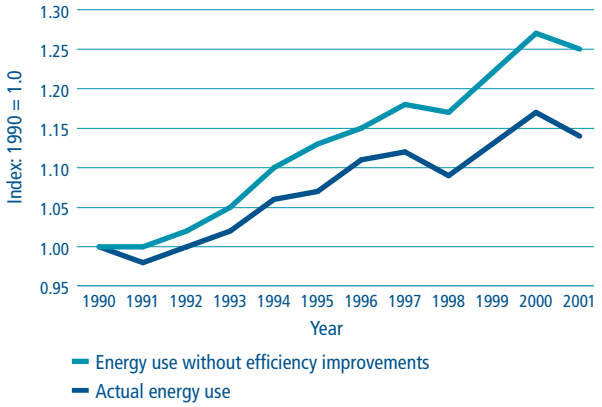
	Sectors						
	Residential	Commercial/ Institutional	Industrial	Transportation	Agriculture	Total	% Change
1990 energy use	1289.0	867.0	2755.0	1878.0	199.0	6988.0	
2001 energy use	1337.0	1054.0	3064.0	2277.0	218.0	7949.0	
Change in energy use	48.0	187.0	309.0	399.0	19.0	961.0	13.8
Explanatory Factor (change due to)							
Activity	280.2	218.5	n/a	344.1		n/a	
Structure	36.5	8.0	n/a	215.1		n/a	
Weather	-28.5	-7.9	n/a	n/a		-36.4	0.5
Energy efficiency	-240.7	-30.7	-311.7	-181.3		-764.4	9.6
Other factors		-1.2		21.4	18.9	39.1	0.5

*The factorization analysis results for the industrial sector for 1995–2001 are as follows:
- activity (economic growth) raised secondary energy use by 665 petajoules;
- changes in the structure of activity decreased secondary energy use by 343 petajoules; and
- energy efficiency decreased secondary energy use by 232 petajoules.

As a result, energy use increased by only 13.8 percent. This change in energy use between 1990 and 2001, with and without changes in energy efficiency, is shown in Figure 2-1. The difference in energy use due to energy efficiency – the energy saving – represents a reduction in energy costs of $10.7 billion a year and a reduction in GHG emissions of over 44 megatonnes. Changes in energy efficiency are estimated for each of the four major end-use sectors and presented in Chapters 4 to 7. The energy efficiency improvements were largest in the residential sector (18.7 percent), followed by the transportation (10.2 percent), industrial[1] (11.3 percent) and commercial and institutional (3.6 percent) sectors.[2]

FIGURE 2-1

Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001



Renewable Energy

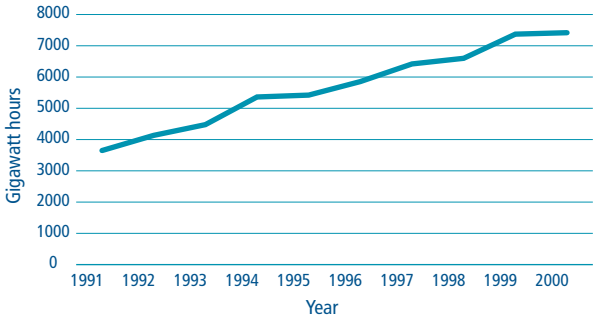
As previously noted, changes in the fuel mix employed by the Canadian economy can reduce GHG intensity. Although in the near term this can be achieved by moving from more- to less-GHG-intensive fuels (e.g. from coal to natural gas), over the longer term the use of renewable energy sources is expected to accelerate this trend.

Figure 2.2 shows the trend in the use in Canada of electricity generated from wind, solar and biomass, indicating a 203 percent increase over 1991–2000. Although representing only a small component of overall electricity use, the proportion of electricity generated from these renewable energy sources increased from 0.75 percent to 1.28 percent over the period, representing a 58 percent increase in its share. Most of this production was derived from biomass.

The graph does not include hydro sources, either conventional or small (less than 20 megawatts). The former accounts for about 60 percent of electricity generated in Canada; installed capacity is over 67 gigawatts. There are over 230 small hydro installations in Canada, with a total capacity of about 1500 megawatts.

FIGURE 2-2

Electricity Production From Renewable Sources



[1] Calculated by coupling the 1990–1995 data from the 2000 database with this year's 1995–2001 data and re-basing them to 1990 in the industrial sector.

[2] The aggregate energy-use data presented in this report are taken from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada* (QRESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of QRESD energy use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix A of Natural Resources Canada's *End-Use Energy Data Handbook, 1990 and 1995 to 2001*.

Chapter 3: Measuring Progress

Background

The primary goal of Natural Resources Canada's (NRCan's) energy efficiency and alternative energy (EAE) initiatives is to change energy consumption patterns to obtain environmental and economic benefits. Part of assessing program progress and performance involves considering program delivery and program effectiveness.

NRCan focuses on the monitoring and tracking of the following three aspects of program delivery:

- program outputs;
- program outcomes; and
- market outcomes.

Program outputs are the items produced regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. These outputs are designed to lead to *program outcomes* – namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase more energy-efficient appliances than they would have purchased if there had been no program. Other important factors that influence consumer behaviour include product price, household income, personal taste and other government and non-governmental programs.

Since program outcomes can directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable *market outcomes*. Market outcomes ultimately reflect the impacts of NRCan programs on changes in energy efficiency, energy intensity, greenhouse gas (GHG) emissions and the use of alternative energy. In this sense, achievement of a targeted market outcome, or observable progress towards a market outcome, serves as an indicator of program effectiveness. An example of a program outcome that leads to a market outcome is a householder's purchase of a more energy-efficient appliance and reduced use of electricity. Depending on the source of electricity, and how the utility changes its electricity-generating methods to meet the change in demand that results from reduced electricity use, this could also lead to a decline in GHG emissions.

Focusing on Results

The government-wide initiative aimed at "managing for results" has encouraged management in all federal departments and agencies to focus more on the impacts of their programs and services on the lives of Canadians. Managing for results requires more than just the monitoring of program delivery; it means clearly defining the results to be achieved, increasing the emphasis on program and market outcomes, measuring and evaluating program performance, and making adjustments to improve the efficiency and effectiveness of programs. It also means reporting on performance in ways that make sense to Canadians.

Measuring program and market outcomes can be time-consuming, costly and difficult. In particular, quantifying program outcomes requires client and data surveys and detailed analyses of energy use. NRCan's National Energy Use Database (NEUD) initiative helps the department track changes in energy consumption at the end-use level. Still, it is difficult to determine the incremental effects of programs because other factors, such as variation in energy prices, also influence these effects. Moreover, because several factors and programs can influence a consumer at the same time, it is difficult to determine the separate contribution of each factor and program to the total effect. Consequently, quantifying program outcomes, impacts and, ultimately, results also requires some knowledge of attribution – or the proportion of the observed or estimated market outcome that can be reasonably attributed solely to program activities and efforts.

This report uses a mix of progress indicators, which are quantitative where possible. The challenge for NRCan is to continuously improve the coverage and quality of

these progress indicators, in general and in order to ensure that they increasingly reflect a focus on results. The following section highlights some of NRCan's more recent efforts to improve the quality of its program performance information.

Highlights of the Office of Energy Efficiency's Program Attribution Research

In 2002–2003, the Office of Energy Efficiency (OEE) completed impact attribution studies for EnerGuide for Houses and for its Dollars to $ense workshop series (a component of Energy Innovators and the Canadian Industry Program for Energy Conservation). Both of these studies employed analytical methods derived from Discrete Choice Theory, which has been used to estimate the change in behaviour that can occur (for an individual or a group of individuals) as a result of a firm's marketing efforts or a utility's program efforts. Discrete Choice Theory methods are only beginning to be applied to the evaluation of public sector programs. Both studies were aimed at estimating the market outcomes, measured in terms of energy savings and GHG emissions reductions that could be attributed solely to program efforts. The studies yielded positive and insightful results that not only allow program managers to gauge the effectiveness of their programs, but also allow the programs to be strategically improved in order to ensure even better outcomes in the future.

The Dollars to $ense study revealed that knowledge levels about how to improve energy efficiency improved significantly for workshop participants, who came from the commercial, private, public and industry sectors. The combined net impact of the three Dollars to $ense workshops (Energy Master Plan, Energy Monitoring and Tracking, and Spot the Energy Savings Opportunities) was a savings of 3.1 petajoules of energy use per year. The rate of uptake, or the installation of different energy efficiency improvement measures (e.g. the installation of more-efficient refrigerators or lighting), that could be attributed to the workshops ranged from 0.4 percent for ovens to almost 40 percent for compact fluorescent lights.

The EnerGuide for Houses (EGH) study also produced positive results. Overall, participants were very satisfied with EGH. Over two thirds of participants recommended EGH to a neighbour, friend or relative. Furthermore, close to 20 percent of participants had a neighbour, friend or relative also participate in EGH. Survey respondents indicated that EGH played an important role in their decisions to undertake various energy-saving home renovations. The study results showed that EGH was most influential in convincing homeowners to improve their foundation and ceiling insulation, mechanical ventilation systems and weather-stripping. The net impact in estimated energy savings ranges between 0.12 and 0.35 petajoules per year.

The OEE will continue to report on the progress of its performance assessment work in the coming years.

Chapter 4: Housing

Energy Use and Greenhouse Gas Emissions

The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling, heating water and operating appliances and lights. This sector accounts for 16.8 percent (1337 petajoules) of secondary energy use and 15.7 percent (74 megatonnes) of greenhouse gas (GHG) emissions.

Most dwellings in Canada are single detached houses, followed by apartments, single attached dwellings and mobile homes (see Figure 4-1). Because single detached and attached houses predominate, most Natural Resources Canada (NRCan) residential building programs focus on these dwellings.

Space and water heating make up 80.2 percent of residential energy use, followed by the shares devoted to operating appliances, lighting and space cooling (see Figure 4-2).

Between 1990 and 2001, residential energy use increased by 3.7 percent, or 47.5 petajoules (from 1289 to 1337 petajoules). From 1990 to 2001, GHG emissions from the residential sector increased by 6.8 percent. A 3.7 percent increase in energy use combined with a 6.8 percent increase in GHG emissions reflects an increase in GHG intensity. This was principally due to an increase in the carbon intensity of generated electricity.

Four main factors tended to influence residential energy use – activity, weather, structure and energy efficiency:

- activity – the increase in the number of households and the size of dwellings (the principal measures of residential activity) increased energy use by 21.7 percent (280 petajoules);

FIGURE 4-1

Canadian Households by Type of Dwelling, 2001

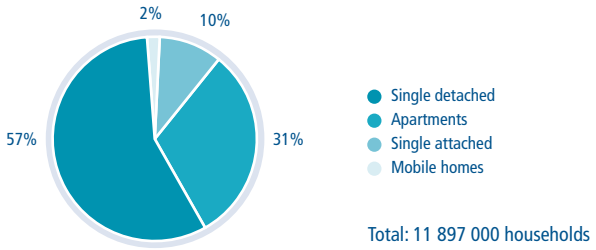
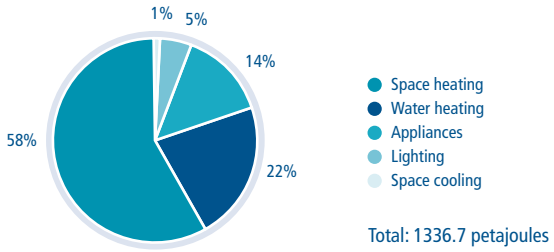


FIGURE 4-2

Residential Energy Use by Purpose, 2001



- weather – warmer weather in 2001 compared with 1990 led to a decrease in space-heating requirements. This decreased energy use by 2.2 percent (29 petajoules);
- structure – the percentage shares of energy end-uses changed over the period such that they increased energy use by 2.8 percent (37 petajoules); and
- energy efficiency – improvements in energy efficiency decreased energy use by 18.7 percent (241 petajoules).

Growth in residential energy use was driven in large part by growth in activity. This increase was partially offset by significant improvements in energy efficiency. Structural changes had a minor impact on residential energy use.

The change in overall residential energy use from the years 1990 to 2001, as well as the energy savings due to energy efficiency, is shown in Figure 4-3. Figures 4-4 and 4.5 show how energy consumption differs for houses built to different standards and in different periods, reflecting improvements in building construction.

NRCan delivers initiatives to increase energy efficiency in the following residential subsectors:

- new houses;
- existing houses; and
- residential equipment, including
  - energy performance regulations; and
  - energy labelling.

FIGURE 4-3

Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001

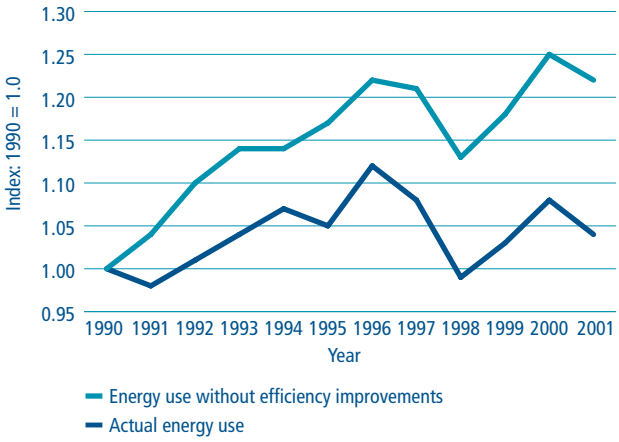


FIGURE 4-4

Annual Heating Consumption for Houses Constructed to Different Standards (From EnerGuide for Houses)

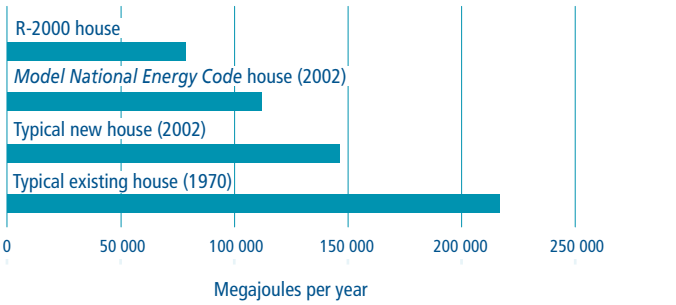
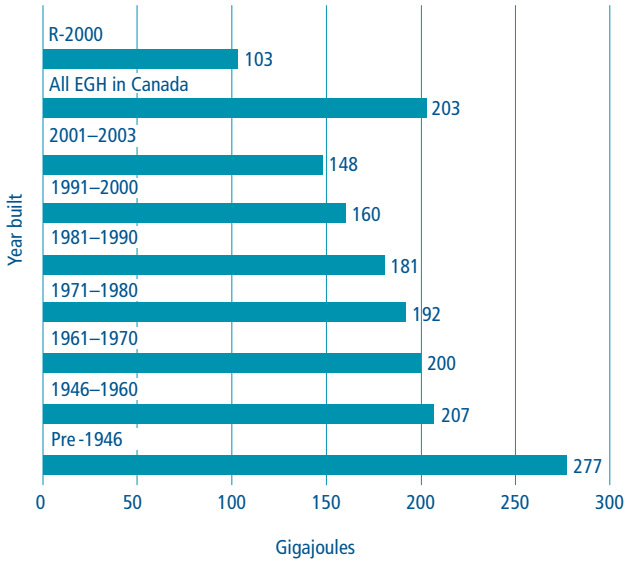


FIGURE 4-5

Average Energy Consumption per Household (From R-2000* and EnerGuide for Houses)



*R-2000 is an official mark of Natural Resources Canada.

New Houses: R-2000 Standard

Objective: To increase market adoption of energy-efficient new houses by promoting changes in construction practices.

The R-2000 Standard encourages Canadian builders to build, and Canadian consumers to purchase, more energy-efficient houses that are environmentally friendly and healthy to live in. Trained and licensed R-2000 homebuilders and other professionals commit to meeting the R-2000 Standard – a technical performance standard that exceeds the requirements for energy efficiency and environmental responsibility in current Canadian building codes.

Key 2002–2003 Achievements

- All previously trained professionals updated their skills, and eight new builders were trained to the revised R-2000 Standard.
- The updated R-2000 Standard introduced.
- National training and certification system implemented for R-2000 builders and service providers.
- Agreement signed with the Heating, Refrigeration and Air Conditioning Institute of Canada to support training. Subsidized courses offered to the industry to increase its capacity to design and install energy-efficient heating and ventilation systems.
- EnerGuide for Houses energy rating system piloted with tract builders.
- Agreements signed with new delivery partners from the Ontario First Nations Technical Services Corporation and the First Nations (Alberta) Technical Services Advisory Group to the Council in order to extend the R-2000 reach and capacity building on First Nations territories.

For more information:
oee.nrcan.gc.ca/r-2000/english/index.cfm

FIGURE 4-6

Number of Eligible R-2000 Housing Starts, 1990 to 2002

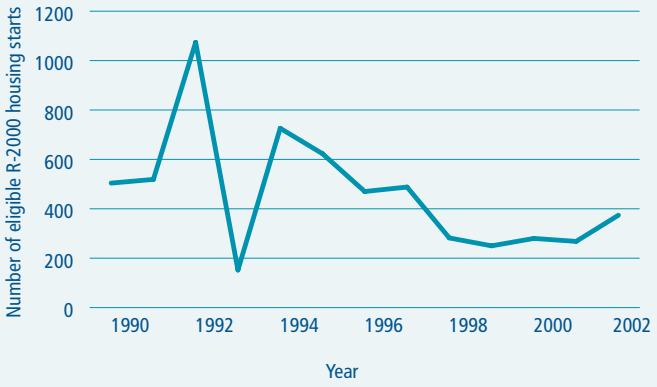
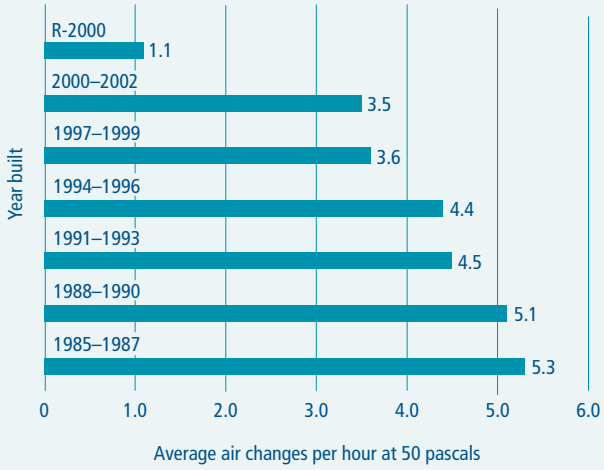


FIGURE 4-7

National Trends in Air Leakage in Houses (R-2000 and EnerGuide for Houses), 1985 to 2002



New Houses: Super E™ Program

Objective: To build capacity for exporting energy-efficient, durable and environmentally friendly Canadian housing technology to foreign markets.

The Super E™ Program is a strategic housing export initiative delivered by NRCan as part of the Team Canada export strategy. Launched in 1998, the Super E™ Program facilitates partnerships between Canadian builders and their foreign counterparts to increase market penetration of Canadian energy-efficient technologies internationally.

- To date, over 70 houses have been built in Japan, and 20 houses have been completed in the United Kingdom with contracts for over 60 more houses already confirmed for 2003–2004. This next year will also see Super E™ projects in Ireland and China.
- Over the past four years, sales generated through the Super E™ Program are estimated at a total of C$8 million. Sales in 2003 are expected to approach C$5 million.
- Over 22 Canadian companies from British Columbia to Prince Edward Island are partnered with over 30 foreign companies in Japan and the United Kingdom.
- NRCan is joined in this program by Canada Mortgage and Housing Corporation and the Department of Foreign Affairs and International Trade.

Key 2002–2003 Achievements

- Establishment of the Super E™ Housing Committee by Japanese members to increase sales of Super E™ houses in Japan.
- The opening of the first Super E™ home in Inverness, Scotland.
- A strategic partnership signed between the program and Zurich Home Warranty of the United Kingdom, where it is the largest home warranty company, will accelerate the adoption of Super E™ standards in the U.K. housing industry.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

Existing Houses: EnerGuide for Houses

Objective: To encourage Canadians to improve the energy efficiency of their homes.

EnerGuide for Houses provides Canadians with the facts they need to improve the energy efficiency of their homes, especially when undertaking home renovation and maintenance projects. It offers homeowners personalized expert advice on how to improve the energy performance of their houses. EnerGuide for Houses was expanded under Action Plan 2000 to include new houses. Its primary purpose is to label new homes for energy performance.

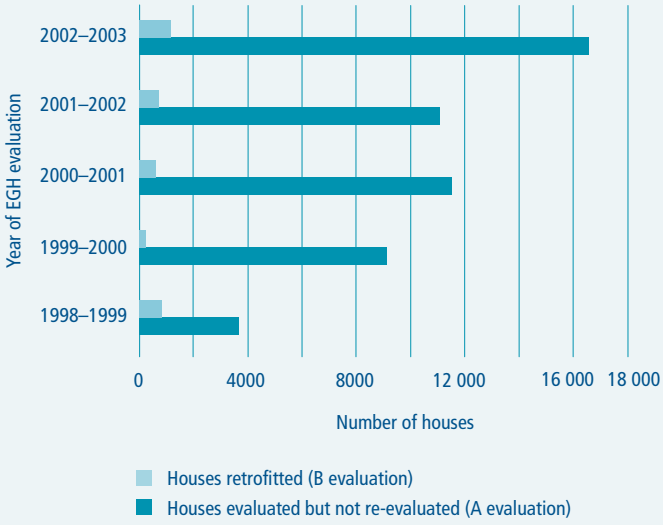
Key 2002–2003 Achievements

- Over 17 700 houses evaluated and labelled.
- Average annual energy savings of 19 percent for homes that undertook retrofit activities; for homes built before 1945, the savings increase to 23 percent.
- Over 90 percent client satisfaction rate with the EnerGuide for Houses service; 76 percent of clients said service "exceeded their expectations."
- Over 60 percent of the clients had implemented at least some of the recommendations by the time of a follow-up survey; an additional 23 percent said they "intended to retrofit."

For more information:
oee.nrcan.gc.ca/houses-maisons/english/choose_e.htm

FIGURE 4-8

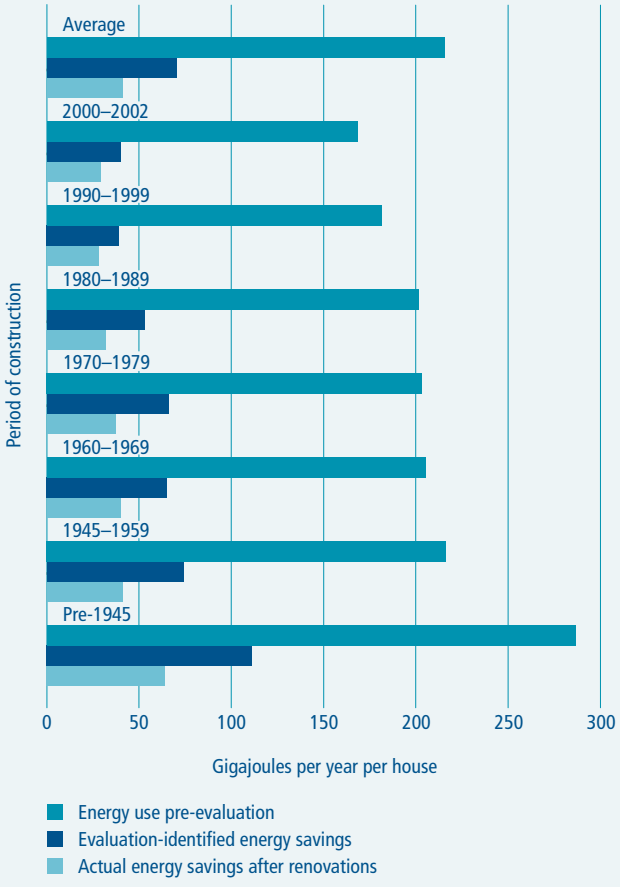
Evaluations Under EnerGuide for Houses



Note: Under EnerGuide for Houses, homes are evaluated to determine the potential for energy savings (an A evaluation). After renovations implementing program recommendations have taken place, some homes are revisited to determine the actual energy savings (a B evaluation).

FIGURE 4-9

Residential Energy Use and Energy Savings per Household



Residential Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy-performance levels and labelling requirements.

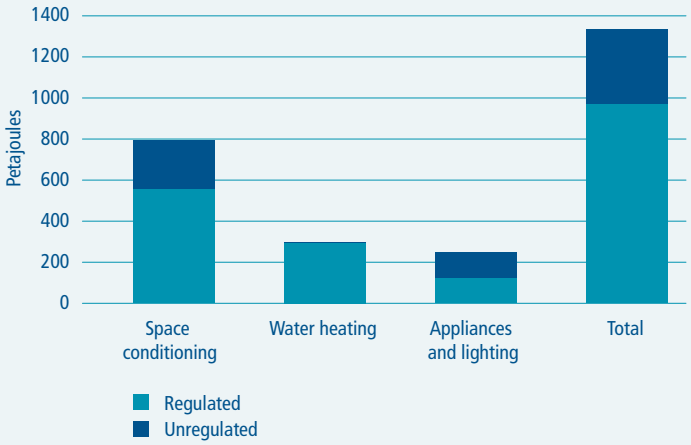
Key 2002–2003 Achievements

- Published seventh amendment to the *Energy Efficiency Regulations*.
- The Regulations cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial-institutional sector.

For more information:
oee.nrcan.gc.ca/regulations/home_page.cfm

FIGURE 4-10

Share of Residential Energy Consumption Subject to *Energy Efficiency Regulations*, 2001



Residential Equipment: Labelling and Promotion

Objective: To promote the production, purchase and use of more energy-efficient equipment.

The Labelling and Promotion Initiative consists of labelling, rating and promotional activities that encourage manufacturers to produce, and consumers to purchase and use, more efficient energy-using equipment. The initiative is made up of EnerGuide for Equipment, which provides comparative information on the energy performance of major household appliances as well as heating, ventilating and air conditioning (HVAC) equipment, and the ENERGY STAR® endorsement label, which allows the consumer to identify the most energy-efficient products available based on a standard set of criteria.

Key 2002–2003 Achievements

- Labelling requirements are now extended to such products as gas fireplaces, windows and sliding doors.

For more information:
energuide.nrcan.gc.ca/ or hvac.nrcan.gc.ca/index_e.htm
or
energystar.gc.ca

FIGURE 4-11

ENERGY STAR® Label

FIGURE 4-12

Average Energy Consumption of New Appliances, 1990 and 2001 Models

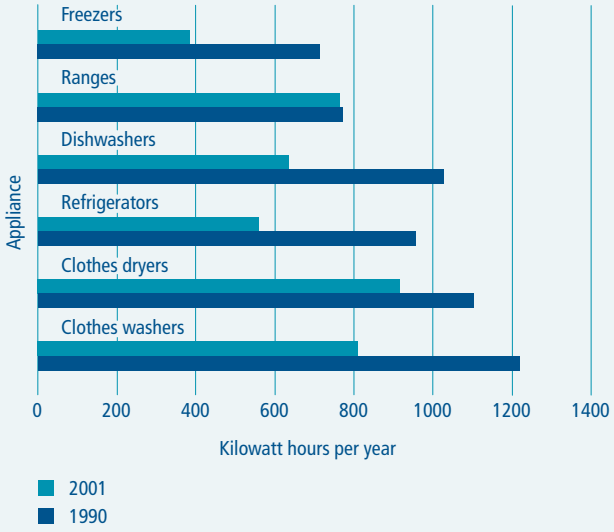


FIGURE 4-13

Unit Energy Consumption for Top-Mounted Auto-Defrost Refrigerators Marketed in Canada, 1991 and 2001 Models

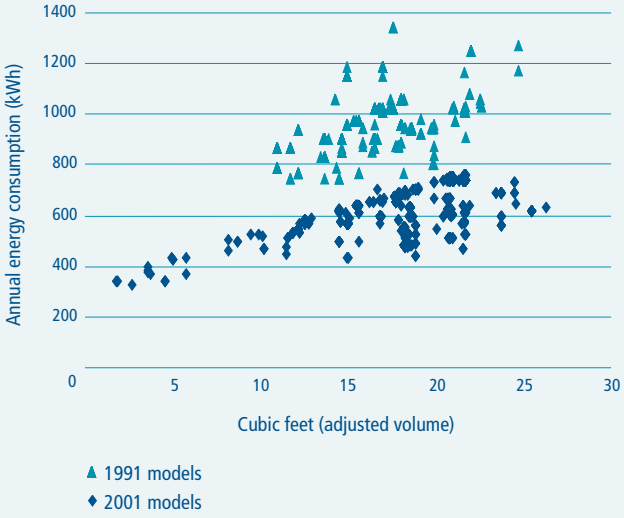
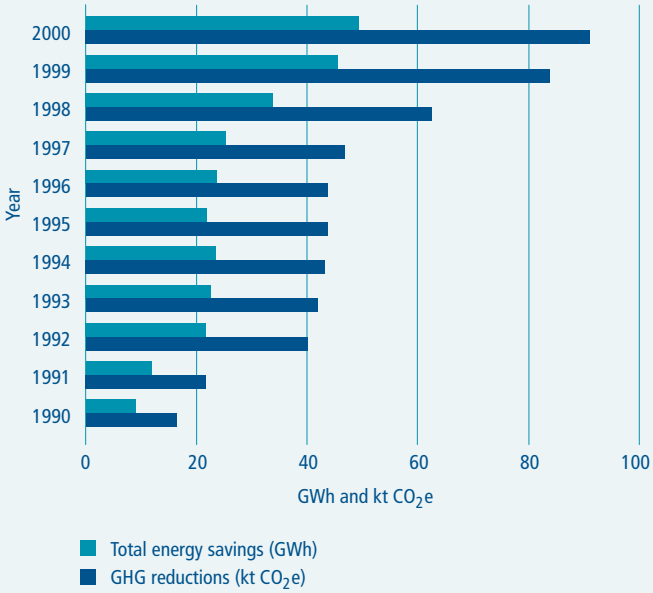


FIGURE 4-14

Impact of EnerGuide Labelling: Total Energy Savings and GHG Emissions Reductions Attributable to EnerGuide for Equipment, 1990 to 2000



Residential Equipment: Housing Energy Technology Program

Objective: To accelerate the development and market adoption of energy-efficient housing technologies.

The program works in partnership with associations, government and industry to develop and deploy highly specialized solutions that help reduce, in a cost-effective manner, the energy consumption and GHG emissions of Canadian houses.

- CETC Advanced Houses Program has led to the identification, accelerated development and broader deployment of a number of promising technologies, i.e. advanced integrated mechanical systems (now trademarked ēKOCOMFORT™) and electronically commutated motors (ECMs).
- CETC development and technical support of the R-2000 Standard has led to extensive technology development and deployment throughout the housing sector. Through its associated Building Energy Simulation Program, CETC's software tools are in use across the country.
- Accelerated development and adoption of low-emissivity coatings, insulated spacers and more energy-efficient frames for windows in new and existing houses. Engineering design tools, such as FRAME/Vision, have become a cornerstone of glazing thermal design and compliance with window energy-rating systems.
- CETC is a lead managing agency for the Canadian Centre for Housing Technology (CCHT), an advanced testing facility for assessing whole-house impacts of emerging technologies. The centre was built, and is managed in partnership with, the National Research Council Canada and Canada Mortgage and Housing Corporation.

Key 2002–2003 Achievements

- The CCHT has enhanced testing capacity to allow greater testing and development of emerging technologies like distributed power, renewable energy technologies and fuel cells. Development and assessment has also assisted advanced integrated mechanical systems, a wastewater heat recovery system, ECMs and Stirling engines.
- A government/industry collaborative research project at the CCHT has quantified the energy and homeowner benefits of ECMs. These motors significantly reduce the electrical consumption costs from running furnace fans on low speed.
- As ēKOCOMFORT™ units now begin to enter the market, the ēKOCOMFORT™ industry consortium is moving to formalize the voluntary performance standard as a full CSA International industry standard.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

Chapter 5: Buildings

Energy Use and Greenhouse Gas Emissions

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

In 2001, the commercial and institutional sector accounted for 13.3 percent (1054 petajoules) of secondary energy use and 13.0 percent (61.7 megatonnes) of greenhouse gas (GHG) emissions.

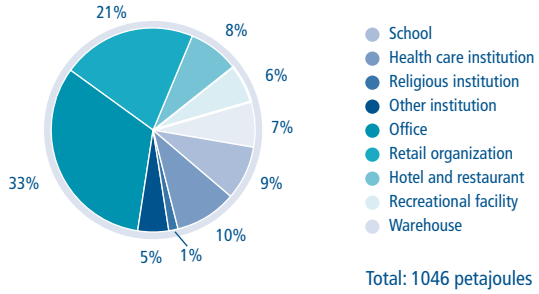
This sector comprises many building types (see Figure 5-1). Retail and office space account for more than half of commercial and institutional sector energy demand. Schools, health care facilities and hotels and restaurants account for another 26.2 percent of that demand. Natural Resources Canada (NRCan) programs address all of these major energy-using building types.

Energy is used for six purposes in commercial and institutional buildings. The largest of these is space heating, which accounts for more than half of this sector's entire energy demand (see Figure 5-2). Each of the remaining five uses of energy in this sector accounts for between 5.0 and 15.0 percent of its energy demand.

Between 1990 and 2001, commercial and institutional energy use increased by 21.5 percent, or 187 petajoules (from 867 to 1054 petajoules). However, GHG emissions from the sector rose by 29.1 percent in the same period. The main factor causing emissions to increase more quickly than energy use was the increased use of energy sources with a higher GHG content.

FIGURE 5-1

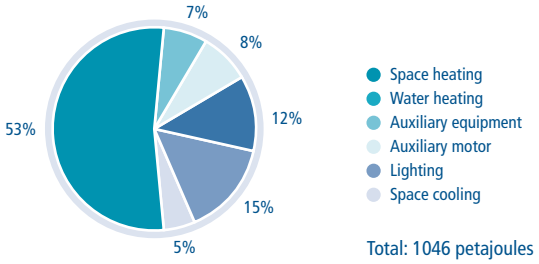
Commercial and Institutional Energy Use by Building Type, 2001



Total: 1046 petajoules

FIGURE 5-2

Commercial and Institutional Energy Use by Purpose, 2001



Total: 1046 petajoules

FIGURE 5-3

Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001

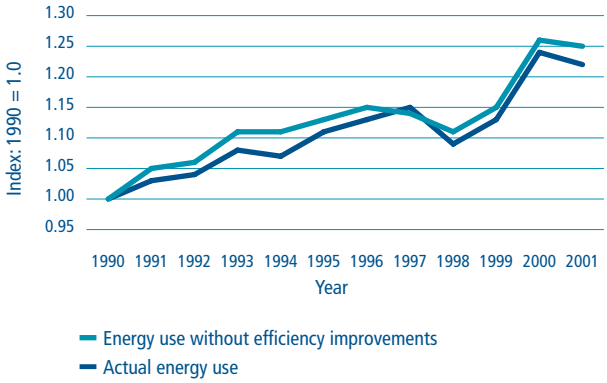
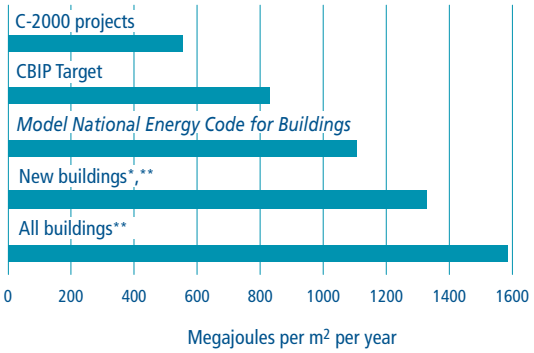


FIGURE 5-4

Energy Use in Commercial Buildings, 1999



* 1990–1999

** Source: Commercial and Institutional Building Energy Use Survey, 2000. Estimates relate only to the surveyed area of populations over 175 000 and in Atlantic Canada populations of over 50 000.

During 1990–2001, activity was the main factor tending to increase energy use; energy efficiency tended to decrease energy use. Structure (the mix of building types) and weather varied by only a minor extent. Specifically, the changes attributed to each of these factors are

- activity – an increase of 219 petajoules in energy use;
- weather – a decrease of 8 petajoules;
- energy efficiency – a decrease of 31 petajoules; and
- structure – an increase of 8 petajoules.

If only activity, weather and structure had been in effect, commercial and institutional energy use would have increased by 25.1 percent (219 petajoules). However, improvements in energy efficiency worked to decrease energy use by 3.6 percent (31 petajoules). As a result, energy use increased by only 21.5 percent. This change in energy use during 1990–2001, as well as the energy savings due to energy efficiency, is shown in Figure 5-3. Figure 5-4 shows how energy use in commercial buildings compares with certain standards.

NRCan delivers initiatives to increase energy efficiency in the following subsectors of the commercial and institutional sector:

- new buildings;
- existing buildings; and
- equipment.

New Buildings: Commercial Building Incentive Program

Objective: To improve the energy efficiency of new commercial, institutional and multi-unit residential buildings.

The Commercial Building Incentive Program (CBIP) provides financial incentives to builders and developers who incorporate energy-efficient features into the design and construction of new commercial, institutional and multi-unit residential buildings. To qualify for the incentive, buildings must be at least 25 percent more energy efficient than similar buildings constructed to the *Model National Energy Code for Buildings* (MNECB).

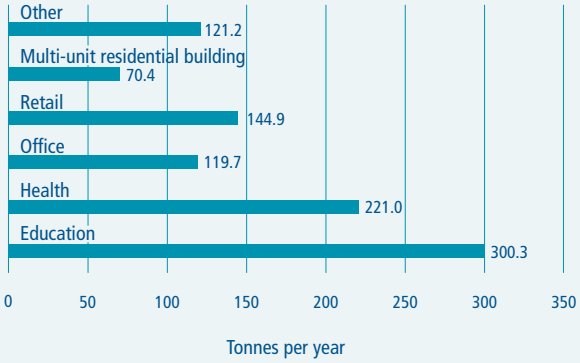
Key 2002–2003 Achievements

- 79 new contributions worth over $3.9 million in total were issued to building owners.
- CBIP buildings average 34.4 percent more energy efficiency than similar buildings constructed to the MNECB.

For more information:
oee.nrcan.gc.ca/newbuildings

FIGURE 5-5

Estimated Average GHG Reductions by Institution Under CBIP, 2002 to 2003



New Buildings: Industrial Building Incentive Program

Objective: To improve the energy efficiency of new industrial buildings.

The Industrial Buildings Incentive Program (IBIP) extends the precepts of CBIP to the industrial sector. IBIP offers an incentive to companies building new energy-efficient industrial facilities, to offset additional design costs inherent in the initial attempts at energy-efficient designs and building/process integration. The design is assessed against a reference generated from the MNECB.

Key 2002–2003 Achievements

- Nine contribution agreements were signed.
- 28 architects and engineers were trained on energy-efficient industrial building design.

For more information:
oee.nrcan.gc.ca/newbuildings

New Buildings: Green Buildings Program

Objective: To reduce energy use, resource consumption and emissions from commercial buildings through design, construction and retrofitting while increasing cost-effectiveness.

The program plays a significant role in establishing goals for energy efficiency and sustainability in commercial buildings through various activities, including C-2000, Green Building Challenge (GBC) and the Integrated Design Process (IDP). The team also provides technical support to NRCan initiatives like CBIP.

- The C-2000 Program has delivered the Mountain Equipment Co-op store in Winnipeg, Manitoba, which was awarded the *2002 Manitoba Sustainable Development Award of Excellence*.
- The CANMET Energy Technology Centre (CETC) launched GBC in 1996, leading more than 20 countries focused on the development and testing of an internationally accepted system for assessing the environmental performance of buildings. GBC is now managed by a third party and continues to grow. GBC process assessments are conducted with GBTool™, an electronic tool developed by NRCan. Results of assessments are then displayed at a series of conferences.
- CETC provides the necessary tools, guidelines and techniques through its IDP to facilitate advanced whole-building energy- and resource-efficient design. IDP leads industry to produce an optimized, integrated building design that fully takes advantage of building component synergies, avoids conflicting operation strategies and provides the owner with on-the-spot cost/benefit analysis for various energy-efficient options.

Key 2002–2003 Achievements

- The first of three phases of the largest, most complex building designed to CETC's C-2000 Program for Advanced Commercial Buildings was successfully completed – the new Red River College (RRC) Princess Street Campus in downtown Winnipeg, Manitoba.
- The Mayo School in Yukon Territory and the RRC Princess Street Campus in Manitoba represented Canada at the 2002 Green Building Challenge in Oslo, Norway, and demonstrated Canada's leadership position in green building.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

Existing Buildings: Energy Innovators Initiative

Objective: To encourage commercial businesses and public institutions to become more energy efficient and reduce their GHG emissions that contribute to climate change.

The Energy Innovators Initiative (EII) helps commercial organizations and public institutions explore energy efficiency options and strategies, offering them access to tools and financial assistance to help reduce energy costs and improve competitiveness. Members join the EII by sending a letter to the Minister of Natural Resources that makes a commitment to energy efficiency.

Key 2002–2003 Achievements

- 59 new projects were signed.
- Over 700 organizations representing about 27 percent of the sector's floor space are Energy Innovators.

TABLE 5-1

Energy Innovators Initiative – Incentive Projects From 2001 to 2003

Federal incentive	$12.7 million
Client investment	$207.2 million
Annual energy savings ($)	$33.5 million
Annual energy savings (gigajoules)	2.8 million

For more information:
oee.nrcan.gc.ca/eii/home.cfm

Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy-performance levels and labelling requirements.

Key 2002–2003 Achievements

- Published sixth amendment to the *Energy Efficiency Regulations* to increase the minimum energy-performance standards for ballasts and room air conditioners and to establish minimum energy-performance standards for dry-type transformers and incandescent reflector lamps.
- The Regulations cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial and institutional sector.

For more information:
oee.nrcan.gc.ca/regulations/home_page.cfm

Equipment: Labelling and Promotion

Objective: To promote the production, purchase and use of more energy-efficient equipment.

The initiative is made up of EnerGuide for Equipment, which provides comparative information on the energy performance of equipment – including heating, ventilating and air conditioning (HVAC) – and the ENERGY STAR® endorsement label, which allows the consumer to identify the most energy-efficient products available based on a standard set of criteria.

Key 2002–2003 Achievements

- Established the ENERGY STAR Initiative in Canada and promoted ENERGY STAR qualified products, office equipment, transformers, lighting and HVAC products used in the commercial and institutional sector.
- Established ENERGY STAR criteria for the Government of Canada and its partners' procurement and incentive programs in the commercial sector.

For more information:
energuide.nrcan.gc.ca/
or
hvac.nrcan.gc.ca/index_e.htm
or
energystar.gc.ca

Equipment: Buildings Program

Objective: To reduce energy consumption, synthetic refrigerant use and GHG emissions in buildings through the use of innovative technologies.

In partnership with stakeholders, the Buildings Program develops, demonstrates and deploys refrigeration technologies in Canadian supermarkets and ice and curling rinks, and intelligent-building technologies in the commercial and institutional sector. These efforts help to decrease energy consumption, synthetic refrigerant use and GHG emissions while maintaining good indoor comfort conditions.

Key 2002–2003 Achievements

- Organized a national workshop on refrigeration systems for supermarkets in March 2003 in Montréal, Quebec, which gathered more than 80 participants from the public and private sectors.
- Provided technical support in a program of prefeasibility studies of advanced refrigeration technologies in Quebec ice rinks, in collaboration with the Association des arénas du Québec inc., the Agence de l'efficacité énergétique du Québec, the Federation of Canadian Municipalities and Gaz Métropolitain.
- Initiated a demonstration project of innovative integrated HVAC and refrigeration technologies in a Loblaw's supermarket in Quebec.
- Organized a national workshop on building recommissioning titled "RECOM Canada 2003" in February 2003 in Ottawa, Ontario, that gathered more than 40 participants from private and public sectors.
- Successfully tested the Diagnostic Agent for Building Operators Fault Detection and Diagnosis module (DABO-FDD), a computerized tool that allows the detection and diagnosis of mechanical system defects in buildings, at CETC – Varennes and Aéroports de Montréal (Dorval). Aéroports de Montréal asked for DABO-FDD installation at the airport's new extension.

For more information:
cetc-varennes.nrcan.gc.ca/en/b_b/bi_ib.html

Equipment: Building Energy Simulation Program

Objective: To contribute to the improvement of design, performance, cost-effectiveness, integration and deployment of energy-efficient building technologies and techniques, through simulation modelling and applications-driven implementation tools for the market.

Through this program, the Simulation Team develops, distributes and supports building simulation software for the Canadian housing and building industry. These software tools are used by architects and engineers to optimize the energy performance of building designs and to demonstrate compliance with such programs as the R-2000 Standard, CBIP and the *Model National Energy Code for Buildings* and the *Model National Energy Code for Houses*. The team is involved in all aspects of the software development process, from design and programming to distribution, maintenance, user training and user support.

- Using CETC software, over 45 000 houses and 800 commercial buildings have been simulated for improved energy efficiency.
- NRCan is first in the world to have a fuel cell model integrated in a building simulation program. This model is an important tool for companies and governments to optimize distributed generation systems for buildings. The team has also initiated an annex of the fuel cell cogeneration task at the International Energy Agency, taking a lead role internationally in the validation of methods for modelling fuel cell cogeneration systems.
- The Simulation Team developed the next generation residential energy analysis software, HOT3000™, which is replacing HOT2000* with a more flexible and expandable core based on the ESP-r program. HOT3000™ can now meet the complex modelling needs of the breadth of energy-saving technologies and strategies entering the market and emerging in industry research and development (R&D). The ESP-r program was created by the University of Strathclyde in Scotland, which remains a collaborator on several simulation projects.

Key 2002–2003 Achievements

- The University Research Network has expanded to include the Canada Mortgage and Housing Corporation as a new partner.
- Building upon the first Canadian conference on building energy simulation (eSim) created by CETC, the network of industry, university and government volunteers organized eSim 2002.
- CETC released the latest version (v.9) of HOT2000, an energy analysis software. HOT2000 is widely used as a compliance tool for R-2000 home builders and EnerGuide for Houses delivery agents and as a general housing energy analysis tool by builders and housing researchers worldwide.
- The commercial building simulation software, EE4, has been customized for use by the Russian government and utilities in delivering conservation programs.
- NRCan developed two Web-based "wizards" that perform accurate building analysis of supermarkets and arenas, virtually and instantaneously, to support design decisions for these types of buildings. The "wizard" tools are part of the EE4 software suite, which is used to detail building data for submissions to CBIP.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_bg_e.html

*HOT2000 is an official mark of Natural Resources Canada.

Community Energy Systems:
Community Energy Systems Program

Objective: To increase the sustainability of Canadian communities by addressing their energy needs.

In partnership with Canadian communities and businesses, energy needs are addressed through a holistic approach to energy efficiency, renewable energy and community energy planning.

NRCan has supported many district energy projects, some of which are based on renewable energy, including those in Charlottetown, Prince Edward Island – biomass and municipal waste fuelled; Fort McPherson, Northwest Territories – cogeneration; Cornwall and Sudbury, Ontario – cogeneration; Windsor and Hamilton, Ontario – cogeneration, heating and cooling; Ajax, Ontario – using waste wood from industry; and Watson Lake, Yukon Territory, and Arviat, Nunavut, and many other northern communities – using waste energy from the local power plants.

NRCan helped design a heating system for the Cree community of Oujé-Bougoumou, in northern Quebec. The system uses sawdust from a local sawmill to provide over 90 percent of the energy, using oil as a backup. Carbon dioxide emissions have been reduced by an estimated 2300 tonnes per year.

NRCan is helping communities to develop Sustainable Community Energy Plans, using tools that are designed to reduce energy demand, emphasize conservation and promote reliance on local renewable energy sources.

Key 2002–2003 Achievements

- Continued to develop a community energy training program and held workshops in Halifax and Port Hawkesbury, Nova Scotia, and Thunder Bay, Ontario.
- Sponsored the Canadian District Energy Association Conference and the Federation of Canadian Municipalities' study tour to Europe.
- Established a microturbine-based R&D facility to test various heat-based cooling technologies. This "tri-generation" (electricity, heat and cooling) will increase the overall energy efficiency of distributed generating systems.
- Publication of two IEA reports: *District Heating and Cooling Connection Handbook* and *Optimization of District Heating Systems by Maximizing Building Heating System Temperature Difference*.
- Established a unique facility to determine the reduction of pressure drop in district energy pipelines and hydronic heating systems due to the application of friction-reducing additives, while simultaneously measuring heat transfer. Friction-reducing additives can reduce the pressure drop (and pumping power) in pipelines by up to 80 percent.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_ces_e.html

Chapter 6: Industry

Energy Use and Greenhouse Gas Emissions

The industrial sector includes forestry, construction and mining as well as all manufacturing. This sector uses energy in industrial processes as a source of motive power, to produce heat or to generate steam. Overall, industrial energy demand accounts for 38.5 percent (3064 petajoules) of secondary energy use and 33.6 percent (159 megatonnes) of greenhouse gas (GHG) emissions (including electricity-related emissions).

Within the industrial sector, energy is consumed primarily in the pulp and paper, other manufacturing, and mining industries. Pulp and paper alone accounted for almost 30 percent of total industrial energy demand in 2001 (see Figure 6-1).

In most industries, energy purchases account for only a small proportion of total expenditures. However, for some relatively energy-intensive industries – cement, chemicals, pulp and paper and aluminum – this share is higher than 13 percent (see Figure 6-2). For cement, in particular, the share is as high as 38 percent.

After decreasing slightly in 1990–1991 as a result of the recession, industrial energy use had increased by about 11.2 percent (309 petajoules) by 2001 (from 2755 petajoules in 1990 to 3064 petajoules in 2001).

Due to data limitations as Statistics Canada converts to a new industrial classification system, the analysis of factors affecting energy use was done using 1995 as the base year. Between 1995 and 2001, industrial energy use increased by 3.0 percent, or 90 petajoules. The main factor that increases industrial energy use is activity:

- activity – a 22.4 percent increase in industrial activity resulted in a 664.6-petajoule increase in energy use; and
- structure – the change in the mix of activity toward less energy-intensive industries (such as electric and electronic) resulted in a 343-petajoule decrease in energy use.

FIGURE 6-1

Industrial Energy Use by Subsector, 2001

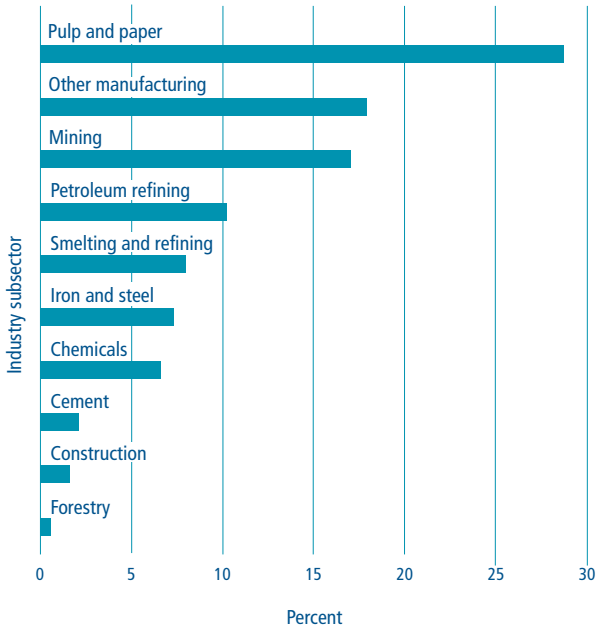


FIGURE 6-2

Cost of Energy to Industry as a Percentage of Total Production Cost, 2001

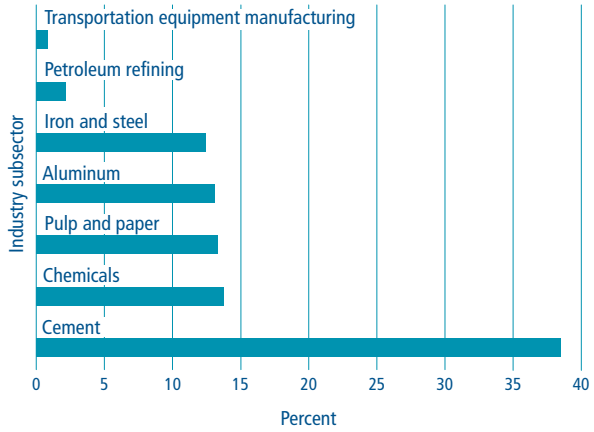
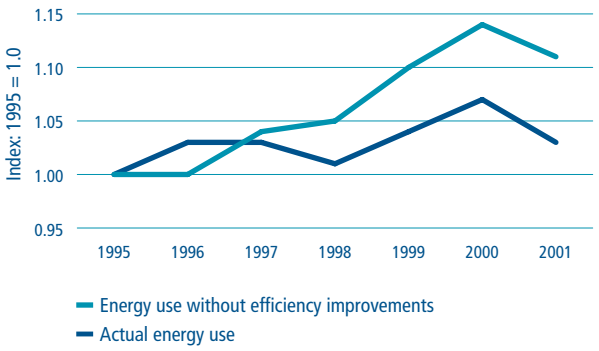


FIGURE 6-3

Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1995 to 2001



Improvements in the energy efficiency of the industrial sector avoided 231.8 petajoules of energy use over 1995–2001. As a result, energy use increased by only 3.0 percent. This change in energy use between 1995 and 2001 and the energy savings due to energy efficiency are shown in Figure 6-3.

Including electricity-related emissions, industrial GHG emissions increased by 10.6 percent. However, excluding electricity-related emissions, industrial GHG emissions over the same period increased by only 0.8 percent.

Natural Resources Canada (NRCan) delivers initiatives to increase energy efficiency in the following subsectors of the industrial sector:

- industrial processes and technologies; and
- equipment.

Industrial Processes and Technologies: Industrial Energy Efficiency

(Canadian Industry Program for Energy Conservation [CIPEC] and Industrial Energy Innovators [IEI])

Objective: To help Canadian industry use energy efficiency investments to improve competitiveness and to contribute to Canada's climate change goals.

CIPEC, a sector-level program, and IEI, a company-level program, both address barriers to planning, implementing, tracking and reporting energy efficiency projects in industry. Key elements include the establishment and tracking of energy efficiency improvement targets and plans, and the development of products and services that overcome barriers to continued energy efficiency improvement. NRCan provides support via employee awareness kits and events, best-practices guides, technical information, energy audits, benchmarking and workshops on energy management.

CIPEC targets all of industry, including mining, manufacturing, construction and forestry as well as upstream oil and gas and electricity generation.

Key 2002–2003 Achievements

- Between 1990 and 2001, the mining, manufacturing and construction sub-sectors achieved an average energy-intensity improvement of 1.8 percent per year and reduced their greenhouse gas (GHG) emissions related to energy use (excluding electricity-related emissions) to 8.4 percent below 1990 levels.
- The total fuel savings for 2001 amounted to $2.8 billion.
- Established three task forces; namely, Upstream Oil and Gas, Construction and Electrical Generation.

For more information:
oee.nrcan.gc.ca/cipec/ieep/

FIGURE 6-4

Industrial Energy Innovators and Action Plans, 1999–2000 to 2002–2003

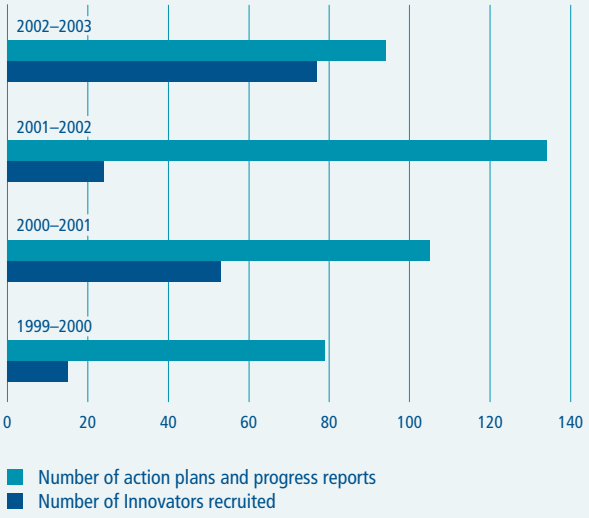


FIGURE 6-5

Mean Five-Year Increases in Energy Consumption, CIPEC Participants vs. Non-Participants

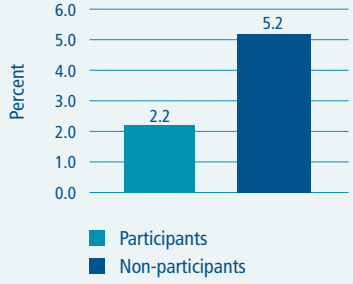
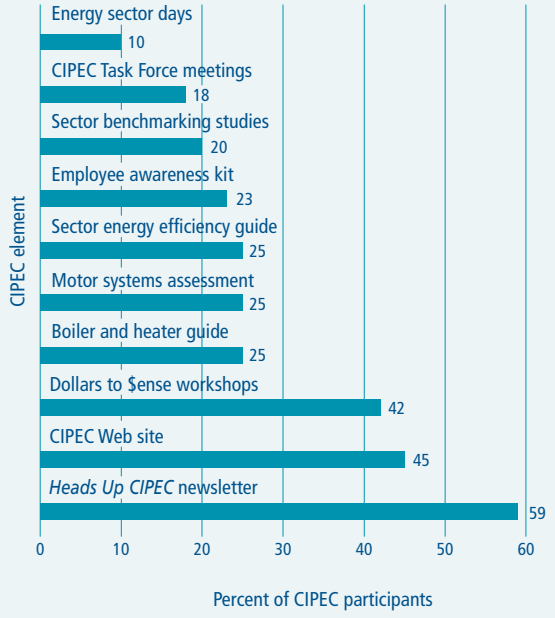


FIGURE 6-6

Level of Participation in Elements of CIPEC



Industrial Processes and Technologies: Advanced Combustion Technologies

Objective: To help industry develop cleaner, more energy-efficient combustion processes, with lower emissions of acid rain precursors, GHGs, particulates and identified priority substances – trace elements and organic compounds.

Research focuses on optimizing the performance of stationary combustion equipment and developing and evaluating new products, fuels and retrofit technologies, using conventional fuels – oil, coal and natural gas – as well as biomass and specialty fuels.

Key 2002–2003 Achievements

- Tested and optimized a Canadian technology to remove SO_2 and NO_x pollutants from the flue gases of coal-fired boilers while producing fertilizer as a byproduct.
- In cooperation with Canadian utilities, boiler manufacturers, the International Energy Agency, air separation equipment manufacturers and the U.S. Department of Energy, Advanced Combustion Technologies designed and implemented experiments and pilot plant tests to investigate burning various coals with oxygen-enriched air as part of an overall integrated emissions abatement approach to capturing/reducing NO_x, SO_x, mercury and GHGs.
- Held the first of three workshops to develop the Clean Coal Technology Roadmap for Canada.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_act_e.html

Industrial Processes and Technologies: Processing and Environmental Catalysis Program

Objective: To solve industrial process problems and undertake research in areas with high potential for significant environmental and economic benefits.

The program's facilities, including semi-pilot scale plants, are used for process testing and the evaluation of novel concepts in chemical and energy conversion, including hydrogen production from hydrocarbon and renewable sources. Clients include oil and gas companies, petrochemical companies, original engine manufacturers, waste oil renderers and specialty ceramic manufacturers.

Key 2002–2003 Achievements

- Development of high-temperature ceramic membranes for hydrogen separation. Target performance was achieved. This is an enabling technology to improve productivity and energy efficiency during hydrogen production and in the petrochemical industry.
- Development of a new generation fuel cell reactor technology that targets improved energy efficiency during synthesis gas production and hydrogen generation, in collaboration with National Research Council Canada and NRCan's CANMET Materials Technology Laboratory.
- Development of a technology for the production of low-sulphur, high-cetane blending stock from waste restaurant grease and vegetable oils. Engine testing of fuels blended with this oil is underway. The Government of Ontario participated in developing applications to soy oil as a feedstock.
- Initiation of a research program on low-temperature hydrogen production from biomass streams.
- Initiation of a research program on carbon-free ammonia fuel cells.
- Patented a technology on the conversion of low-grade waste heat to electricity for increased industrial plant efficiency.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_pec_e.html

Industrial Processes and Technologies: Industrial Process Engineering Program

Objective: To enable industry to continuously improve its energy efficiency and productivity, while decreasing emissions of GHGs and other pollutants.

The program focuses on industrial drying and catalytic flow reversal reactor technology. It seeks to meet its objective by performing leveraged research and development (R&D), introducing novel technologies, performing incremental improvements, performing industrial audits and disseminating technical information.

Key 2002–2003 Achievements

- The team working on the catalytic flow reversal reactor (CH4MIN) received the 2002 Public Service Award of Excellence. The CH4MIN technology will help reduce GHG emissions from coal mines.
- Published an evaluation of wood kiln control practices in Canada.
- With the International Energy Agency, initiated an annex on drying technology. Eight countries, led by Canada, are participating in the annex and working on three topics related to efficient drying.
- Adapted the jet-spouted bed-drying technology for processing food and agri-food products. This energy-efficient technology was developed in collaboration with Manitoba Hydro, to improve the quality of dried products in food processing plants.

For more information:
cetc-varennes.nrcan.gc.ca/en/indus.html

Industrial Processes and Technologies: Industrial Process Integration Program

Objective: To support the development and adoption of process integration in various industries.

The program focuses on methodologies for combined heat-and-power optimization, total-site optimization, batch-processes optimization and water-pinch optimization in the agri-food, pulp and paper and textile industries, and on the building of international-calibre Canadian capacity in process integration.

Key 2002–2003 Achievements

- Developed and hosted a two-day course on optimizing industrial cogeneration and managing site utility systems aimed at industry, utility providers, consultants and government representatives.
- Completed a process integration study at the Norampac Inc. paperboard mill in Red Rock, Ontario. Reduction of annual production costs by $3.6 million, with a payback period of less than 12 months, and GHG emissions reduction of about 25 000 tonnes per year.
- Started process integration studies in the Rolland Paper Mill in Saint-Jérôme, Quebec, and the Kruger Newsprint Mill in Bromptonville, Quebec.
- In collaboration with NRCan's Office of Energy Efficiency, completed a pan-Canadian consultation to identify the following: the importance of energy efficiency in Canadian industries; the role that process integration might play in Canadian companies; and the activities for the Government of Canada to prioritize to better meet the needs of companies.
- Developed a program aimed at promoting the knowledge and application of process integration techniques in Canadian industry.

For more information:
cetc-varennes.nrcan.gc.ca//en/indus.html

Industrial Processes and Technologies:
Industry Energy Research and Development (IERD) Program

Objective: To encourage and support the development and application of leading-edge, energy-efficient and environmentally responsible processes, products, systems and equipment in industry.

Financial support is provided for commercially confidential applied R&D activities, which is repayable if the project is commercially successful. Program clients from all industrial sectors range from small- and medium-sized companies to multinational corporations.

Key 2002–2003 Achievements

- Turbocor Inc. of Montréal, Quebec, has developed an oil-less, non-chlorofluorocarbon compressor for refrigeration applications. This represents a breakthrough in industrial and commercial refrigeration and is generating energy savings of 30 percent. Turbocor won a Canada's Energy Efficiency Award in early 2003.
- Société des technologies de l'aluminium du Saguenay (STAS) in Chicoutimi, Quebec, is developing, in partnership with Lauralco in Deschambault, Quebec, an automated anode replacement and positioning system. This system will increase energy efficiency of the aluminium smelting process and reduce GHG emissions.
- Sorentec, in Québec, Quebec, is a new company specializing in cooling technology. It has developed new equipment for the rapid cooling of processed foods. The energy savings with the newly available commercial kitchen blast chillers is about 40 percent compared with conventional technologies.
- Airborne Pollution Control Inc. of Calgary, Alberta, is developing an energy-efficient sodium-based flue gas cleaning system for coal-powered generating plants. The project will demonstrate that coal with higher than desirable sulphur level can be used. The resulting flue gas can then be cleaned in a manner to eliminate SO_x as well as reduce NO_x and particulate emissions. Products recuperated from the gas cleaning are further processed and transformed into chemical fertilizers.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/factsheet_industry_energy_research_and_development_program_e.html

Industrial Processes and Technologies:
Emerging Technologies Program (ETP)

Objective: To support the identification and demonstration of new and emerging energy-efficient technologies.

Projects are co-managed and cost-shared with industry and other stakeholders, such as gas and electric utilities, other governments and equipment manufacturers. Financial support is provided for the development and testing of pilot plants, prototypes and full-scale field trials to evaluate operating performance, energy efficiency and environmental impacts. NRCan's financial support is repayable from any cost savings or revenues realized from a project.

Since 1991, ETP and its forerunner, the Industrial Targeted Program, have contributed $19 million to 105 projects worth $143 million, mostly within the industrial sector.

Key 2002–2003 Achievements

- Ontario Power Generation concluded a study and pilot installation of Fuel Lean Gas Reburn™ technology applied to the 4000-megawatt coal-fired power plant at Nanticoke, Ontario. The project was co-financed by NRCan and Union Gas Limited and involved innovative computer simulation prior to pilot installation. Testing and modelling work concluded that with a 7 percent injection of natural gas, NO_x reductions of 30–35 percent are achievable.
- NRCan is supporting Ishmail Seating Components Inc. of Mississauga, Ontario, in its development of a production-scale process that recycles polymer waste material into moulded seating components. Pressure

on landfill sites will be alleviated and substantial energy reduction will be achieved by bypassing the conventional waste-reclamation process. Energy will also be saved by eliminating the production of plywood seating components.

- NRCan supported Sustainable Energy Technologies Ltd. of Calgary, Alberta, to complete the development and demonstration of a power inverter and DC converter for grid interactive solar photovoltaic applications and other renewable and alternative energy technologies.
- NAVA Composites Inc. of Vancouver, British Columbia, completed sea trials on a 38-foot (11.6-metre) prototype sport and/or fishing boat with support from NRCan. The substantially lighter weight of hull and key components, minimized hull resistance and improved thrust efficiency provide up to 40 percent fuel savings.
- NRCan supported Vehicle Projects LLC, in Denver, Colorado, in its Phase 1 Prototype and Preliminary Work of developing and testing the world's first fuel-cell-powered mine loader. This project involves 10 international partners and is funded by government (the U.S. Department of Energy and NRCan) and the private sector.
- Westport Research Inc. of Vancouver, British Columbia, with NRCan support, has delivered and installed a natural gas engine for stationary power generation to Grande Prairie, Alberta. A one-year field trial of a low-emissions (17.8 percent less carbon dioxide) natural gas engine for stationary power generation utilizing the Westport high-pressure direct injection technology is underway at the water/wastewater treatment facility in Grande Prairie.
- Participation with several leading Canadian utilities in the Canadian Clean Power Coalition to study, develop and demonstrate clean coal technology for power generation.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/funding_programs_etp_e.html

Industrial Processes and Technologies: Energy Technologies for High-Temperature Processes (EHTP)

Objective: To investigate technologies and develop knowledge to ensure the sustainability of Canada's coal, carbon and metallurgical industries.

EHTP has expertise in carbonization, combustion, agglomeration, thermal rheology, petrography and environmental and carbon science technologies to address energy efficiency, GHG reduction and related needs of industry. Key areas include alternative iron-making technology, fuel products, iron and steel process efficiency, standardization and analysis of emissions.

Key 2002–2003 Achievements

- EHTP experimentally evaluated the suitability of blending Canadian and Indian coals to make high-quality coke for the Steel Authority of India Limited (SAIL). The experimental work shows that models developed earlier at the CANMET Energy Technology Centre accurately predict the quality of coke made from blends of coals from Canada, India and Australia. The results of this work were presented to the SAIL representative in New Delhi on December 12, 2002. As a result of this presentation, SAIL has removed technical specifications that prevented Canada from selling coking coal to India.
- The quality of cokes from three Canadian coke plants has been evaluated by EHTP and compared with coke quality from best practices. As a result, Dofasco Inc. has set targets for improved coke quality to improve energy efficiency and achieve GHG reduction targets.
- EHTP has begun new research studies with the Canadian metallurgical coal industry with the aim of developing more competitive, more energy-efficient and better metallurgical coal products by blending coals from different Canadian mining properties before exporting the coals.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_ehtp_e.html

Industrial Processes and Technologies: Minerals and Metals Program

Objective: To reduce GHG emissions from four targeted areas in the Minerals and Metals Sector by a proposed 1.65 million tonnes per year over five years (2001–2002 to 2005–2006).

The Minerals and Metals Program under the *Government of Canada Action Plan 2000 on Climate Change* is part of the $500-million federal initiative over five years in support of Canada's *National Implementation Strategy on Climate Change* and *Canada's First National Climate Change Business Plan*. The Program is implemented by the CANMET Mining and Mineral Sciences Laboratories and allocates $10 million to four initiatives: (1) Supplementary Cementing Materials ($1.1 million); (2) Concrete for Roads ($3.5 million); (3) Studies/Monitoring for GHG Reduction ($2 million); and (4) Enhanced Recycling Technologies ($3.4 million). These four elements are overseen by a steering committee with representatives from NRCan (chair), Environment Canada and Industry Canada. Each of these four areas has a separate advisory committee consisting of experts in the field and representatives of interested industry and government groups.

Key 2002–2003 Achievements

- The goal of the Enhanced Recycling Program is to increase the recycling of aluminum by 100 000 tonnes per year (t/yr) by 2010 and the recycling of steel by 200 000 t/yr by 2010, yielding total GHG reductions in carbon dioxide equivalent (CO_2e) of 700 000 t/yr. The Enhanced Recycling Program has raised awareness of recycling, both actual and potential, among a broad group of stakeholders across Canada, especially at the municipal and regional level.
- Work to date under the Studies/Monitoring measure has identified areas of significant potential reductions in GHG emissions: (a) replacement of diesel power by fuel cells in mining, with estimated savings of up to 1 million t/yr; (b) alternatives to SF_6, a powerful GHG used in magnesium production, with associated savings of up to 1 million t/yr CO_2e; (c) cogeneration of electricity from off gases (e.g. steel production); and (d) replacing lime in mine effluent treatment with cement kiln dust, with approximate reductions of 0.2 million t/yr. In the long term, inert anodes in aluminum production could save an additional 10 million t/yr.
- A baseline study on the current use of Supplementary Cementing Materials (SCMs) has been completed. SCMs are used in concrete production to replace Portland cement. Each tonne of Portland cement replaced saves about one tonne of CO_2.
- Recent work on behalf of the Cement Association of Canada indicates that vehicles, especially heavy trucks, use 15 percent less fuel on a rigid concrete surface compared with a flexible asphalt surface. Studies suggest that replacing highways on the National Highway System with a concrete surface would reduce CO_2 emissions by 0.9 million t/yr. Action Plan 2000's Concrete Roads Program has undertaken a validation study to verify and expand on this historical data, in cooperation with National Research Council Canada.

For more information on SCMs:
www.ecosmart.ca

Equipment: Energy Efficiency Standards and Regulations

Objective: To eliminate the less energy-efficient models of energy-using equipment from the market through minimum performance regulations under the *Energy Efficiency Act*.

The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or interprovincial trade in, prescribed products that fail to meet minimum energy performance levels and labelling requirements.

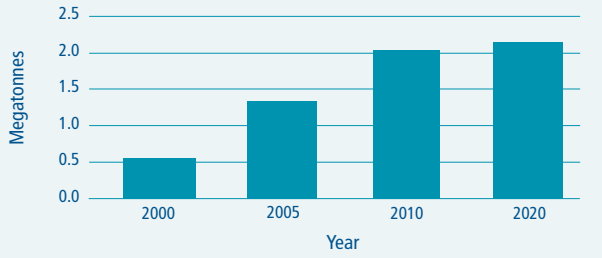
Key 2002–2003 Achievements

- Published sixth amendment to Canada's *Energy Efficiency Regulations* to increase the minimum energy performance standards for ballasts and room air conditioners and to establish minimum energy performance standards for dry-type transformers and incandescent reflector lamps often used in the industrial sector.

For more information:
oee.nrcan.gc.ca/regulations/home_page.cfm

FIGURE 6-7

Estimated Reduction in CO_2 Emissions From Motor Regulations, 2000 to 2020



Equipment: Labelling and Promotion

Objective: To promote the production, purchase and use of more energy-efficient equipment.

The initiative is made up of EnerGuide for Equipment, which provides comparative information on the energy performance of equipment – including heating, ventilating and air conditioning (HVAC) – and the ENERGY STAR® endorsement label, which allows industrial purchasers to identify the most energy-efficient products available based on a standard set of criteria.

Key 2002–2003 Achievements

- Initiated the development and promotion of Internet-based decision-making tools for industrial purchasers of electric motors and other energy-using equipment.

For more information:
energuide.nrcan.gc.ca/
or
hvac.nrcan.gc.ca/index_e.htm
or
energystar.gc.ca

Equipment: Mine Ventilation

Objective: To reduce energy consumption associated with mine ventilation by using the concept of "ventilation on demand," ventilation infrastructure automation and ventilation network optimization and management.

Providing ventilation to dilute and remove pollutants at a suitable working temperature accounts for about 40 percent of the energy consumed underground by a mining operation. This energy is consumed either as electricity by the primary and auxiliary fans or air conditioning (cooling) systems or from fossil fuels for heating sub-zero winter air. Historically, mine ventilation systems were designed to run at maximum flow 24 hours a day and seven days a week year-round due to a lack of control flexibility. This is gradually changing. Furthermore, within the energy consumption are linear-through-to-cubic relationships between a given airflow reduction and the power savings that ensue. This makes ventilation management a worthwhile endeavour economically and environmentally. Today, however, the benefits have to be determined on a case-by-case basis due to the numerous qualifiers involved. For the future, NRCan is looking to improve this evaluation process through the use of "production simulators."

Key 2002–2003 Achievements

- Feasibility study of using "ventilation on demand" within INCO Limited's Creighton Mine's deep ore zone to minimize ventilation costs and avoid the need for mechanical refrigeration.
- NRCan scientist has begun Ph.D. studies at the University of British Columbia in collaboration with an industrial partner. The thesis deals with linking mine-ventilation delivery and modelling with computerized mine-production simulation models to reduce ventilation costs.

For more information:
nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mines/air/air-e.htm

Chapter 7: Transportation

Energy Use and Greenhouse Gas Emissions

The transportation sector consists of three subsectors: passenger, freight and off-road. Passenger and freight transportation accounted for 57.8 percent and 38.5 percent, respectively, of transportation energy use, with off-road representing only 3.6 percent in 2001. The passenger subsector is composed of three modes: road, rail and air. The freight subsector, as defined by Natural Resources Canada (NRCan), comprises road, rail and marine. Road transport uses the most energy, accounting for 77.8 percent of total transportation energy use in 2001. Of this amount, 61.8 percent was passenger energy use and 38.2 percent was freight energy use (see Figure 7-1). All NRCan transportation energy-use programs focus on the energy used in road transportation.

Transportation energy use increased by 21.3 percent (399 petajoules) over 1990 to 2001 (see Figure 7-2). Passenger transportation energy use increased by 8.9 percent (108 petajoules), while freight transportation energy use increased by 42.5 percent (262 petajoules). Two main factors were responsible for this increase – activity and structure:

- activity – due to increases in population and economic activity, there was greater transportation activity (measured as passenger-kilometres for passenger transportation and tonne-kilometres for freight transportation). This increased transportation energy use by 19.3 percent (344 petajoules). The freight and passenger segments contributed to this increase by 71.3 percent and 28.7 percent, respectively; and
- structure – shifts between modes of transport were significant in passenger (where there has been a sharp increase in the stock of light trucks) and freight (where freight trucks are growing significantly faster than rail and marine) segments, resulting in an increase of 12.1percent in transportation energy use (215 petajoules).

FIGURE 7-1

Transportation Energy Use by Mode, 2001

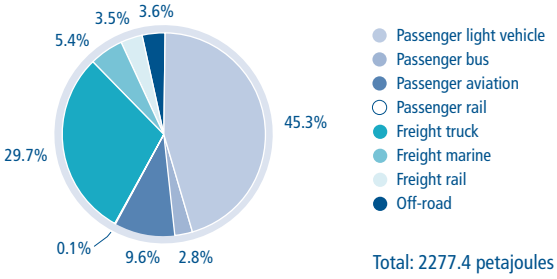


FIGURE 7-2

Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001

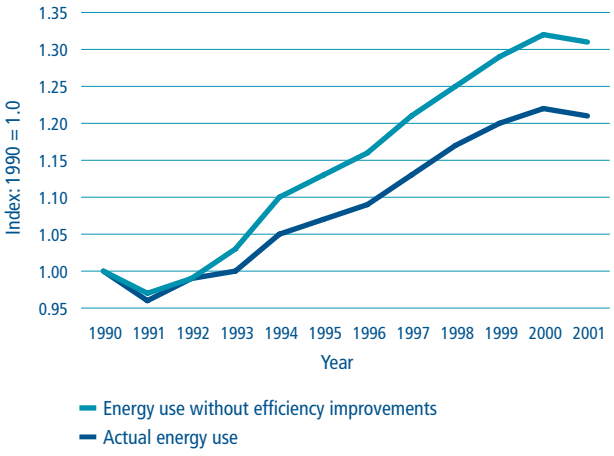


FIGURE 7-3

Market Shares of New Passenger Car and Light Truck Sales, 1990 to 2001

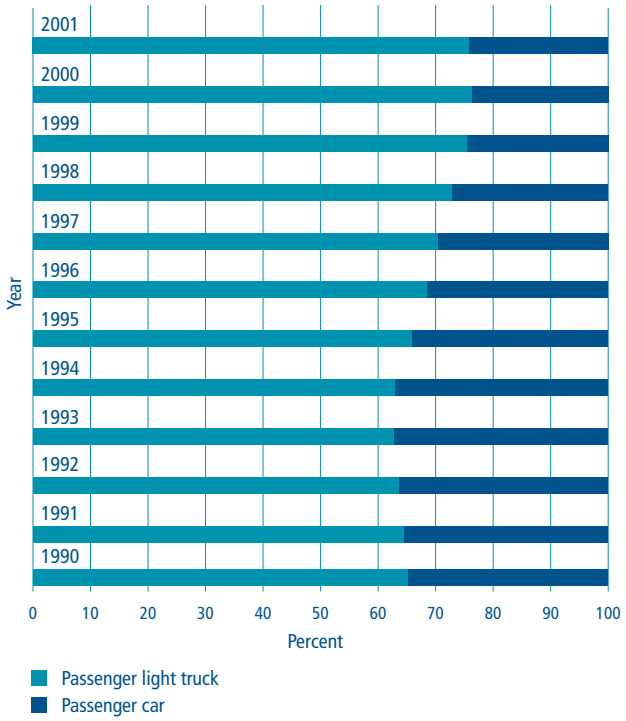
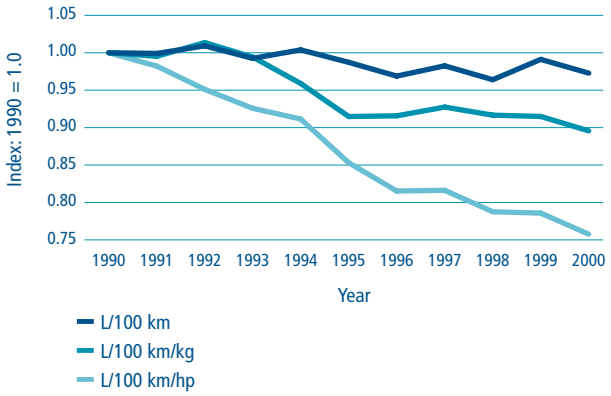


FIGURE 7-4

New-Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 2000



If only activity and structure had changed, transportation energy use would have increased by 31.3 percent (559 petajoules). However, improvements in energy efficiency worked to decrease energy use by 10.2 percent (181 petajoules). As a result, energy use increased by only 21.3 percent. This change in energy use between 1990 and 2001, as well as the energy savings due to energy efficiency, is shown in Figure 7-2.

The transportation sector accounts for 28.6 percent (2277 petajoules) of secondary energy use and 34.4 percent (163 megatonnes) of greenhouse gas (GHG) emissions. From 1990 to 2001, transportation energy use increased by 21.3 percent, and GHG emissions increased by 20.7 percent. The change in GHG intensity of transportation energy use was negligible.

Figure 7-3 shows how the market share of new light trucks has increased over the period, reflecting the growth in popularity of sport-utility vehicles (SUVs) and minivans. However, the market shares seem to have stabilized in the past two years. Figure 7-4 demonstrates that on a per-kilogram or per-unit-of-horsepower basis, fuel efficiency has improved markedly. However, average fuel economy has been stable because new vehicles continue to get heavier and sport more powerful engines.

NRCan delivers initiatives in the following areas to increase the efficiency of motor vehicles and encourage the use of alternative fuels:

- personal vehicles;
- fleet vehicles;
- transportation research and development (R&D);
- alternative transportation fuels; and
- transportation technologies.

Vehicles: Vehicle Efficiency

Objective: To improve the fuel efficiency of new motor vehicles.

This initiative, Vehicle Efficiency, is intended to bring about a 25 percent improvement in the fuel efficiency of new light-duty vehicles sold in Canada by 2010. NRCan is leading negotiations with the automotive industry and the United States to reach agreement on a voluntary fuel efficiency target for new vehicles. The initiative is seeking improvements in fuel efficiency starting as early as 2004. GHG reductions of about 5.2 megatonnes in 2010 are also being sought.

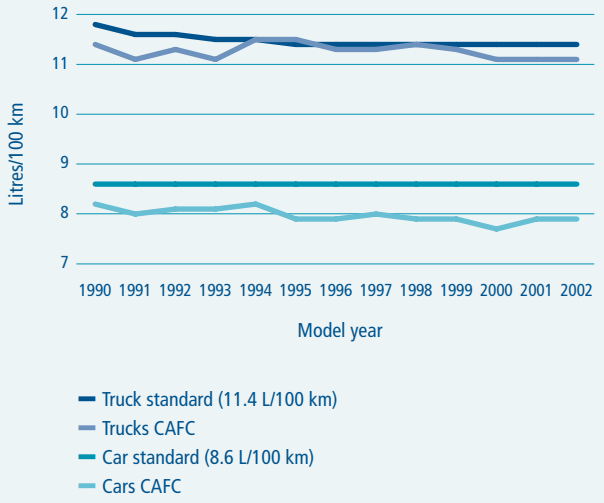
Key 2002–2003 Achievements

- A joint study by NRCan and the U.S. Department of Energy was published, entitled *Examining the Potential for Voluntary Fuel Economy Standards in the United States and Canada*. Presentations have been given at conferences and workshops on the findings of the study.

For more information:
oee.nrcan.gc.ca/english/programs/motorvehicles.cfm

FIGURE 7-5

Company Average Fuel Consumption (CAFC) vs. Canadian Voluntary Standards



Vehicles: Personal Vehicles

Objective: To improve motor vehicle fuel efficiency by encouraging private motorists to develop energy-efficient vehicle purchase, use and maintenance practices.

Personal Vehicles promotes awareness among Canadian motorists on the importance of improving vehicle fuel efficiency to reduce vehicle emissions and mitigate other vehicle-related environmental impacts. The initiative helps motorists understand how their automobile purchases and driving and maintenance habits affect climate change and the environment. It does this through various kits, guides, information dissemination and educational activities and strategic alliances with the public and private sectors.

Key components include the EnerGuide fuel-consumption label for vehicles and the annual *Fuel Consumption Guide*, which provide fuel consumption data for new light-duty vehicles; the Idle-Free Campaign, which seeks to curb vehicle idling; and the Auto$mart Student Driving Kit, which helps driver instructors teach fuel-efficient driving to novice drivers. Recently the initiative started the development of a national public awareness and education campaign, in collaboration with the tire manufacturing industry, to encourage Canadian motorists to adopt good tire maintenance and inflation practices.

Key 2002–2003 Achievements

- 150 new driver instructors were recruited this year and are now using the Auto$mart Student Driving Kit. More than 800 000 novice drivers have been exposed to fuel-efficient driving training to date.
- The Idle-Free Awareness Campaign was successfully implemented in two cities and is currently being extended to eight others.
- NRCan signed an agreement with the Rubber Association of Canada (representing tire manufacturers) to develop and deliver a national public awareness and education campaign on tire maintenance and inflation. Transport Canada and Environment Canada have also joined the campaign.

For more information: oee.nrcan.gc.ca/vehicles/

FIGURE 7-6

Vehicle Fuel Efficiency Awareness

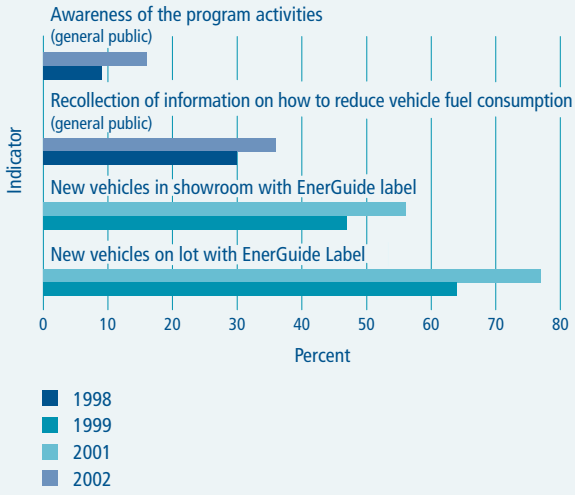


FIGURE 7-7

Number of New Drivers Educated Using the Auto$mart Student Driving Kit

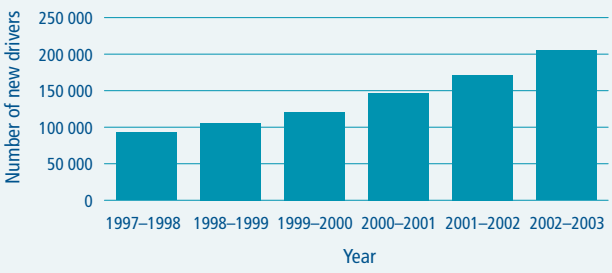
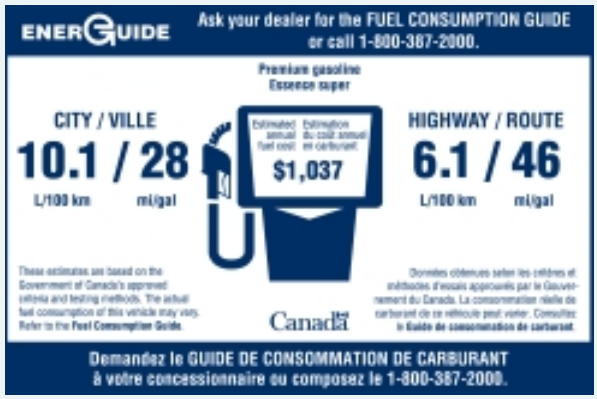


FIGURE 7-8

EnerGuide Label for New Vehicles



Vehicles: Fleet Vehicles

Objective: To improve the fuel efficiency and reduce the GHG emissions in commercial road transportation fleet operations and all other non-Government of Canada vehicle fleets.

Fleet Vehicles provides information materials, workshops, technical demonstrations, driver training programs and special projects, such as the Truck Stop Idle-Free/Quiet Zone Campaign, to help fleet operators assess and pursue opportunities to increase energy efficiency in their operations. NRCan delivers the initiative in partnership with fleet and industry associations and other levels of government.

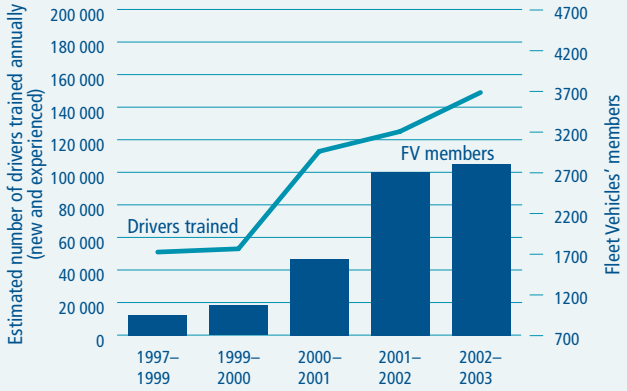
Key 2002–2003 Achievements

- The SmartDriver Initiative trained more than 149 000 new and experienced drivers and introduced over 1000 new instructors to the Fleet Vehicles initiative.
- To date, the Fleet Vehicles initiative has registered over 2800 members, representing more than 409 000 commercial vehicles.
- SmartDriver for Forestry Trucks was developed and launched in partnership with the Forest Engineering Research Institute of Canada.
- The Truck Stop Idle-Free/Quiet Zone Campaign was successfully piloted, with 14 truck stops participating nation-wide.

For more information:
fleetsmart.nrcan.gc.ca/

FIGURE 7-9

Drivers Trained and Participation in the Fleet Vehicles Initiative



Transportation Research and Development: Canadian Lightweight Materials Research Initiative (CliMRI)

Objective: To develop low-density, high-strength, lightweight materials to achieve weight reductions in ground transportation vehicles.

Outcomes of this government-industry-university research initiative are two-fold: reducing GHG emissions through improved vehicle efficiency and improving the competitive performance of Canadian companies and associated part suppliers in the primary metals, automotive, truck, bus and rail-car manufacturing industries. CLiMRI also funds projects that focus on the manufacturing processes of the materials.

Key 2002–2003 Achievements

- CANMET Materials Technology Laboratory (CANMET-MTL) developed a pilot-scale process for seam-welding aluminum tubes. These tubes are used in hydroforming, a metal-shaping process used in the automotive industry. This advancement in tube hydroforming broadens the applicability of this manufacturing process, leading to greater use of lightweight metals in vehicles. Six papers, two reports and seven presentations were made in this area.
- CANMET-MTL optimized the heat treatment process for alloy A356, commonly used in the automotive industry. In addition to improving the mechanical properties, this process minimizes GHG emissions and reduces energy consumption by one third. Two foundries have already adopted the shorter heat-treatment cycle in their production.
- In the creation of cast automotive parts, "test bars" are poured for quality control. CANMET-MTL has developed a new test-bar mould that can better identify mechanical properties in the actual casting, enabling foundries to consistently produce premium-quality castings and reduce scrap.
- CANMET-MTL also developed CANMET Property Predictive Software, based on an artificial intelligence model that can predict mechanical properties of automotive aluminum alloys derived from chemistry, heat treatment and casting variables.

For more information:
climri.nrcan.gc.ca/default_e.htm

Transportation Research and Development: Fuel-Cell-Powered Mining Vehicles

Objective: To develop the technology to replace diesel power by hydrogen fuel cell power in underground mining vehicles.

NRCan has taken a leadership role in this North American consortium. If this initiative is successful, Canada stands poised to capture world markets for applied fuel cell technology in mining – a clear example of the link between innovation and economic growth.

The application of fuel cell technology to underground mining by retrofitting diesel-powered vehicles would provide several benefits. These include eliminating underground diesel emissions and reducing heat and noise, thus improving the work environment for underground miners; reducing a significant portion of carbon dioxide emissions (1 million tonnes per year), thus giving the mining industry an opportunity to contribute to Kyoto Protocol emissions targets; and decreasing operating costs by lowering mine ventilation needs by more than 35 percent (ventilation is responsible for 40 percent of the electrical consumption in an underground mine) and by significantly improving vehicle productivity (hydrogen-fuel-cell power systems are twice as efficient in delivering power as conventional diesel equipment).

The prototype locomotive propelled with hydrogen fuel cells, the only example of its kind, has been undergoing surface testing by NRCan since the beginning of 2002, most recently at its experimental mine in Val-d'Or, Quebec. NRCan also provided the expertise of scientists and engineers who integrated the fuel cell with the locomotive and its control systems and conducted surface testing. The locomotive is now at the Experimental Mine at Val-d'Or undergoing long-term reliability testing of the fuel cell. It is expected that many different types of vehicles, including underground diesel loaders – the mainstay of metal mine production – will eventually use this technology, and pilot projects are now underway in Canada, the United States and other countries.

Key 2002–2003 Achievements

- The fuel cell locomotive was subjected to various refuelling tests in order to quantify the power-consumption curve for mine locomotive power plants and the hydrogen consumption rate, cost and electrolysis plant refuelling aspects.
- Mine regulatory issues have been addressed to have fuel cells in operation in underground Canadian mines.
- A ground-breaking Canadian mine cost-benefit study was carried out to quantify operational cost savings of using fuel cell mine vehicles versus diesel mine vehicles (significant electrical consumption and operating cost reductions are possible) as well as capital costs (ventilation equipment savings are possible, but initial fuel cell costs are still high).
- The fuel cell underground mine loader (main production vehicle) project has been initiated and partners assembled. Initial design issues for the fuel cell mine loader have been addressed.
- A series of reports were issued on the following projects: suitability of fuel cells for underground use, locomotive power plant design, locomotive performance, locomotive refuelling, mine vehicles duty cycles and fuel cell power plant requirements (a cost-benefit study). The technology transfer has been made through a special session of the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) 2003 Annual General Meeting.
- Initial discussions held to commercialize Canadian-built underground locomotives with Canadian fuel cell technology for the international road-tunnelling excavation market.

For more information:
www.nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mines/mines-e.htm

Alternative Transportation Fuels: Vehicle Fuels

a) Future Fuels Initiative (National Biomass Ethanol Program)

Objective: To increase Canada's fuel ethanol production and use in the transportation sector.

This initiative aims to increase the supply and use of fuel ethanol produced from biomass such as plant fibre and corn, wheat and other grains. The major component of the Initiative is the renewal of the National Biomass Ethanol Program, a contingent loan guarantee program intended to reduce the financial risk of new plant construction. Other activities include public education, economic and market analyses, research of standards and harmonization of policies where possible.

Key 2002–2003 Achievements

- Several plant proposals have advanced over the course of the year.
- Two provinces announced plans to introduce legislation to require ethanol in their gasoline.
- The Council of Energy Ministers Working Group on Ethanol and Biofuels has facilitated joint federal, provincial and territorial information sharing, research and public awareness.

For more information:
oee.nrcan.gc.ca/vehiclefuels

b) Canadian Transportation Fuel Cell Alliance

Objective: To evaluate different fuelling options for fuel cell vehicles, develop the supporting framework for the fuelling infrastructure and demonstrate their GHG emissions reductions.

The Canadian Transportation Fuel Cell Alliance (CTFCA) is a private-public sector partnership initiative made up of technology developers, fuel providers, auto manufacturers, federal and provincial government officials, academia and non-governmental organization representatives. The CTFCA demonstrates and assesses the technical feasibility and the economic and emissions implications of hydrogen refuelling options for fuel cell vehicles. The initiative will also develop a supporting framework for hydrogen refuelling through standards, codes, certification and training.

Key 2002–2003 Achievements

- Two demonstration projects were funded under this initiative. These include supporting the development of a hydrogen refuelling apparatus for a natural-gas reformer and demonstrating an electrolysis technology for a mobile hydrogen-fuelling station.
- Studies were completed on fuel pathways and GHGs, with six pathways analyzed.

For more information:
nrcan.gc.ca/es/etb/ctfca/index_e.html

c) Natural Gas Vehicles Initiative

Objective: To promote the development and use of natural gas vehicles in Canada.

The Natural Gas Vehicles Initiative targets the natural gas industry in regions of Canada serviced by Alberta natural gas. The Initiative provides financial contributions for each factory-built natural gas vehicle, for dealers to sell new factory-built natural gas vehicles and for road vehicles converted to use natural gas. The Initiative also funds marketing and awareness activities and co-funds R&D.

Key 2002–2003 Achievements

- 23 new qualified units were sold and 17 units converted.
- One new site for natural gas fuelling was opened.

For more information:
oee.nrcan.gc.ca/vehiclefuels

Transportation Technologies:
Transportation Energy Technologies Program

Objective: In partnership with industry, to develop and deploy leading-edge transportation technologies that minimize environmental impacts, increase the potential for job and economic growth and extend the lifespan of Canada's energy resource base.

Program staff work with stakeholders in the domestic and international transportation industries, including original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial and territorial governments, research organizations, universities, other federal departments, the U.S. Department of Energy and the International Energy Agency.

- Over the last 15 years, work in partnership with Canada's fuel cell industry has established Canada as a world leader in fuel cell and refuelling technologies; for example, the world's first hydrogen fuel cell bus was demonstrated in Canada.
- Since the 1980s, the program has supported student vehicle challenges, bringing university and college students from across North America together with automotive manufacturers to modify existing vehicles to run a variety of alternative fuels.
- The program has supported the development of alternative transportation fuel technologies, for example, for natural gas and propane vehicles, which has led to a Canadian industry that is now exporting commercial products.

Key 2002–2003 Achievements

- Organization and sponsorship of world-class conferences, including the 2002 World Hydrogen Energy Conference in Montréal, Quebec; the Canadian Electric Vehicle Conference; and the 2002 Windsor Workshop on Transportation Technology.
- Initiation of a project with Hydrogenics Corporation to develop a hybrid fuel cell bus that incorporates ultra-capacitors.
- The first public E-85 fuelling station in Canada was opened in Ottawa, Ontario, to dispense a mix of 85 percent ethanol and 15 percent gasoline for automobiles.
- Signing of an agreement with Dynetek Industries Ltd. of Calgary, Alberta, to develop lightweight hydrogen-storage cylinders at 700-bar (10 000-psi) pressure.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/programs_tet_e.html

Chapter 8: Renewable Energy

Introduction

Renewable energy sources are those that produce electricity or thermal energy without depleting resources. Renewable energy includes solar, wind, water, earth and bioenergy, including energy from waste.

Natural Resources Canada (NRCan) delivers several initiatives to encourage the development and use of emerging renewable energy sources and technologies. However, these initiatives do not apply to the following renewable energy resources:

- large-scale hydro-electricity, a well-established renewable energy source; and
- ethanol fuel production from agricultural feedstocks, which is covered under Agriculture and Agri-Food Canada programs.

Each renewable energy source depends on one or more energy production technologies, with their own level of economic attractiveness. Some technologies are mature and well recognized (e.g. hydro-electricity), others are emerging in the marketplace, and many are in the laboratory stage but offer promise for the long term. Renewable energy sources compete in many markets, including those for electricity, mechanical power, thermal energy (process heat, space heating and cooling and water heating and cooling) and transportation fuels (see Table 8-1).

Renewable Energy Use

In 2000, renewable energy generation capacity from renewable sources accounted for 62 percent of total Canadian electricity capacity (see Table 8-2). Most of the renewable energy used in Canada comes from either hydro-electricity or thermal energy from biomass such as wood-waste sources.

TABLE 8-1

Renewable Energy Markets and Technologies Used in Canada

Electricity	*Thermal Energy*
Hydro-electricity	Biomass (e.g. roundwood, pellets, wood chips)
Tidal power	Ground-source heat pumps (e.g. earth energy)
Biomass (e.g. wood waste)	Solar air-heating systems
Biogas (e.g. methane from landfill sites)	Solar hot-water systems
Wind turbines	
Photovoltaic systems	
Mechanical Power	*Transportation*
Wind water pumps	Ethanol from biomass

TABLE 8-2

Electricity Generation Capacity From Renewable Sources (Includes Hydro)

Year	*Renewable electricity generation capacity (MW)*	*% of total capacity*
2000	68 986	62
1999	68 686	62
1998	68 340	62
1997	68 202	61
1996	67 101	59
1995	66 542	57
1994	63 175	56
1993	63 114	56
1992	62 895	58
1991	61 116	58
1990	59 557	58

Hydro-Electricity

Hydraulic power is a renewable energy based on the water cycle – evaporation, precipitation and flow of water toward the ocean. Canada has abundant water resources, and its geography provides many opportunities to produce low-cost energy. Tapping the energy from moving water has played an important role in the economic and social development of Canada for the past three centuries.

In 2002, hydro power accounted for about 60 percent of total electricity generation. Small-scale hydro-electric projects, with a capacity of 20 megawatts or less, constitute about 4 percent of Canada's electricity-generating capacity. Small-scale hydro has good potential for increased production.

Biomass

Bioenergy is a renewable source of energy derived from organic substances known as biomass. Biomass is supplied by agricultural wastes, such as chaff, straw, grain screenings, husks and shells, food-processing residues and methane. Other biomass supplies include animal litter and manure, landfill gas methane, urban wastes to be incinerated and sewage for biogas. Bioenergy contributes about 6 percent of Canada's primary energy, mostly for industrial process heat, electricity generation and residential space heating. Corn and other agricultural products are also used to generate ethanol and biodiesels for the transportation market.

Bioenergy production represents Canada's second largest renewable energy source. Most bioenergy is produced from organic refuse and used with the facilities in which the energy conversion takes place. The pulp and paper industry produces and uses most of Canada's bioenergy. Industrially produced heat and electricity, independent power producers' electricity, electricity from urban wastes and residential wood heat are all considered commonplace in Canada's energy mix.

Home heating with wood usually takes the form of stand-alone wood stoves, water or forced-air wood furnaces, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters. About 3 million Canadian households use wood for home heating. Canadians usually prefer roundwood, but alternatives include wood chips and pellets.

Earth Energy

As a result of the sun heating the surface of the planet, the temperature of the earth that is one or two metres below the surface remains fairly constant – between 5 and 10°C. This is warmer than outside air during the winter and cooler than outside air during the middle of summer. A ground-source heat pump takes advantage of this temperature difference by using the earth or the ground water as a source of heat in the winter and as a "sink" for heat removed from indoor air in the summer. For this reason, ground-source heat pumps are known as earth energy systems (EESs).

During winter, EES installations remove heat from the earth using a liquid, typically an antifreeze solution, that circulates within an underground loop. It then upgrades the heat with a conventional heat pump and transfers it to indoor space or the water heating system. During summer, the system reverses this process to operate as an air conditioner. EES installations supply less than 1 percent of the market for space and water heating and cooling in Canada.

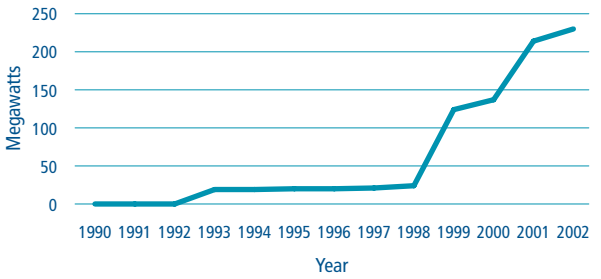
Wind Energy

Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada has a large wind resource potential because of its large size and northern location. A 1992 NRCan study estimated the technical wind energy potential in Canada at about 28 000 megawatts. If developed, this could supply 11 percent of total Canadian electricity consumption. In 2002, wind energy accounted for less that 1 percent of Canada's total electricity generation.

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 (see Figure 8-1).

FIGURE 8-1

Canadian Wind Power Capacity, 1990 to 2002



Solar Energy

Three main technologies use energy from the sun:

- passive solar technologies mean that buildings are designed and located to maximize their reception of solar energy;
- active solar thermal systems convert solar radiation into thermal energy for heating air or water in residential, commercial and industrial applications; and
- solar electric (photovoltaic) systems use solar radiation to produce electricity.

During the 1990s, NRCan assisted a Canadian company in developing a perforated solar absorber to preheat ventilation air and reduce a building's fuel requirements for space heating. This technology is more cost-effective than conventional solar air heating technologies and is gaining acceptance in Canada and abroad. Systems have been installed on industrial, institutional and commercial buildings throughout Canada.

The installed photovoltaic power capacity in 2002 was 10 megawatts, with an estimated annual production of 8 gigawatt hours of electricity. The bulk of this capacity is either "off grid" (not connected to an electrical transmission system), where the price of photovoltaics is competitive with conventional stand-alone power systems, or an extension of a grid to a given location.

Typical applications include telecommunications systems, water pumping and purification, remote monitoring and control, remote residences, coast-guard lighting and beacon systems, and numerous consumer applications, such as hand-held calculators. The Canadian Coast Guard is the largest individual user of photovoltaic systems in Canada, with an estimated 7000 navigational buoys, beacons and lighthouses.

Canada has about 100 grid-connected photovoltaic systems installed on residential rooftops and buildings, providing on-site power with a combined capacity of 368 kilowatts. Significant reduction in equipment costs were observed, with Canadian photovoltaic panel prices decreasing to $7.14 per watt in 2002 compared with $11.09 per watt in 1999 (a reduction of 14 percent per year).

NRCan delivers several initiatives to increase the use of small-scale renewable energy in Canada. The following is the array of NRCan renewable energy programs.

Renewable Energy Programs: ENergy from the FORest (ENFOR)

Objective: To improve the understanding of the role of biomass production for energy and to improve biomass productivity from natural forests and from plantations growing willow and poplar.

ENFOR, managed by the Canadian Forest Service (CFS) of NRCan, undertakes research and development (R&D) on the production and harvesting of forest biomass for energy through the private sector, universities or CFS research centres. ENFOR also investigates the broader environmental effects of harvesting from forests and short-rotation plantation culture, focusing on sustaining forest productivity and improving the sequestration and storage of atmospheric carbon in forest ecosystems. ENFOR also supports research on information systems to determine the quantity and quality of biomass in Canadian forests.

Key 2002–2003 Achievements

- Several species/varieties of willow and poplar have been assessed for production in Quebec, Ontario and the Prairie Provinces. Plantation establishment has been successful throughout much of Canada, and industry is now engaged in the large-scale planting of fast-growing poplars.
- The CFS, acting as the Canadian lead for the International Energy Agency (IEA) Bioenergy Agreement, continued its collaboration, with a series of workshops, seminars and publications.
- Publications from the IEA: *Sustainable Production of Woody Biomass for Energy* describes the activities of the four forest-related tasks (including ENFOR) in the agreement and how they link to sustainability issues. *Socio-economic Drivers in Implementing Bioenergy Projects: An Overview* describes the activities and goals of Task 29: Socio-Economic Aspects of Bioenergy Systems.
- Major successes include the Forest Biomass Inventory of Canada; the modelling of whole-tree harvesting/nutrient cycling; the Carbon Budget Model of the Canadian Forest Sector; and the development and testing of species, clones and production technologies for energy plantations.
- Publication: Hall, J. Peter, 2002. *Sustainability of Renewable Biomass for the Production of Energy*, presented at the GLOBE 2002 conference in Vancouver, British Columbia.

For more information:
nrcan.gc.ca/cfs-scf/science/resrch/bioenergy/

Renewable Energy Programs: Initiative to Purchase Electricity From Emerging Renewable Energy Sources

Objective: To purchase electricity from emerging renewable energy sources (ERES) that are certified by a third party as having low environmental impact, with the objective of reducing greenhouse gas (GHG) and other air pollution emissions associated with federal electricity consumption.

Between 1998 and 2001, NRCan entered into three pilot projects to purchase electricity from ERES for federal facilities in Alberta, Saskatchewan and Prince Edward Island. NRCan has pledged to purchase 20 percent of its electricity from ERES by 2010.

Key 2002–2003 Achievements

- The Government of Canada received its first full year of electricity from ERES in Saskatchewan and Prince Edward Island. An estimated 32.4 gigawatt hours (GWh) and 13 GWh were delivered to the grid in Saskatchewan and Prince Edward Island, respectively. This resulted in estimated emissions reductions of 29 000 tonnes of GHGs in Saskatchewan and 11 000 tonnes in Prince Edward Island.
- NRCan continues to receive 10 000 GWh of electricity from ENMAX Corporation in Alberta. This purchase results in GHG emissions reductions of about 9000 tonnes annually.
- The Prince Edward Island and Saskatchewan governments are purchasing electricity from ERES for their facilities.
- SaskPower constructed a second wind farm in Saskatchewan in fall 2002. This wind farm provides electricity for SaskPower facilities, provincial government facilities and SaskPower's green power purchases.
- The governments of Ontario and Alberta committed to purchasing electricity from renewable sources. Ontario will target 20 percent of its electricity use, and Alberta will enter into long-term contracts for 210 GWh annually.

For more information:
nrcan.gc.ca/redi

Renewable Energy Programs: Photovoltaic and Hybrid Systems Program

Objective: To support the development and application of solar photovoltaic (PV) technologies in Canada.

The Photovoltaic and Hybrid Systems Program contributes to increasing the use of PV energy technologies in Canada by developing technologies and removing barriers and by facilitating the development of a Canadian-based globally competitive PV industry. It also contributes to the development of policies and programs.

In collaboration with Canadian industry and universities as well as international energy research organizations, the CANMET Energy Technology Centre – Varennes undertakes R&D activities and fosters information exchanges that will encourage the adoption of PV-hybrid systems; validates the performance and safety of utility-interactive DC to AC inverters; supports the development of building-integrated PV technologies and systems; and facilitates the development and adoption of harmonized standards and codes for PV and distributed generation systems in Canada.

Key 2002–2003 Achievements

- Signed an agreement with the Yukon Energy Solution Centre and the Arctic Energy Alliance to collaborate in the assessment and promotion of renewable energy in off-grid residences.
- Completed the preparation of the national Interconnection Guideline for small decentralized energy production, forging a way for alternative energy sources to become part of the electricity supply mix in Canada.

For more information:
www.micropower-connect.org

- Co-hosted a workshop, with the Institute of Electrical and Electronics Engineers, on the grid connection of inverter-based distributed generators to identify the challenges and R&D needs of the industry in Canada.
- Co-hosted a workshop, with the Royal Architectural Institute of Canada and the University of British Columbia, that will contribute to mainstreaming building-integrated technology in Canada.

For more information:
cetc-varennes.nrcan.gc.ca/en/er_re.html

Renewable Energy Programs: Renewable Energy Capacity-Building Program (RECAP)

Objective: To build the capacity of planners, decision-makers and industry to implement renewable energy and energy efficiency projects.

The Program works to meet its objective by developing decision-making tools that reduce the cost of pre-feasibility studies, training people to better analyse the technical and financial viability of possible projects, disseminating knowledge to help people make better decisions and connecting buyers and sellers to help implement projects and expand markets.

Key 2002–2003 Achievements

- RECAP has developed and promoted a new RETScreen® International Renewable Energy Decision Support Centre Web site and CD. Available on the Web site and CD are the RETScreen® International Renewable Energy Project Analysis Software, the new RETScreen® Engineering and Cases Electronic Textbook, the new Renewable Energy Project Analysis Course and a new Interactive Marketplace.
- A RETScreen® GHG Baseline Project Analysis Software Model (in collaboration with the Prototype Carbon Fund) and a RETScreen® Combined Heat and Power Project Analysis Software Model are also under development.
- RECAP, in collaboration with the Renewable Energy Deployment Initiative and the Office of Energy Efficiency, has developed, promoted and delivered a one-day Renewable Energy Training Seminar.
- Within the last two years, more than 1200 people were trained in Canada at 47 seminars. The trainees included planners, decision-makers and contractors from Aboriginal and northern communities, and federal and municipal facilities, as well as industry sellers, planners, designers and installers.
- RECAP has provided post-training technical support and project facilitation services. Additional Canadian project facilitation services supported by the RECAP team were 4 Aboriginal and northern energy centres, 160 Aboriginal and northern community studies, 40 federal facility studies and 71 municipal facility studies.
- RECAP has developed, promoted and delivered a new two-day RETScreen® International Trainer Certification Workshop.
- The International network of certified RETScreen® trainers is now being established, with 76 people trained so far.

For more information:
cetc-varennes.nrcan.gc.ca/en/er_re/rcer_recb.html
or
retscreen.net

Renewable Energy Programs:
Renewable Energy Deployment Initiative (REDI)

Objective: To stimulate the demand for renewable energy systems by helping the supply industry in its marketing and infrastructure development efforts, including the provision of financial incentives.

REDI targets four systems: solar water-heating, solar air-heating, earth energy, and high-efficiency, low-emissions biomass combustion. REDI promotes these systems in the business, federal and non-business markets through three means: a financial incentive, market assessment and information and awareness.

Key 2002–2003 Achievements

- $968,452 in REDI financial incentives was distributed among 50 projects valued at $5 million; the projects were completed in 2002–2003.
- Gathered data on solar thermal collector areas installed in Canada from 1995 to 2001. A total of 170 432 square metres, which saved 250 terajoules annually, was recorded to the IEA for its annual survey of solar thermal market development.
- Released the report entitled *Survey to Gauge Awareness, Knowledge and Interest Levels of Canadians Toward Solar Domestic Hot Water Systems*.
- Contributed to the development of the Canadian Bioenergy Association, which was launched in October 2002 as the first Canadian association for the development of bioenergy.
- Initiated earth energy projects with the Canada Customs and Revenue Agency and initiated the communication strategies to increase the deployment of renewable energy technologies in the federal sector.
- In collaboration with the Canadian Electricity Association and the Geothermal Heat Pump Consortium, helped to establish the Canadian GeoExchange Coalition, which is comprised of energy utilities and industry stakeholders consolidating efforts to promote earth energy in Canada.
- In collaboration with industry partners, produced several new publications on renewable energy, including the following:
  - *Commercial Earth Energy Systems: A Buyer's Guide*
  - *Discover the Production and Uses of Biogas*
  - *Discover the Benefits of Residential Wood Heating*
  - Two solar water-heating case studies
  - *Earth Energy in Our Community* (available on DVD)
  - *REDI Project Profile No. 1 – Textile Manufacturing Industry*

For more information:
nrcan.gc.ca/redi

TABLE 8-3

REDI for Business Projects Completed, 1998 to 2002

	Number of projects	*Estimated GHG reduction (tonnes CO_2/yr.)*	*Cost of system*	*NRCan contribution*
1998–1999	10	2 909.0	$1,428,063	$176,392
1999–2000	9	260.8	$479,633	$119,910
2000–2001	24	5 825.4	$1,849,918	$327,078
2001–2002	51	23 476.0	$6,708,120	$1,362,399
2002–2003	50	7 649.9	$5,077,937	$968,452
Total	**144**	**40 121.1**	**$15,543,671**	**$2,954,231**

Renewable Energy Programs:
Renewable Energy Technologies (RET) Program

Objective: To support efforts by Canadian industry to develop renewable energy technologies.

Technologies supported include bioenergy (combustion, biochemical conversion of biomass to ethanol, thermochemical conversion of biomass to bio-oil and biogas, and biomass preparation and handling), small hydro projects (less than 20 megawatts), active solar applications and wind energy. Activities are directed toward improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics to potential users and helping industry commercialize its products in domestic and foreign markets.

With ongoing support from NRCan and other federal departments, Iogen Corporation is continuing on a successful path to full-scale commercialization of its process for producing fuel ethanol from agricultural residues, such as straw. The company's pre-commercial demonstration plant in Ottawa, Ontario, is processing 25 tonnes per week of wheat straw into fermentable sugar. This major achievement affirms Iogen's position as the world leader in developing this complex technology.

Key 2002–2003 Achievements

- Suncor Energy Products Inc., in partnership with NRCan's RET and REDI programs, launched the first solar car wash in Canada to use solar pool-heating technology at Suncor's Sunoco gas station in Markham, Ontario.
- Energy Ottawa, with the support of the Government of Canada, installed newly developed hydro-turbine technology at its small hydro-generating site, increasing the efficiency of the plant by 30 percent.
- Tembec, in partnership with the Government of Canada, installed and began operating trials on a novel system to produce combustible biogas from pulp mill sludges.
- The BIOX Corporation, with support from NRCan, successfully scaled up its innovative biodiesel production technology from an experimental-sized unit to a one-million-litre pilot plant.

For more information:
canren.gc.ca

Renewable Energy Programs: Wind Power Production Incentive (WPPI)

Objective: The WPPI is a 15-year, $260-million program to support the installation of 1000 megawatts of new wind energy capacity by March 31, 2007.

The WPPI encourages electric utilities, independent power producers and other stakeholders to gain experience in wind power, an emerging energy source. The incentive is about $0.01 per kilowatt hour of production and represents about half of the current cost of the premium charged for wind energy in Canada for facilities where good wind resources exist. Eligible recipients can receive the incentive for 10 years.

By displacing other electricity sources and through continued momentum, wind-power capacity installed under the WPPI is projected to reduce GHG emissions by three megatonnes annually by 2010.

Key 2002–2003 Achievements

- Received 87 letters of interest for 3600 megawatts of wind-energy projects from developers, utilities and businesses. By the end of the fiscal year, five projects were completed or under construction, for a total new capacity of about 93 megawatts. Two projects were in Ontario (9.75 megawatts), two in Alberta (75.2 megawatts) and one in Saskatchewan (5.94 megawatts), resulting in a commitment of more than $40 million of incentive payments over 10 years.

For more information:
canren.gc.ca/wppi

Chapter 9: Federal House in Order

Introduction

The Government of Canada is the country's largest single enterprise. It is working to get its own house in order by setting a target of 31 percent reduction in greenhouse gas (GHG) emissions from its own operations by 2010.

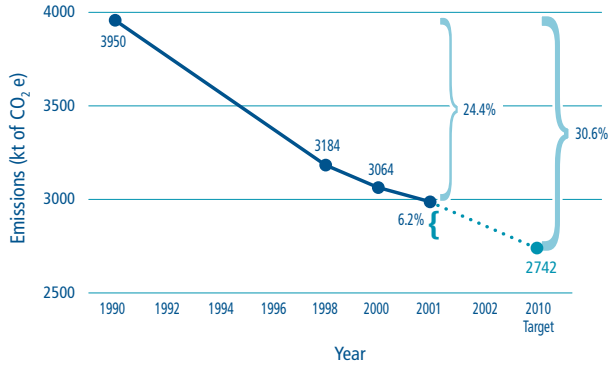
Since 1990, through building retrofits, better fleet management, strategic "green power" purchases and the downsizing of operations, the Government of Canada has already achieved a 24 percent emissions reduction. The Government of Canada will reduce its emissions by a further 12 percent by 2010.

The Government of Canada will achieve its goal by additional building retrofits, fuel switching and increased use of renewable energy within government operations. Moreover, the Government of Canada can help to "create the market" for certain new technologies on the verge of becoming viable. Key departments, which are responsible for 95 percent of government GHG emissions, have been assigned specific targets and must report annually on their progress.

The task of target sharing has been undertaken by means of a three-year action plan and entails assigning specific targets to the 11 key departments. Natural Resources Canada (NRCan) is taking a lead role in managing this task and in providing the services to departments and agencies that will help them achieve their targets. The Leadership Challenge encourages the reduction of all federal emissions by engaging the active participation of the departments, agencies and Crown corporations that were not designated with a target.

FIGURE 9-1

GHG Emissions Reductions From Federal Operations



The Federal House in Order initiative consists of various complementary activities – including GHG inventory and tracking, purchases of emerging renewable electricity or green power and efforts to reduce "outside emissions" (a pilot project for transit passes through payroll deduction for federal employees was launched October 2002). It also has three supporting programs:

- Federal Buildings Initiative;
- Federal Industrial Boiler Program; and
- Federal Vehicles Initiative.

Federal Buildings Initiative (FBI)

Objective: To assist Government of Canada organizations to implement energy efficiency improvements, leading to reduced energy use, GHG emissions and operating costs.

The FBI facilitates comprehensive energy efficiency upgrades and building retrofits for departments, agencies and Crown corporations of the Government of Canada through private-public partnerships with energy management firms. The FBI provides a range of products and services, including advice and consultation on organization readiness and project applicability; lists of energy management firms qualified to implement projects; project-financing options through guaranteed savings; a national network for energy management training; model energy performance contracts; and employee awareness training.

Key 2002–2003 Achievements

- $1-million worth of incremental energy savings were achieved.
- Energy intensity improved by 20 percent, and GHG emissions reductions of 15–20 percent were achieved.

For more information:
oee.nrcan.gc.ca/fbi/home_page.cfm

Federal Industrial Boiler Program (FIBP)

Objective: To provide technical and project management services to assist federal facilities implement energy reduction projects.

The FIBP's extensive experience in building energy systems and access to the engineering and scientific network within the CANMET Energy Technology Centre ensures that environmentally responsible technologies are considered when federal government clients replace or modify their space heating and cooling systems. Since its inception in 1991, the FIBP has worked with many departments, including Agriculture and Agri-Food Canada, Correctional Service Canada (CSC), National Defence, Environment Canada, and the Department of Foreign Affairs and International Trade (DFAIT), to reduce their energy costs. Under the FIBP, GHG emissions are reduced by an average of 4.7 kilotonnes per year.

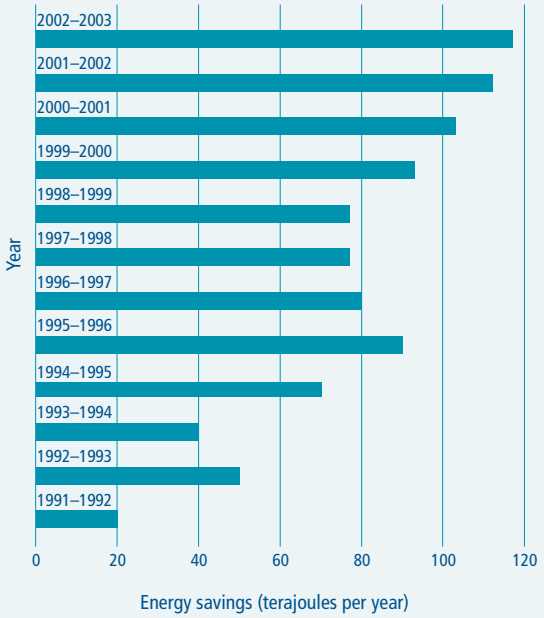
Key 2002–2003 Achievements

- Conducted a study for Environment Canada to compare the operating costs, environmental emissions and GHG production from heating plants operating on No. 6 fuel oil with those operating on No. 2 fuel oil.
- Worked with DFAIT at its embassy in New Delhi, India, to implement a cogeneration-based site power generation system.
- Participated in CSC's sustainable development strategy by inspecting heating systems in federal penitentiaries across the country to recommend options for improving energy efficiency and reducing operating costs and GHG emissions.
- Reviewed operations and systems at Communications Research Centre Canada (CRC), an agency of Industry Canada. The CRC is entering into a second energy management services company contract to implement FIBP report recommendations.

For more information:
nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/research_programs_fibp_e.html

FIGURE 9-2

Annual Energy Savings From the FIBP, 1991–1992 to 2002–2003



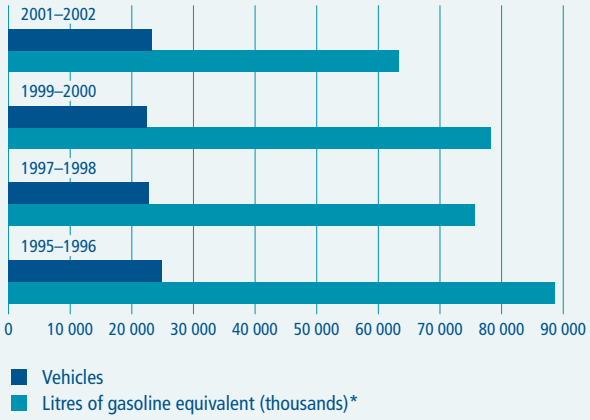
Federal Vehicles Initiative

Objective: To assist federal government departments increase the energy efficiency of their motor vehicle fleets and reduce the environmental impact of federal vehicle operations and to promote the *Alternative Fuels Act* within the federal fleet.

The Initiative provides fleet managers with an assessment of fleets as well as technical advice and encouragement on acquiring and using alternative transportation fuels (ATFs). Four departments participate in planning and reporting on the Initiative: Treasury Board of Canada Secretariat, NRCan, Environment Canada and Public Works and Government Services Canada.

FIGURE 9-3

Federal Fleet Size and Fuel Consumption, 1995–1996 to 2001–2002



*Gasoline equivalent is computed by dividing the lower heating value of the alternative fuel by the lower heating value of gasoline and multiplying this result by the alternative fuel consumption value.

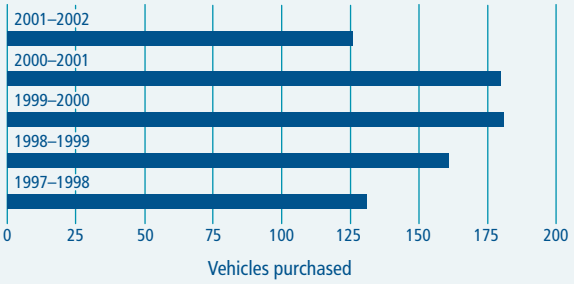
Key 2002–2003 Achievements

- In 2002–2003, over 200 vehicles used E-85 (a fuel consisting of 85 percent ethanol) regularly. This represents about 1 percent of the federal vehicle fleet and is more than double the number in the preceding year.
- Over 130 hybrid gasoline-electric vehicles were operating in the federal vehicle fleet.
- Over 10 percent of the newly acquired vehicles could operate on alternative fuels, an increase from the 3 percent of the preceding year.

For more information:
oee.nrcan.gc.ca/greening/home.cfm

FIGURE 9-4

Annual Purchases of ATF Vehicles for the Federal Fleet, 1997–1998 to 2001–2002



Chapter 10: Intergovernmental Cooperation

Introduction

This chapter describes Natural Resources Canada's (NRCan's) intergovernmental cooperation with respect to efficiency and alternative energy (EAE) during the reporting period at three levels: municipal, provincial/territorial and international. Other examples of intergovernmental cooperation are set out in previous chapters in the Key Achievements sections of specific EAE program initiatives.

Federal-Provincial and Federal-Territorial Cooperation

Provincial and territorial governments delivered a substantial number of EAE programs during the reporting period to reduce energy costs, increase competitiveness, improve air quality and generate economic and trade opportunities. Coordination between the federal and provincial/territorial levels is essential to avoid duplication and ensure efficient program delivery. During the reporting period, the governments cooperated at the general level and at the level of specific program initiatives.

General Cooperation

Cooperation Agreements

- NRCan had a Letter of Cooperation (LOC) on EAE with the Agence de l'efficacité énergétique du Québec during the reporting period. The LOC ensures an efficient consultation and exchange of information between the two governments, and it helps coordinating EAE activities in the province and creating opportunities for joint projects. The management committee established under the LOC met twice a year during the period to review policy and program developments, progress on joint program initiatives and areas for further cooperation.
- The LOC played a considerable role in facilitating the conduct of three activities in particular:
  - the management of the licensing agreement for EnerGuide for Houses (which is delivered in Quebec by the Agence de l'efficacité énergétique);
  - the conclusion of a contribution agreement between NRCan's Office of Energy Efficiency (OEE) and the Agence de l'efficacité énergétique under the Commercial Building Incentive Program regarding projects submitted to NRCan by public organizations in Quebec. The cooperation framework that was agreed upon in February 2000 is now being applied to other NRCan energy sector programs aimed at the public sector in Quebec; and
  - the management of the agreement between NRCan (CANMET Energy Technology Centre – Varennes, Quebec) and the Agence de l'efficacité énergétique relating to the Programme d'intervention en réfrigération dans les arénas du Québec. Among activities, an important study was completed to evaluate the potential energy savings and greenhouse gas emissions reduction in Quebec's arenas.
- Another LOC on energy efficiency and renewable energy was signed in 2001 between the Government of Canada and the Government of Yukon with similar objectives, i.e. facilitating information exchange and creating opportunities for joint projects in Yukon Territory. Close cooperation between these two governments has also resulted in the creation of the Canada–Yukon Energy Solutions Centre in Whitehorse, Yukon Territory, which started its operations in December 2000. The Centre provides access to relevant technical services for the Yukon population, undertakes outreach and public education activities and delivers assigned energy efficiency and renewable energy programs in Yukon Territory.

The Government of Canada also contributed to the Arctic Energy Alliance in Whitehorse, Northwest Territories, to facilitate opportunities for energy

EAE projects in the Northwest Territories. The Arctic Energy Alliance promotes EAE programs and delivers EnerGuide for Existing Houses in the Northwest Territories.

National Advisory Council on Energy Efficiency (NACEE)

- NRCan created NACEE in April 1998 to advise and guide the OEE on the most effective way to achieve its mission. During 2002–2003, NACEE members included representatives from across Canada who had the opportunity to comment on the OEE's business plan and programs.

Cooperation at the Program Level

R-2000 Standard

- In 2002–2003, the R-2000 Standard was delivered in seven provinces (Alberta, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario and Saskatchewan) and in Yukon Territory. Provincial home builders' associations, except in Manitoba and Yukon Territory, also participated. There were three types of cooperation during the period:
  - Representatives from most provinces and Yukon Territory participated as members of regional R-2000 advisory committees;
  - In New Brunswick, Newfoundland and Labrador, Nova Scotia and Saskatchewan, the provincial governments and NRCan supported R-2000 through financial or in-kind contributions; and
  - In Manitoba and Yukon Territory, the provincial and territorial governments delivered R-2000 under a licensing agreement with NRCan.

EnerGuide for Houses

- Several provinces and Yukon Territory participated in the EnerGuide for Houses Advisory Committee.
- Yukon Housing Corporation and the Agence de l'efficacité énergétique du Québec are the delivery agents of EnerGuide for Houses in their jurisdictions, under licensing agreements with NRCan.

Federal Buildings Initiative (FBI)

- British Columbia and New Brunswick have replicated several elements of the FBI into programs aimed at improving the energy efficiency and environmental performance of their buildings.

Commercial Building Incentive Program (CBIP)

- Provinces and territories distributed information on CBIP. Provincial and territorial health and education departments were active participants in the program as eligible parties.

Canadian Industry Program for Energy Conservation (CIPEC)

- The excellence of the CIPEC concept and its ability to instigate positive change was affirmed when India chose the CIPEC model as the basis for the Indian Industrial Programme for Energy Conservation (IIPEC). Following CIPEC's lead, IIPEC is establishing a series of energy management sector task forces, including cement, pulp and paper and textiles. In April 2002, representatives of IIPEC toured Canadian facilities of CIPEC partners in Ontario and Quebec, joined a CIPEC Cement Task Force meeting and met with officials from the OEE and other federal departments, non-governmental organizations, academia and research labs. Two participants from the Indian delegation attended an OEE customized Dollars to $ense textile workshop.

Energy Innovators Initiative (EII)

- The EII relies on partners to promote energy efficiency and facilitate access to its members as well as to provide sectoral information. Partners include the Association of Canadian Community Colleges, the Canadian School Boards Association, the Canadian College of Health Service Executives, the Association des gestionnaires de parcs immobiliers institutionnels, the Hotels Association of Saskatchewan, the Alberta Hotel & Lodging Association, the Manitoba Hotel Association and the British Columbia & Yukon Hotels' Association. As well, a dynamic partnership has been established with BC Hydro to assist in identifying new retrofit projects with large energy users. Additionally, the EII works with the Agence de l'efficacité énergétique du Québec to facilitate program delivery to the province's institutional sector.

Equipment Energy Efficiency Regulations

- NRCan and five provinces (British Columbia, New Brunswick, Nova Scotia, Ontario and Quebec) regulate the energy efficiency performance of prescribed equipment. They share information and consult through CSA International's Advisory Committee on Energy Efficiency.

Initiative to Purchase Electricity From Emerging Renewable Energy Sources

- The February 2000 federal budget announced that the Government of Canada would expand the pilot Green Power Initiative to procure $15 million of renewable energy over the next 10 years in Saskatchewan and Prince Edward Island. NRCan entered into discussions with SaskPower and Maritime Electric on the purchase of green power for federal facilities in the provinces they serve.

Residential Wood Combustion

- NRCan is a member of the Intergovernmental Working Group on Residential Wood Combustion, which is co-chaired by Environment Canada and the Newfoundland and Labrador Department of Environment. The Federal Smog Management Plan calls for four initial joint actions on residential wood combustion:
  - assess the effectiveness of pilot wood-stove change-out programs and consider options for a national program;
  - complete an update of CSA International standards on wood stoves, fireplace inserts and solid-fuel-burning central systems, and further the development of similar standards for fireplaces;
  - support public education on cleaner wood burning with advanced technologies and sustainable wood use; and
  - develop a federal regulation on residential wood combustion, focusing on cleaner-burning appliances.

- NRCan chairs the cross-jurisdictional steering committee that was responsible for the deployment of a Canada-wide education campaign on safe, clean and efficient residential wood heating. NRCan worked with health industry partners, the Canadian Lung Association, the Canadian Environmental Network and Fire Prevention Canada on the campaign, which ran from fall 2002 to March 2003.

Personal Vehicles

- NRCan completed anti-idling pilot projects with the cities of Mississauga and Sudbury, Ontario. The goal of the projects was to test the effectiveness of (a) municipal-based awareness campaigns promoting the benefits of not idling vehicles needlessly and (b) a Web-based tool kit of information to launch their own anti-idling campaigns. The results of the pilots provided a template for future campaign roll-outs in other Canadian cities.

Federal-Municipal Cooperation

- The town of Banff, Alberta, mandated the R-2000 Standard for new residential construction by the Banff Housing Corporation.
- A number of municipalities received financial incentive contributions in 2002–2003 under CBIP.
- A number of municipalities registered as Energy Innovators during the period, and some received financial assistance under the EII.

Green Municipal Funds

- The Green Municipal Funds were created in Budget 2000 by an endowment of $125 million to the Federation of Canadian Municipalities (FCM). The funds were doubled in Budget 2001 to the current total of $250 million – $50 million for the Green Municipal Enabling Fund (GMEF) and $200 million for the Green Municipal Investment Fund (GMIF).
- Cooperation takes place on several levels in the delivery of the Green Municipal Funds:
  - The Government of Canada signed an Agreement with the FCM, a non-profit organization, to deliver the Green Municipal Funds.
  - Moneys for the Green Municipal Funds endowment were provided equally by NRCan and Environment Canada who signed a Memorandum of Understanding.
  - Provincial, territorial and municipal officials cooperate to promote projects with innovative environmental solutions within municipalities across Canada because each municipal application must be accompanied by a provincial or territorial letter of support.

– The Government of Canada shares in the governance of the Green Municipal Funds, along with representatives from the public and private sectors, including municipal officials and technical experts, through participation on a Peer Review Committee and a governing Council. The FCM Board of Directors, with delegated GMF decision-making authority, reviews council recommendations and decisions.

International Cooperation

NRCan also cooperates with several international organizations and foreign governments. Canada benefits from this cooperation in two ways:

- Canada learns about improved ways of designing and delivering EAE programs; and
- This cooperation helps reduce trade barriers to energy-using products through the harmonization of energy efficiency tests and performance standards.

International Energy Agency (IEA)

The IEA, based in Paris, France, is an autonomous agency linked with the Organisation for Economic Co-operation and Development (OECD). The IEA is the key energy forum for its 26 member countries, which include Canada. IEA member governments have committed to sharing energy information, coordinating energy policies and cooperating in the development of rational energy programs. The IEA and its Governing Board are assisted in their work by several standing groups and special committees, which bring together energy specialists from member countries.

The Standing Group on Long-Term Cooperation (SLT) is the key committee on the policy side. The SLT develops policy analyses to promote conservation and the efficient use of energy, the increased use of alternatives to oil and other measures to increase long-term energy security while protecting the environment. The SLT also monitors energy developments in member countries and makes recommendations on energy policy through a regular series of individual country reviews. The Energy Efficiency Working Party (EEWP) of the SLT undertakes IEA work on specific issues related to energy efficiency. Canada is represented at the EEWP by NRCan's OEE.

Canada is an active member of the Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET). CADDET is an international information network to help managers, engineers, architects and researchers find out about energy-using technologies that have worked in other countries. CADDET is part of an IEA Agreement known as the Energy and Environmental Technologies Information Centres (EETIC). Within the CADDET organization, Canada cooperated with some 10 OECD countries and the European Union during the reporting period.

Canada also collaborates with research centres in member countries on several agreements and programs oriented toward research and development (R&D) and technology.

Organisation for Economic Co-operation and Development

As a member of the OECD, Canada participates in the organization's analytical work to support member countries' national climate change policy development. As well, Canada cooperates with the OECD to conduct peer reviews of environmental conditions and the progress of each member country and to scrutinize efforts to meet domestic objectives and international commitments.

Research and Development

NRCan facilitates R&D and commercial business ventures abroad by Canadian firms by undertaking a wide variety of activities, including participating in various IEA tasks and supporting technical and trade-oriented workshops and conferences.

Mexico

NRCan signed a Memorandum of Understanding (MOU) on EAE cooperation with the Mexican Energy Secretariat in June 1996. The objective of the MOU is to contribute to the EAE objectives of Canada and Mexico by

- improving the design and delivery of EAE programs implemented or sponsored by NRCan and Mexico's National Commission for Energy Savings (Comisión Nacional para el Ahorro de Energía [CONAE]); and
- enhancing trade, investment and exchanges (technical and other) related to energy-efficient products, energy management services and alternative energy goods and services.

In November 2002, the OEE sponsored two Dollars to $ense workshops in Mexico City; one for industry and the other for the Ministry of Health. Mexican government officials and private sector participants were pleased with both workshops. The workshops aimed to enable participants to

- identify and capitalize on immediate savings opportunities;
- develop new, cost-saving energy management solutions;
- be more competitive while enhancing their corporate image;
- assemble a money-saving energy management team; and
- promote a more comfortable, more productive workplace.

NRCan also presented information on vehicle fuel efficiency at a November 2002 workshop organized by CONAE and Pemex in Mexico City.

Tunisia

For the reporting period, NRCan provided training to the Agence Nationale des Énergies Renouvelables (ANER) de Tunisie on the factorization method that NRCan uses in its Canadian analysis. This activity helped inform key decision-makers in Tunisia about Canada's energy efficiency efforts. The activity also supports bilateral relations with the Government of Tunisia.

United States

Motor Vehicle Fuel Efficiency and Fuels – NRCan and the U.S. Department of Energy (DOE) signed an MOU about road transportation, energy efficiency and alternative fuels. The MOU provides a formal mechanism for negotiating and harmonizing North American policy on fuel efficiency, fuel quality and alternative transportation fuels. The MOU provides a framework for sharing information and combining efforts on joint studies. In 2002–2003, completed studies included one on the potential for voluntary fuel economy standards in the United States and Canada, and another on vehicle and fuel transitions over the next 50 years.

A joint study sponsored by the DOE's Office of Policy and NRCan's OEE was published in February 2003 entitled *Examining the Potential for Voluntary Fuel Economy Standards in the United States and Canada*. This study reviewed the voluntary agreements in place in Europe and Japan, updated previous analysis of available fuel economy technologies and costs, and modelled the impact of different structures of voluntary agreement on individual manufacturers.

Under the MOU, a joint project was carried out to assess possible transitions in vehicle technologies and fuels through 2050. The project involved NRCan and DOE staff and several experts drawn from the Argonne National Laboratory, Oak Ridge National Laboratory and National Renewable Energy Laboratory. Several presentations have been given at conferences on the findings of this work.

United States and Mexico

NRCan continues to participate with the United States and Mexico in the North American Energy Working Group's Energy Efficiency Experts Group to promote the harmonization of energy efficiency test methods, mutual recognition of conformity assessment systems for energy efficiency standards and cooperation on trilateral energy efficiency labelling programs. During the review period, test standards for three products were assessed, and equivalent standards of performance were then instituted in Mexico. Work has begun to determine the prospects for Mexico's participation in the ENERGY STAR® high-efficiency program currently promoted in Canada and the United States. Other opportunities for harmonizing these types of programs are being explored.

Appendix 1:
NRCan's Efficiency and Alternative Energy Initiatives and Expenditures, 2002–2003

	(millions of dollars)
General Programs	**$10.4**
Outreach	
National Energy Use Database	
Community Energy Systems Program	
Energy Efficiency – Equipment	**8.8**
Energy Efficiency Standards and Regulations	
Equipment Labelling and Promotion	
EnerGuide for Industry	
Mine Ventilation	
Energy Efficiency – Buildings	**38.2**
R-2000 Standard	
Super E™ Program	
EnerGuide for Houses	
Housing Energy Technology Program	
Commercial Building Incentive Program	
Industrial Building Incentive Program	
Green Buildings Program	
Federal Buildings Initiative	
Federal Industrial Boiler Program	
Energy Innovators Initiative	
Buildings Program	
Building Energy Simulation Program	
Energy Efficiency – Industry	**41.3**
Industrial Energy Efficiency (Canadian Industry Program for Energy Conservation; Industrial Energy Innovators)	
Advanced Combustion Technologies	
Processing and Environmental Catalysis Program	
Industrial Process Engineering Program	
Industrial Process Integration Program	
Industry Energy Research and Development Program	
Emerging Technologies Program	
Energy Technologies for High-Temperature Processes	
Minerals and Metals Program	

	(millions of dollars)
Energy Efficiency – Transportation	**13.2**
Vehicle Efficiency	
Personal Vehicles	
Fleet Vehicles	
Federal Vehicles Initiative	
Canadian Lightweight Materials Research Initiative	
Alternative Energy – Transportation	**3.9**
Fuel-Cell-Powered Mining Vehicles	
Vehicle Fuels	
Transportation Energy Technologies Program	
Alternative Energy – Renewable Energy Sources	**18.5**
ENergy from the FORest (ENFOR)	
Initiative to Purchase Electricity From Emerging Renewable Energy Sources	
Photovoltaic and Hybrid Systems Program	
Renewable Energy Capacity-Building Program	
Renewable Energy Deployment Initiative	
Renewable Energy Technologies Program	
Wind Power Production Incentive	
Total[1]	**$134.2**

[1]Total does not add due to rounding.

Appendix 2:
Data Presented in the Report

The aggregate energy use data presented in this report are taken from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada* (QRESD). Differences exist between this report and *Canada's Emissions Outlook: An Update* (CEO Update) concerning the sector allocations of QRESD energy use data. The CEO Update's sector allocation is based on Environment Canada's *Trends in Canada's Greenhouse Gas Emissions 1990–1997*, whereas this report uses a definition better suited for the purpose of energy end-use analysis. Some modifications to the original Statistics Canada data were required and are documented in Appendix B of NRCan's *Energy Use Data Handbook*, *1990 and 1995 to 2001*.

FIGURE 2-1: Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	1.00	1.02	1.05	1.10	1.13	1.15	1.18	1.17	1.22	1.27	1.25
Actual energy use	1.00	0.98	1.00	1.02	1.06	1.07	1.11	1.12	1.09	1.13	1.17	1.14

FIGURE 2-2: Electricity Production From Renewable Sources

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gigawatt hours	3649	4134	4477	5362	5422	5855	6419	6599	7372	7418

FIGURE 4-1: Canadian Households by Type of Dwelling, 2001

	Number of households	Percent
Single detached	6 754 000	57
Apartments	3 631 000	31
Single attached	1 246 000	10
Mobile homes	266 000	2
Total	**11 897 000**	

FIGURE 4-2: Residential Energy Use by Purpose, 2001

	Energy Use (petajoules)	Percent
Space heating	775.9	58
Water heating	296.0	22
Appliances	185.9	14
Lighting	62.4	5
Space cooling	16.5	1
Total	**1336.7**	

Figure 4-3: Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.22	1.21	1.13	1.18	1.25	1.22
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.05	1.12	1.08	0.99	1.03	1.08	1.04

FIGURE 4-4: Annual Heating Consumption for Houses Constructed to Different Standards (From EnerGuide for Houses)

	Megajoules per year
R-2000 house	78 747
Model National Energy Code house (2002)	112 101
Typical new house (2002)	146 274
Typical existing house (1970)	216 812

FIGURE 4-5: Average Energy Consumption per Household (From R-2000 and EnerGuide For Houses)

Year built	Average energy consumption (gigajoules)
Pre-1946	277
1946–1960	207
1961–1970	200
1971–1980	192
1981–1990	181
1991–2000	160
2001–2003	148
All EGH in Canada	203
R-2000	103

FIGURE 4-6: Number of Eligible R-2000 Housing Starts, 1990 to 2002

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Number of R-2000 housing starts	504	519	1074	152	726	623	470	488	282	250	280	268	374

FIGURE 4-7: National Trends in Air Leakage in Houses (R-2000 and EnerGuide for Houses), 1985 to 2002

Year built	Average air changes per hour at 50 pascals
1985–1987	5.3
1988–1990	5.1
1991–1993	4.5
1994–1996	4.4
1997–1999	3.6
2000–2002	3.5
R-2000	1.1

FIGURE 4-8: Evaluations Under EnerGuide for Houses (number of houses)

Year of EGH evaluation	2002–2003	2001–2002	2000–2001	1999–2000	1998–1999
Houses retrofitted (B evaluation)	1153	709	607	225	832
Houses evaluated but not re-evaluated (A evaluation)	16 564	11 087	11 509	9106	3672

Note: Under EnerGuide for Houses, homes are evaluated to determine the potential for energy savings (an A evaluation). After renovations implementing program recommendations have taken place, some homes are revisited to determine the actual energy savings (a B evaluation).

FIGURE 4-9: Residential Energy Use and Energy Savings per Household (gigajoules per year per house)

Period of construction	Pre–1945	1945–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2002	**Average**
Energy use pre-evaluation	286	216	205	203	201	181	168	**215**
Evaluation-identified energy savings	111	74	65	66	53	39	40	**70**
Actual energy savings after renovations	64	41	40	37	32	28	29	**41**

FIGURE 4-10: Share of Residential Energy Consumption Subject to *Energy Efficiency Regulations*, 2001 (petajoules)

	Regulated	Unregulated
Space conditioning	555.19	237.23
Water heating	293.25	2.76
Appliances and lighting	120.268	127.928
Total	**968.708**	**367.918**

FIGURE 4-12: Average Energy Consumption of New Appliances, 1990 and 2001 Models (kilowatt hours per year)

Appliance type	1990	2001
Freezers	714	384
Ranges	772	763
Dishwashers	1026	634
Refrigerators	956	559
Clothes dryers	1103	916
Clothes washers	1218	810

FIGURE 4-14: Impact of EnerGuide Labelling: Total Energy Savings and GHG Emissions Reductions Attributable to EnerGuide for Equipment, 1990 to 2000

Year	Total energy savings (GWh)	GHG reductions (kt CO_2e)
2000	91.1	49.3
1999	83.8	45.4
1998	62.4	33.8
1997	46.7	25.3
1996	43.7	23.7
1995	40.3	21.8
1994	43.2	23.4
1993	41.9	22.6
1992	40.1	21.7
1991	21.7	11.8
1990	16.4	8.9
Cumulative Annual	**531.3**	**287.7**

FIGURE 5-1: Commercial and Institutional Energy Use by Building Type, 2001

Building type	Energy use (petajoules)	Percent
School	89.24	8.53
Health care institution	102.70	9.82
Religious institution	15.36	1.47
Other institution	51.29	4.90
Office	340.53	32.56
Retail organization	222.76	21.30
Hotel and restaurant	84.03	8.03
Recreational facility	64.54	6.17
Warehouse	75.53	7.22
Total	**1045.98**	

FIGURE 5-2: Commercial and Institutional Energy Use by Purpose, 2001

Purpose	Energy use (petajoules)	Percent
Space heating	565.84	53
Water heating	70.37	7
Auxiliary equipment	79.20	8
Auxiliary motor	121.16	12
Lighting	154.02	15
Space cooling	55.41	5
Total	**1046.00**	

FIGURE 5-3: Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001 (index 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	1.05	1.06	1.11	1.11	1.13	1.15	1.14	1.11	1.15	1.26	1.25
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.13	1.15	1.09	1.13	1.24	1.22

FIGURE 5-4: Energy Use in Commercial Buildings, 1999

	Megajoules per m^2 per year
C-2000 projects	553
CBIP target	829
Model National Energy Code	1105
New buildings*,**	1328
All buildings**	1585

*1990–1999

**Source: Commercial and Institutional Building Energy Use Survey, 2000. Estimates relate only to the surveyed area of populations over 175 000 and in Atlantic Canada populations over 50 000.

FIGURE 5-5: Estimated Average GHG Reductions by Institution Under CBIP, 2002 to 2003

Building type	Average GHG savings (tonnes per year)
Other	121.2
Multi-unit residential building	70.4
Retail	144.9
Office	119.7
Health	221.0
Education	300.3

FIGURE 6-1: Industrial Energy Use by Subsector, 2001

	Energy use (petajoules)	Percent
Pulp and paper	880.1	28.7
Other manufacturing	549.1	17.9
Mining	521.6	17.0
Petroleum refining	311.3	10.2
Smelting and refining	246.1	8.0
Iron and steel	224.5	7.3
Chemicals	201.3	6.6
Cement	63.5	2.1
Construction	47.8	1.6
Forestry	18.3	0.6
Total	**3063.6**	

FIGURE 6-2: Cost of Energy to Industry as a Percentage of Total Production Cost, 2001

Industry subsector	Energy cost/ Total production cost (percent)
Cement	38.49
Chemicals	13.75
Pulp and paper	13.32
Aluminum	13.12
Iron and steel	12.48
Petroleum refining	2.18
Transportation equipment manufacturing	0.84

Note: These reflect as accurately as possible the current definitions in the QRESD.

FIGURE 6-3: Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1995 to 2001 (index: 1995 = 1.0)

	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	1.00	1.04	1.05	1.10	1.14	1.11
Actual energy use	1.00	1.03	1.03	1.01	1.04	1.07	1.03

FIGURE 6-4: Industrial Energy Innovators and Action Plans, 1999–2000 to 2002–2003

	1999–2000	2000–2001	2001–2002	2002–2003
Number of active Innovators	15	53	24	77
Number of Innovators with action plans	79	105	134	94

FIGURE 6-5: Mean Five-Year Increases in Energy Consumption, CIPEC Participants vs. Non-Participants

	Percent
Participants	2.2
Non-participants	5.2

FIGURE 6-6: Level of Participation in Elements of CIPEC

CIPEC element	Percent of CIPEC participants
Heads Up CIPEC newsletter	59
CIPEC Web site	45
Dollars to $ense workshops	42
Boiler and heater guide	25
Motor systems assesment	25
Sector energy efficiency guide	25
Employee awareness kit	23
Sector benchmarking studies	20
CIPEC Task Force meetings	18
Energy sector days	10

FIGURE 6-7: Estimated Reduction in CO_2 Emissions From Motor Regulations, 2000 to 2020

	2000	2005	2010	2020
Reduction in CO_2 emissions (Mt)	0.56	1.33	2.03	2.14

FIGURE 7-1: Transportation Energy Use by Mode, 2001

	Energy use (petajoules)	Percent
Passenger light vehicle	1030.6	45.25
Passenger bus	64.2	2.82
Passenger aviation	218.7	9.60
Passenger rail	3.0	0.13
Freight truck	675.9	29.68
Freight marine	123.2	5.41
Freight rail	78.7	3.46
Off-road	83.1	3.65
Total	**2277.4**	

FIGURE 7-2: Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 2001 (index 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use without energy efficiency improvements	1.00	0.97	0.99	1.03	1.10	1.13	1.16	1.21	1.25	1.29	1.32	1.31
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.17	1.20	1.22	1.21

FIGURE 7-3: Market Shares of New Passenger Car and Light Truck Sales, 1990 to 2001 (percent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Passenger car market share	75.8	76.3	75.3	72.8	70.4	68.4	65.8	62.8	62.7	63.5	64.4	65.1
Light truck market share	24.1	23.7	24.7	27.2	29.6	31.6	34.2	37.2	37.3	36.5	35.6	34.9

FIGURE 7-4: New-Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 2000 (index 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
L/100 km	1.00	1.00	1.01	1.00	1.00	0.99	0.97	0.98	0.96	0.99	0.97
L/100 km/kg	1.00	1.00	1.01	0.99	0.96	0.91	0.92	0.93	0.92	0.91	0.90
L/100 km/hp	1.00	0.98	0.95	0.93	0.91	0.85	0.82	0.82	0.79	0.79	0.76

FIGURE 7-5: Company Average Fuel Consumption (CAFC) vs. Canadian Voluntary Standards (litres/100 km)

Model year	Truck standard (11.4 L/100 km)	Trucks CAFC	Car standard (8.6 L/100 km)	Cars CAFC
1990	11.8	11.4	8.6	8.2
1991	11.6	11.1	8.6	8.0
1992	11.6	11.3	8.6	8.1
1993	11.5	11.1	8.6	8.1
1994	11.5	11.5	8.6	8.2
1995	11.4	11.5	8.6	7.9
1996	11.4	11.3	8.6	7.9
1997	11.4	11.3	8.6	8.0
1998	11.4	11.4	8.6	7.9
1999	11.4	11.3	8.6	7.9
2000	11.4	11.1	8.6	7.7
2001	11.4	11.1	8.6	7.9
2002	11.4	11.1	8.6	7.9

FIGURE 7-6: Vehicle Fuel Efficiency Awareness (percent)

Year	Awareness of program activities (general public)	Recollection of information on how to reduce vehicle fuel consumption (general public)	New vehicles in showroom with EnerGuide label	New vehicles on lot with EnerGuide label
1998	9	30	0	0
1999	0	0	47	64
2001	0	0	56	77
2002	16	36	0	0

FIGURE 7-7: Number of New Drivers Educated Using the Auto$mart Student Driving Kit

Year	Number of new drivers educated
1997–1998	92 700
1998–1999	105 975
1999–2000	120 600
2000–2001	147 150
2001–2002	171 225
2002–2003	204 975

FIGURE 7-9: Drivers Trained and Participation in the Fleet Vehicles Initiative

Year	Drivers trained	FV members
1997–1999	51 000	946
1999–2000	53 000	1068
2000–2001	112 846	1643
2001–2002	125 000	2707
2002–2003	149 000	2805

FIGURE 8-1: Canadian Wind Power Capacity, 1990 to 2002 (MW)

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	0	0	19	19	20	20	21	24	124	137	214	230

FIGURE 9-1: GHG Emissions Reductions From Federal Operations*

	1990	1998	2000	2001	2002	2010 Target
GHG emissions (kt CO_2e)	3950	3184	3064	2987	n/a**	2742

* All values have changed as a result of a change to the 1998 baseline.
** Data are not yet available for 2002/2003 fiscal year.

FIGURE 9-2: Annual Energy Savings From the FIBP, 1991–1992 to 2002–2003

	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003
Terajoules per year	20	50	40	70	90	80	77	77	93	103	112	117

FIGURE 9-3: Federal Fleet Size and Fuel Consumption, 1995–1996 to 2001–2002

	1995–1996	1997–1998	1999–2000	2001–2002
Number of vehicles	24 854	22 796	22 462	23 313
Litres of gasoline equivalent (thousands)*	88 725	75 684	78 281	63 300

*Gasoline equivalent is computed by dividing the lower heating value of the alternative fuel by the lower heating value of gasoline and multiplying this result by the alternative fuel consumption value.

FIGURE 9-4: Purchases of ATF Vehicles for the Federal Fleet, 1997–1998 to 2001–2002

	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002
Number of vehicles	131	161	181	180	126

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