1999 – 2000

Improving Energy Performance in Canada

Report to Parliament under the *Energy Efficiency Act*

Natural Resources Canada
Ressources naturelles Canada
Canada

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, 2000, in accordance with section 36 of the Act.

Respectfully submitted,

Ralph Goodale
Minister of Natural Resources

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Minister's Foreword

This seventh report under the *Energy Efficiency Act* describes what Natural Resources Canada (NRCan) has done to help improve Canada's energy efficiency. From 1990 to 1998, Canada's energy efficiency improved by 6.1 percent, saving Canadians almost $5 billion per year and reducing annual greenhouse gas emissions by some 25 megatonnes.

As a northern nation with a large landmass and a high standard of living, Canada is a heavy energy user. Our use of energy has a great impact on the environment, adding to greenhouse gas emissions that contribute to climate change. Our international commitment is linked, in part, to our energy performance – to how we use energy and the types of energy we consume.

It is important, therefore, that we use energy more responsibly. This applies to each and every one of us – how we heat our homes and how we drive our cars – as well as to Canadian businesses and public institutions. We must all turn to energy-efficient appliances, buildings and cars, and alternative and renewable energy sources. NRCan makes key contributions to improving Canada's energy performance through initiatives related to energy efficiency, renewable energy and alternative transportation fuels. These programs encourage and help Canadians improve their energy use through information, training, incentives, and innovative research and development.

Last year, the Government of Canada committed more than $1.1 billion over the next five years to climate change initiatives, many of them energy-efficiency and alternative-energy measures, to reduce the greenhouse gas emissions from our energy use.

The Government of Canada will continue to lead Canada's efforts to improve its energy performance, putting the tools in place to meet today's energy demands, while building a higher quality of life. And we will continue to work with our partners to ensure that Canada is the world's smartest energy developer and user, and a living model of sustainable development.

Ralph Goodale

Executive Summary

This seventh Report to Parliament under the *Energy Efficiency Act* reviews the progress of the energy efficiency and alternative energy (EAE) initiatives of Natural Resources Canada (NRCan) during the 1999–2000 fiscal year. These initiatives are a critical foundation on which Canada can expand its national implementation strategy on climate change.

NRCan's EAE initiatives are designed to reduce greenhouse gas (GHG) emissions by lessening the amount of energy required for a given level of service (energy efficiency), or by replacing some carbon-intensive energy sources with energy generated from sources that produce fewer or no GHG emissions, such as wind power or small hydro power (alternative energy). During 1999–2000, NRCan's EAE initiatives used six policy instruments to pursue these objectives:

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

This report contains many quantified indicators of the progress of NRCan's initiatives in improving energy use. Since many factors affect energy consumption, it is not always possible to establish a clear causal link between changes in energy use and NRCan's EAE initiatives; more work needs to be done in this area. Future reports will present further refinements of these indicators and additional indicators.

This report deals with secondary energy use, which is the consumption of energy in the residential, agricultural, commercial and institutional, industrial and transportation sectors (it does not address the consumption of energy to produce and deliver energy to the marketplace or to convert energy from one form to another). Secondary energy use totalled 7665 petajoules in 1998. The industrial sector was responsible for 39 percent of this energy use, followed by the transportation sector (28 percent), the residential sector (17 percent), the commercial sector (12 percent) and the agricultural sector (3 percent). Almost $82 billion, or 9 percent of the country's gross domestic product, was spent on secondary energy in Canada during 1998.

Secondary energy use – including emissions produced indirectly by power generators to meet end-use demand for electricity – produces about 66 percent (451 megatonnes) of total greenhouse gas (GHG) emissions in Canada. Between 1990 and 1998, secondary energy use increased by 9.2 percent. However, related GHG emissions increased by over 10 percent, because of a 1.1 percent increase in the GHG intensity of energy use. NRCan estimates that there was an improvement in energy efficiency of more than 6 percent between 1990 and 1998; although this was more than offset by changes in activity levels (hence the rise in energy consumption). This improvement in energy efficiency represents an annual saving for Canada of almost $5 billion in expenditures on energy, and an annual reduction in GHG emissions from secondary energy use of approximately 25 megatonnes.

This report includes introductory chapters on the policy context of EAE programs, a description of the *Energy Efficiency Act* and *Energy Efficiency Regulations*, and trends since 1990 in energy use, energy efficiency and GHG emissions. These are followed by chapters on each energy use sector, with a discussion of energy use and energy efficiency, and descriptions of initiatives, achievements and progress indicators. The report concludes with chapters on renewable and community energy, and NRCan's intergovernmental co-operation in EAE matters.

Quantifiable indicators have been used where possible in the report. Between 1990 and 1999, significant progress has been achieved, as indicated in the following section.

Selected Programs and Progress Indicators

The Act and Regulations

Energy Efficiency Regulations

- Residential sector: energy efficiency gains of 18 to 45 percent for household appliances since 1990.
- Commercial sector: lighting regulations estimated to save 10 petajoules of electricity by 2000 (equals 2.3 percent of electricity use by this sector in 1998).
- Industrial sector: changes to electric motor regulations estimated to save 16.3 petajoules by 2010 (equals 2.1 percent of electricity use by this sector in 1998).

Residential Sector

R-2000 HOME Program

- An R-2000 house costs 38 percent less to heat than a conventional new house.

EnerGuide for Houses

- Performed energy efficiency evaluations on more than 9500 houses (equals 0.08 percent of Canadian households), with homeowners reducing energy consumption by 13 percent through recommended measures (1999–2000).

Reno$ense

- Persuaded partners to contribute funding – ten times that of NRCan – in order to distribute across Canada over 600 000 copies of the 20-page "Energy Fitness Guide for Your Home" (1999–2000).

Refrigeration and Intelligent Buildings Program

- Quebec's Agence de l'efficacité énergétique and the Association des arénas du Québec agreed to NRCan's proposal to undertake an energy efficiency program for obsolete and inefficient refrigerator systems in the province's ice arenas. The program will provide technological innovation, assistance and training.

Commercial and Institutional Sector

Commercial Building Incentive Program

- Approved grants for 34 building designs that would use 30 percent less energy on average than designs based on the *Model National Energy Code for Buildings* (1999–2000).

Energy Innovators Initiative

- 584 organizations have been recruited into the program. They represent 25.3 percent ($2.4 billion) of the total energy bill of the commercial and institutional sector.
- Since its introduction in April 1998, the Energy Innovators pilot retrofit incentive has contributed $8.6 million of federal funds to stimulate a twenty-four-fold investment ($206 million) by Energy Innovators. The resulting projects are expected to reduce energy costs by $19 million per year and GHG emissions by 161 kilotonnes per year.

Federal Buildings Initiative

- Total investment in FBI projects of $180 million, with estimated annual energy savings of $24 million.

Federal Industrial Boiler Program

- Since 1991–1992, increased the annual level of energy savings to almost 600 terajoules, the equivalent of the annual energy use of almost 250 000 new refrigerators.

Industrial Sector

Industrial Energy Efficiency Initiative

- Recruitment of 254 Industrial Energy Innovator companies, representing 74 percent of industrial energy use.
- During 1990 to 1998, 27 of the 39 industrial sectors improved their energy efficiency. Five sectors had efficiency gains of 37 to 55 percent.
- During 1990 to 1999, the energy intensity of the 21 CIPEC task forces improved on average by 2 percent per year.

Industry Process Integration

- NRCan transferred to Cascades Inc. software it developed to reduce water consumption and energy use. A network optimization study using the software at a Cascades pulp and paper mill demonstrated the possibility of reducing water consumption by 80 percent and GHG emissions by up to 25 300 tonnes per year (1999–2000).

Processing and Environmental Catalysis

- NRCan proved the concept of a novel technology to convert low-grade heat to electricity using pyroelectric conversion. It is estimated to yield a 10-percent reduction in energy consumption for a typical pulp and paper mill (1999–2000).

Transportation Sector

Motor Vehicle Fuel Consumption Initiative

- Reduction of 2.4 percent in the fuel consumption of new light-duty vehicles between 1990 and 1999, despite increases in the weight and power of these vehicles.

EnerGuide for Vehicles

- A majority of car manufacturers introduced the new EnerGuide fuel consumption label for passenger cars, vans and light-duty trucks (1999–2000).

Alternative Transportation Fuels

- Increase in the number of stations selling ethanol-blended gasoline from 266 to 1140 between 1990 and 2000.

Transportation Energy Technologies Program

- NRCan helped organize and sponsor several vehicle "challenge" events for students to raise awareness of more climate-friendly vehicles and vehicle fuels, including the Electrathon, the Future Car Challenge, Sunrayce and the Ethanol Vehicle Challenge.

Renewable and Community Energy

Green Power Initiative

- The February 2000 Government of Canada budget expanded the pilot initiative to permit the procurement of $15 million of renewable energy over the next ten years for federal facilities in Saskatchewan and Prince Edward Island.

Renewable Energy Deployment Initiative

- Approved nine applications from Canadian businesses for renewable energy systems, representing investments of $0.5 million (1999–2000).

Renewable Energy Technologies Program

- The 600-kW Tacke wind turbine, erected in 1995 with NRCan support, achieved the milestone of supplying 5000 MWh to Ontario's power grid.

Renewable Energy and Hybrid Systems for Remote Communities Program

- The number of users of RETScreen®, a software program developed by NRCan to assess potential renewable energy projects at one tenth the cost of conventional analyses, increased to 10 000 individuals and organizations in 130 countries.

Intergovernmental Co-operation

Municipal

- The February 2000 Government of Canada budget provided $25 million for a Green Municipal Enabling Fund and $100 million for a Green Municipal Investment Fund under agreements with NRCan and Environment Canada. Both funds support energy and environmental projects by municipalities.

Provincial

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

International

- NRCan chairs the Steering Group on Energy Standards under the Asia–Pacific Economic Co-operation (APEC). The group has identified priority products to harmonize test standards within the APEC region and technical procedures to achieve this.

Introduction

Natural Resources Canada (NRCan) promotes the sustainable development and use of Canada's energy resources as part of the department's mandate. Significant to fulfilling this responsibility are NRCan's efforts to ensure Canadians of the economic and environmental benefits of improved energy efficiency and increased use of alternative energy sources. The Government of Canada's *Energy Efficiency Act* gives the Minister of Natural Resources the authority to promote energy efficiency and alternative energy (EAE). It also requires the Minister to table an annual report before Parliament on the administration and enforcement of the Act.

This is the seventh Report to Parliament under the *Energy Efficiency Act*. It covers NRCan's activities to promote energy efficiency and the use of renewable energy and alternative transportation fuels during the fiscal year, from April 1, 1999 to March 31, 2000.

Chapter 1 describes

- the policy context for NRCan's EAE activities;
- NRCan's strategy and policy instruments for encouraging Canadians to invest in greater EAE;
- NRCan's measures of progress in achieving greater EAE; and
- the Act, the *Energy Efficiency Regulations* and the program for developing and administering the Regulations for energy performance and labelling.

Chapter 2 outlines the connection between energy use and greenhouse gas (GHG) emissions and reports on changes in energy use, energy efficiency and GHG emissions from 1990 to 1998.

Chapters 3 to 6 address each of the energy use sectors, with descriptions of program initiatives, achievements and progress indicators.

Chapter 7 covers renewable and district energy initiatives.

Chapter 8 describes NRCan's intergovernmental (provincial-territorial, municipal and international) co-operation in EAE.

NRCan's EAE initiatives are managed by

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

Appendix 1 lists all of NRCan's EAE initiatives and expenditures in 1999–2000. Appendix 2 presents all of the data represented in the Figures in the report.

This report was prepared by the Office of Energy Efficiency, with contributions from CANMET's Energy Technology and Mineral Technology Branches, the Energy Resources Branch and the Canadian Forest Service.

Chapter 1

Policy Context and Legislation

Federal Policy and Programs on Energy Efficiency and Alternative Energy

Energy use has been a policy concern since the 1970s. Governments responded to the oil crises of 1973 and 1979 by promoting energy conservation to reduce reliance on imported oil. At that time, most consuming countries regulated energy prices at below world levels, making it unlikely that the marketplace would do much, if anything, to improve energy efficiency.

By the mid-1980s, world oil shortages had become world oil gluts. Governments believed that the marketplace, left alone, would attain an optimal level of energy efficiency improvements, and they deregulated energy prices and markets and phased out most energy conservation programs.

By the end of the 1980s, however, 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 mostly result from energy use) spurred a major expansion of federal programs designed to improve energy efficiency and increase the use of alternative energy sources, which took into account the need to

- ensure flexibility as programs mature and a clearer understanding develops of the opportunities for energy efficiency and alternative sources of energy;
- promote an internationally competitive Canadian industry and meet trade commitments; and
- meet other policy objectives, especially fiscal restraint.

The Energy Efficiency and Alternative Energy (EAE) program, launched by Natural Resources Canada (NRCan) in 1991, supports economically feasible increases in energy efficiency and the use of alternative energy sources. It encourages investment in corporate and consumer EAE opportunities and it seeks to engage all sectors of the economy and Canadian society in rethinking and improving energy use (see Appendix 1 for a listing of NRCan EAE program initiatives and expenditures in 1999–2000).

The EAE program uses a variety of policy instruments, including leadership, information, voluntary actions, financial incentives, research and development (R&D) and regulation. In all cases, it emphasizes partnership with stakeholders, such as other levels of government, the private sector and non-governmental organizations. In this manner, the program helps 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. On the supply side of the energy market, the program ensures that Canada participates in the development of technology for tapping renewable energy sources and alternative transportation fuels, as well as increasing the energy efficiency of the production of energy.

NRCan's EAE program also provides a foundation for long-term processes that can respond to evolving environmental and economic development priorities: enhanced statutory authority, improved data-gathering and analytical capabilities, and information and planning links with strategic allies.

In 1992, Canada signed and ratified the *United Nations Framework Convention on Climate Change*. Under this convention, Canada and other countries agreed to work to stabilize GHG emissions at 1990 levels by 2000. On February 20, 1995, federal and provincial ministers of energy and environment approved the National Action Program on Climate Change (NAPCC), which Canada tabled at the first meeting of the Conference of the Parties to the Framework Convention in Berlin, Germany, in April 1995. The NAPCC included the promotion of energy efficiency in all sectors of the economy as a key strategic element.

To broaden awareness of the need to act and reinforce the impetus to voluntary action, federal and provincial ministers of energy and environment agreed in February 1995 to establish the Climate Change Voluntary Challenge and Registry (VCR). It was incorporated in October 1997 under the name Canada's Climate Change Voluntary Challenge and Registry Inc. (VCR Inc.) as a non-government not-for-profit organization. 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 which is posted on the Internet.

The federal budget of February 1997 provided $60 million over three years, commencing April 1, 1998, 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.

In December 1997, Canada participated in the third Conference of the Parties to the Framework Convention on Climate Change, held in Kyoto, Japan. Participating countries agreed to reduce GHG emissions from 1990 levels within the period of 2008 to 2012. Canada pledged to reduce its emissions by 6 percent. The Kyoto Protocol applies to the six most important GHGs. Although carbon dioxide (CO_2) accounts for about 76 percent of Canada's GHG emissions, and its reduction is often considered the main solution to climate change, reducing the emissions of such gases as methane and nitrous oxide is important as well.

Countries tried to reach agreement on the operating rules for the implementation of the Kyoto Protocol at the Sixth Conference of Parties (COP6) in The Hague in November 2000. At that meeting, consensus could not be reached on all issues and negotiations were suspended. COP6 negotiations resumed in Germany in July 2001, where political agreement was reached on major issues. Technical discussions will continue in Morocco in the fall of 2001 at COP7, and at other international meetings. 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 early 1998, the federal, provincial and territorial governments established a National Climate Change Process to examine the impact, costs and benefits of the Kyoto Protocol and the implementation options open to Canada. From the spring of 1998 to the winter of 1999–2000, the process engaged more than 450 experts from across Canada to examine the climate change challenge. Their recommendations were provided to governments to help develop a national climate change implementation strategy for consideration by federal, provincial and territorial governments in the fall of 2000. NRCan officials provided a great deal of support, analysis, advice and guidance to this National Climate Change Process.

In February 1998, the federal budget provided $150 million over three years for a Climate Change Action Fund to help Canada develop its response to the Kyoto Protocol. The fund has four components:

- *Public Education and Outreach* builds public awareness and understanding of climate change and encourages action to reduce GHG emissions;
- *Technology Early Action Measures* (TEAM) shares with the private sector the risk of demonstrating cost-effective technology projects that will lead to reductions in GHG emissions;
- *Science, Impacts and Adaptation* supports further research to advance our knowledge of the magnitude, rate and regional distribution of climate change and its impact on Canada, as well as helping to develop adaptation strategies;
- *Foundation Analysis* supports the National Climate Change Process and the analysis of options for reducing Canada's GHG emissions.

In April 1998, the Office of Energy Efficiency (OEE) was established within NRCan, with a mandate to renew, strengthen and expand Canada's commitment to energy efficiency, particularly in relation to the Kyoto Protocol. Programs delivered by the OEE target all

final energy consumers and emphasize partnerships and economic investments. Their objective is to overcome the market barriers posed by inadequate information and knowledge about energy efficiency and alternative transportation fuels, as well as to address institutional deterrents in energy-use markets and economic constraints facing energy users.

Under the direction of the Minister of Natural Resources, the OEE is also responsible for identifying opportunities for new and heightened energy efficiency measures. A National Advisory Council on Energy Efficiency assists in this work by providing advice and guidance to the OEE. The council comprises energy efficiency experts and leaders from all sectors of the economy. The OEE also reports annually on the state of energy efficiency in Canada and manages Canada's Energy Efficiency Conference, an energy efficiency technology products and services trade show, and Canada's Energy Efficiency Awards.

NRCan's Office of Energy Research and Development (OERD) coordinates and funds non-nuclear, energy-related R&D for the Government of Canada in partnership with 12 federal departments and agencies. Each, in line with its own mandate, lends their physical resources and expertise to study issues facing Canada's energy sector. As a response to climate change and, more specifically, Canada's Kyoto commitments, OERD, through the Program of Energy Research and Development (PERD), dedicates over 50 percent of its annual $53 million R&D budget to study options related to energy efficiency ($17 million) and alternative energy ($11 million). In addition, PERD directs some $4.4 million of its funding toward studies aimed at understanding climate change and developing mitigation or adaptation options related to it. The OERD also coordinates NRCan's response on energy science and technology (S&T) to government policy and program initiatives (for example, the Technology Innovation Strategy which forms part of the National Implementation Strategy on Climate Change).

In February 1999, the federal budget provided $1.6 million over three years to assist the Federation of Canadian Municipalities (FCM) to develop and implement the national Municipal Building Retrofit Program under a contribution agreement with NRCan. During 1999–2000, the FCM undertook market research on the municipal building stock, municipal energy efficiency and renewable energy activities, market barriers and energy efficiency opportunities. The survey results provide the basis for the business plan of the program, under which the FCM will help municipalities identify, develop, finance and implement comprehensive building energy retrofits.

In January 2000, federal, provincial and territorial ministers of energy and the environment (Joint Ministers' Meeting, or JMM) announced the Baseline Protection Initiative as one of the first major policy initiatives to be taken under Canada's National Implementation Strategy on Climate Change. Baseline protection will ensure that participants will not be disadvantaged for their early actions to reduce GHG emissions if a future policy initiative based on past emissions levels is adopted. Through baseline protection, Canadian legal entities will be able to register eligible actions taken since 1990 so that the emissions reductions realized from these actions can be included or "protected" in their emissions baseline. Since January, NRCan has managed a consultative process related to the design of this initiative on behalf of Canada's National Climate Change Process. The rules of baseline protection are expected to be finalized and the system opened to accept registrations during the 2000–2001 fiscal year.

The February 2000 budget provided funding for several EAE initiatives:

- It extended for another three years the $20-million annual funding for the four EAE initiatives announced in the February 1997 budget (see above);

- It provided funds for a Green Municipal Enabling Fund (GMEF) and a Green Municipal Investment Fund (GMIF) under agreements with NRCan and Environment Canada. The Federation of Canadian Municipalities (FCM) will manage the two funds:
  - The GMEF is a $25-million endowment, available for five years, to contribute to feasibility studies to assess the technical, engineering, environmental and/or economic viability of proposed energy and environmental projects in municipal operations.
  - The GMIF is a $100-million endowment to operate in perpetuity, to provide loans and loan guarantees to eligible recipients to carry out energy and environmental projects. The GMIF will also provide grants and long-term loans for pilot projects that demonstrate innovative technologies and/or processes in applications with an investment payback in excess of ten years.

Building on a successful initial purchase of green power in Alberta, the budget expanded the pilot initiative to permit the procurement of $15 million of renewable energy over the next ten years for federal facilities in Saskatchewan and Prince Edward Island. The budget also indicated that the Government of Canada will strive to increase its purchases of green energy for federal facilities located in all regions of Canada.

This report covers progress in energy efficiency and alternative energy measures in operation during the Government of Canada's 1999–2000 fiscal year. Achieving the Kyoto targets will not be easy, but NRCan's initiatives under the *Energy Efficiency Act* provide a firm base for building the necessary additional initiatives.

Energy Efficiency Strategy

Most of NRCan's EAE initiatives deal solely with energy efficiency. These initiatives are presented in chapters 3, 4, 5 and 6 by end-use sector – residential, commercial and institutional, industrial and transportation. The goal of these initiatives 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 more energy-efficient buildings, equipment, systems and vehicles;
- ensuring that energy-consuming equipment is used in the most energy-efficient way (e.g., furnaces are kept well-tuned and vehicles are operated at optimal speeds);
- influencing the energy-use practices of individuals and organizations (e.g., persuading people to walk, cycle or use public transit, instead of driving their own vehicles); and
- developing technologies to give consumers, industry and communities new opportunities to improve energy efficiency.

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 to 1990 levels or below will probably require fundamental changes in how we produce and use energy. We will have to make considerably greater use of alternative energy sources, and continue to make changes in how we use energy.

Alternative energy includes renewable sources other than large hydro-electric facilities (e.g., bioenergy and solar energy), new applications of conventional sources (e.g., natural gas or propane used as a transportation fuel) and new fuels such as hydrogen for vehicles powered by 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 electricity in Canada. Some technologies, especially those involving the use of forestry biomass and propane and natural gas in vehicles, are already commercially available and accepted. Some have found applications in specialized markets, such as remote communities. Other technologies are still in the early stages of development. Chapters 6 and 7 describe what NRCan is doing to help develop alternative sources of energy and encourage their use.

NRCan's activities emphasize the most technically promising and marketable alternative transportation fuels, such as propane, natural gas and alcohol. Federal initiatives are helping to expand the infrastructure (e.g., fuelling stations) for the sale of these 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. Program areas include

- the development of alternative fuels and advanced propulsion systems – gaseous fuels, alcohols, hydrogen, fuel cells, electric vehicles and hybrids and related systems;
- advanced energy storage systems – lightweight cylinders, adsorption technologies and flywheels;
- emissions control technologies – for diesel and alternatively fuelled engines, lean burn catalysts and enhanced combustion chamber design;
- vehicle transportation systems efficiency – advanced materials and processes, driving cycle analysis, auxiliaries and regenerative braking systems; and
- fuelling infrastructure – fuelling station hardware, hydrogen systems and battery charging systems.

It is generally recognized that renewable sources of energy, such as hydraulic, biomass, wind and solar energy, can do much to mitigate climate change. NRCan allocates most of its support for renewable energy to R&D to reduce costs, improve performance, develop safety and performance standards, and increase the scope of renewable energy technologies. The department also provides modest incentives for investments in renewable energy systems, disseminates information to consumers and assesses economic and environmental aspects of renewable sources of energy.

In 1996, NRCan released its *Renewable Energy Strategy – Creating a New Momentum*, a strategy to promote a strong and viable renewable energy industry in Canada. The strategy calls for the department to act as a catalyst in the development and marketing of renewable energy technologies. It aims to improve the environmental performance of the energy sector and to enhance the sustainability and diversity of Canada's energy mix. The Government of Canada will continue to support R&D to advance renewable energy performance and reduce costs. It will continue its information activities and support the deployment of renewable energy technologies to expand consumer awareness and market acceptance of alternative energy sources.

Under the strategy, NRCan launched a Green Power Initiative, under which the department is displacing some of its electricity purchases away from sources that emit GHGs to those that produce power from renewable energy sources.

Policy Instruments

NRCan's key policy instruments are

- 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 the energy efficiency and use of alternative energy in Government of Canada operations.

Information

NRCan disseminates energy efficiency information to consumers, using methods that range from broad distribution (see "NRCan Information Dissemination") to individual consultations with clients. The method depends on the client.

NRCan Information Dissemination

NRCan's broad range of marketing and communications activities aim to

- increase awareness among Canadians of the environmental impact of energy use; and
- encourage consumers to increase the efficiency of their energy use and switch to alternative sources of energy.

These activities include publications, exhibits, advertising, toll-free lines, conferences, Web sites, workshops and promotional products.

NRCan disseminates EAE information to the general public as well as to more specific audiences. It makes information available through a wide range of products on such topics as home and industrial energy efficiency, energy technology, renewable energy, heating systems, appliances, new buildings, energy-efficient transportation and alternative and future transportation fuels.

While NRCan organizes and participates in a wide range of EAE-related conferences each year, in May 1999 it held Canada's first-ever national conference, trade show and awards program on energy efficiency in Ottawa, Ontario. Canada's Energy Efficiency Conference brought together national and international experts from business, industry and government to explore opportunities to improve energy use to help meet Canada's international climate change commitments. More than 500 delegates attended the conference. Canada's Energy Efficiency Awards attracted 160 submissions and conferred awards to 15 winners in six categories. More than 60 exhibitors were featured in Canada's Energy Efficiency Trade Show.

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 (e.g., buildings, vehicles, equipment) are important determinants of energy use. In a typical initiative, a company or institution (or a group of companies or institutions) will volunteer or agree to take action to save money and reduce environmental impacts. 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 natural gas vehicles and refuelling infrastructure.

Regulation

Regulation involves setting energy performance levels and labelling requirements for certain types of equipment and working with provincial governments to improve the energy efficiency provisions in Canadian building codes.

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) imported or shipped from province to province. The Act also gives the Government of Canada the authority to establish regulations for the collection of statistics and information on energy use and alternative energy.

Research and Development

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

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 Program of Energy Research and Development (PERD). PERD and TEAM are the only federal interdepartmental S&T investment funds focused on the energy sector and its economic and environmental effects.

Figure 1 shows how these policy tools work together to increase energy efficiency, that is, how they help to reduce the amount of energy needed to obtain a certain level of service.

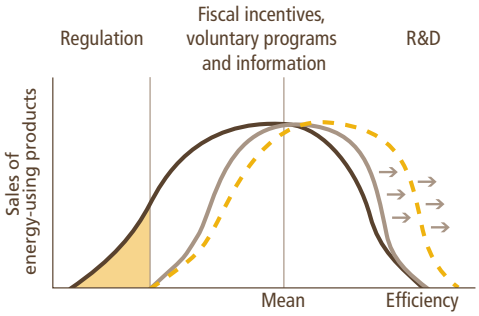
Measuring Progress

The primary goal of NRCan's EAE initiatives is to change energy consumption patterns to obtain environmental and economic benefits. To assess progress, three aspects of program delivery must be considered:

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

Program outputs are the items that a program produces regularly, such as information and marketing materials, training, demonstration projects, voluntary agreements, technology development, financial incentives and regulations. Program outputs are designed to lead to *program outcomes* – namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase more energy-efficient appliances than they would if there had been no program.

FIGURE 1
Moving the Market



Since program outcomes 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, in terms of changes in energy efficiency, energy intensity, the use of alternative energy and GHG emissions. An example of 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, this could lead to a decline in GHGs.

Measuring program and market outcomes can be 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 (see box on following page) helps the department track changes in energy consumption at a disaggregated level. Nevertheless, it is still difficult to determine the incremental effects of programs because other factors, such as a change in energy prices, also influence these effects. Moreover, because several programs can affect a consumer at the same time, it is difficult to determine the separate contribution of each program to the total effect.

Recent implementation of results-based management of the PERD will provide better information on the results of its energy science and technology investments.

This report uses a mix of progress indicators, which are quantitative where possible. However, the reader should bear in mind that it is difficult to determine incrementality and attribution when reviewing the outcome indicators. The challenge for NRCan is to continuously improve the coverage and quality of these progress indicators.

The *Energy Efficiency Act* and Regulations

The Act

The *Energy Efficiency Act*, which came into force on January 1, 1993, gives the Government of Canada the authority to make and enforce regulations concerning the EAE program, primarily

- energy performance levels for energy-using products, doors and windows that are imported into Canada or shipped from one province to another;
- energy labelling of energy-using products, doors and windows that are imported into Canada or shipped from one province to another (NRCan's energy labelling initiatives are described in Chapter 3, "Residential Sector"); and
- the collection of statistics and information on energy use and alternative energy.

Under the Act, before a prescribed product is imported into Canada or shipped from one province to another, the dealer must submit an energy efficiency report that describes the product and its energy performance. Also, dealers that import prescribed products must provide the Canada Customs and Revenue Agency (CCRA – formerly Revenue Canada) with an extra copy of the customs release documents, which indicate the nature of the products and the purpose of importation. The copy is forwarded to NRCan for compliance verification.

National Energy Use Database

NRCan launched the National Energy Use Database (NEUD) to improve its knowledge of energy consumption and energy efficiency at the end-use level in Canada and to support its analytical expertise. By improving NRCan's understanding of where and how energy is used in Canada, the database reveals opportunities to improve energy efficiency. Over time, the NEUD helps track the effectiveness of the programs designed to address these opportunities. In these ways, the database supports national efforts to mitigate the impact of energy use on the environment.

In conjunction with partners in government and the academic community, the OEE supports the development of energy end-use data in all sectors of the economy and the expansion of Canada's expertise in analysing energy use by

- reviewing existing data in each end-use sector (residential, agricultural, commercial and institutional, industrial and transportation);
- assessing the information needs in each sector;
- expanding existing surveys or creating new ones to meet these data needs; and
- managing a network of energy end-use data analysis centres for specific sectors at selected universities across Canada.

The NEUD has funded several surveys to collect data on energy consumption at the end-use level, the characteristics of energy-using equipment and buildings, the attitudes of Canadian consumers toward energy use and the adoption of energy-efficient technologies. To further support analytical requirements, NEUD is undertaking a new survey on energy use and characteristics of buildings in the commercial sector, and is collecting information on major household appliances in Canada.

The OEE created a detailed end-use analysis framework that contributes to historical reviews of energy efficiency in Canada (such as *Energy Efficiency Trends in Canada*), as well as prospective analyses of energy use (such as *Canada's Energy Outlook*).

The Minister of Natural Resources has the authority to designate inspectors to ensure compliance with the Act and Regulations. In addition, the Governor in Council may make regulations regarding

- testing of energy-using products;
- detention, disposition or destruction of seized goods;
- exemptions; and
- implementation of the provisions of the Act.

The Regulations

The purpose of the *Energy Efficiency Regulations* is to eliminate less efficient energy-using equipment from the Canadian market by establishing minimum energy performance levels.

Regulations under the *Energy Efficiency Act* prohibit the import of and interprovincial trade in energy-using products that fail to meet a prescribed level of energy efficiency. NRCan establishes the products and levels after conducting energy and economic analyses and consulting with stakeholders. The major stakeholders are the provincial and territorial governments, manufacturers of energy-using equipment and their associations, energy utilities and public interest groups. In choosing products to regulate and their efficiency levels, NRCan is guided by the following considerations:

- energy savings;
- economic attractiveness;
- impact on Canadian manufacturers; and
- harmonization with other jurisdictions, especially the provinces and the United States.

The Regulations state the required performance level and testing procedures for specific products. NRCan helps develop these standards when it funds and participates in standards-writing committees, under the auspices of CSA International.

Regulations under the federal *Energy Efficiency Act* complement energy efficiency regulations in British Columbia, New Brunswick, Nova Scotia, Ontario and Quebec for products sold in these provinces. They also parallel regulations in the United States. The performance levels for products covered by the federal Regulations are largely harmonized with those prescribed in provincial regulations for the same products.

The main compliance activities of the program are monitoring the industry and enforcing the Regulations. To detect noncompliance, NRCan monitors the industry through various means. The Regulations set out the two elements of the compliance system:

- Verification Mark – A certification organization must verify the energy performance of products to ensure they meet energy performance levels set out in the Regulations. A province may also verify the energy performance of a product if the province's energy performance requirements meet or exceed those of the Government of Canada. No one can sell or lease the product until it has a verification mark.
- Customs Release Documents – Dealers who import a prescribed product must submit customs clearance documents to the CCRA, which sends NRCan a copy of the completed document.

NRCan's approach to compliance is set out in the "Compliance Policy for the *Energy Efficiency Act* and the *Energy Efficiency Regulations*," released in March 1995. Several key elements of the compliance system are set out below:

- Monitoring imports – The Act and the Regulations require that dealers report the energy performance of prescribed products to NRCan before importing these products. NRCan ensures that the products meet performance requirements. Officials follow up on cases of noncompliance or incomplete customs information.

- Third-party monitoring – Third-party monitoring of affected industries is the responsibility of independent certification organizations accredited by the Standards Council of Canada, such as CSA International, Underwriters Laboratories Inc. and Intertek Testing Services.
- Inspections – NRCan conducts periodic marketplace audits.

NRCan has produced a comprehensive *Guide to Canada's Energy Efficiency Regulations*, as well as fact sheets on several topics. These documents are available on the OEE Web site (http://oee.nrcan.gc.ca).

Compliance Achievements 1999–2000

- NRCan and the CCRA processed records relating to the importation into Canada in 1999–2000 of over 102 million prescribed products.
- NRCan conducted a testing program for dehumidifiers which confirmed their compliance with new requirements as of January 1999.

Regulatory achievements related to specific products are set out in Chapters 3, 4 and 5.

Chapter 2

Energy Use and Greenhouse Gas Emissions in Canada

Introduction

Canadians enjoy an abundance of energy from a variety of sources. Our high standard of living is partly attributable to our having a reliable supply of energy, which is available at a reasonable cost.

Owing to this abundant supply of energy, Canada has developed industries with particularly strong energy demands. This comparative advantage in the supply of energy has also helped Canadians deal with the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. As a result, Canada consumes more energy per capita than most countries.

The amount of money spent on energy indicates its importance to this country and its economy. Canadians spend almost $82 billion per year on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes (this comprises secondary energy use, explained under "Energy Use and Greenhouse Gas Emissions"). This represents over 9 percent of our gross domestic product. Although the economic importance of energy varies from region to region, energy is always fundamental to our way of life.

Energy Use and Greenhouse Gas Emissions

We typically speak of two types of energy use: primary and secondary. Primary energy use represents the total requirements for all users of energy, energy in transforming one energy form to another (e.g., coal to electricity) and energy used by suppliers in providing energy to the market (e.g., pipeline fuel). 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 over 11 percent between 1990 and 1998, from 9742 petajoules to 10 826 petajoules.

Secondary energy use (7665 petajoules) accounted for almost 71 percent of primary energy use in 1998. It was responsible for about 66 percent (451 megatonnes) of total GHG emissions in Canada, if we include indirect emissions – namely, those produced by electric utilities to meet end-use electrical demand. This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Carbon dioxide is the major greenhouse gas (GHG), representing the majority of Canada's GHG emissions. All subsequent references to CO_2 and GHG include both emissions from the electricity used by secondary energy users and those attributable directly to secondary energy use.

Secondary energy use increased by 9.2 percent from 1990 to 1998, but GHG emissions attributable to secondary energy use increased by over 10 percent, because of a 1.1 percent increase in the GHG intensity of energy users. By 1998, the oil share of secondary energy use had fallen by 0.2 percentage points from 1990 levels, from 36.6 percent to 36.4 percent,

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 Emission 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 D of NRCan's *Energy Efficiency Trends in Canada 1990–1998*.

and the natural gas share declined from 25.3 percent to 25.1 percent. The electricity share increased slightly and the share of other fuels, mainly biomass, also increased.

The industrial sector is the largest energy user, accounting for 39 percent of total secondary energy use in 1998. The transportation sector is the second-largest energy user at 28 percent, followed by the residential sector at 17 percent, the commercial and institutional sector at 12 percent and the agricultural sector at 3 percent.

Energy Efficiency

NRCan annually publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use (and GHG emissions) since 1990 and the contribution of key factors to this change in energy use – variations in activity, structure, weather and efficiency:

- 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 towards 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. The weather effect is most significant in the residential and the commercial and institutional sectors, where heating and cooling requirements account for the major share of energy use; and
- *energy efficiency* – the amount of energy used to provide a given level of service.

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 there are other factors affecting energy use that 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 that have not been captured.

Secondary energy use increased by 9.2 percent between 1990 and 1998 (from 7018 to 7665 petajoules). Two factors contributed to this increase (see Table 1):

- activity (economic growth) raised secondary energy use by 15.4 percent (1080 petajoules); and

TABLE 1
Explanation of Changes in Secondary Energy Use, 1990 to 1998

	Sectors						
	Residential	Commercial-Institutional	Industrial	Transportation	Agriculture	Total	% Change
1990 Energy Use (PJ)	1319	867	2755	1878	199	7018	
1998 Energy Use (PJ)	1288	944	3027	2182	225	7666	
Change in Energy Use (PJ)	-31	77	272	304	26	648	9.2
Explanatory factor (change due to)							
Activity						1079.8	15.4
Structure						214.7	3.1
Weather						-87.7	-1.2
Energy efficiency (PJ)	-165	-17.8	-145	-103.1	0	-430.2	-6.1
Other factors						-129.7	-1.8

- changes in the structure of activity raised secondary energy use by 3.1 percent (214 petajoules) – the industrial sector shifted to more energy-intensive activities and road transport grew more rapidly than other modes of transportation.

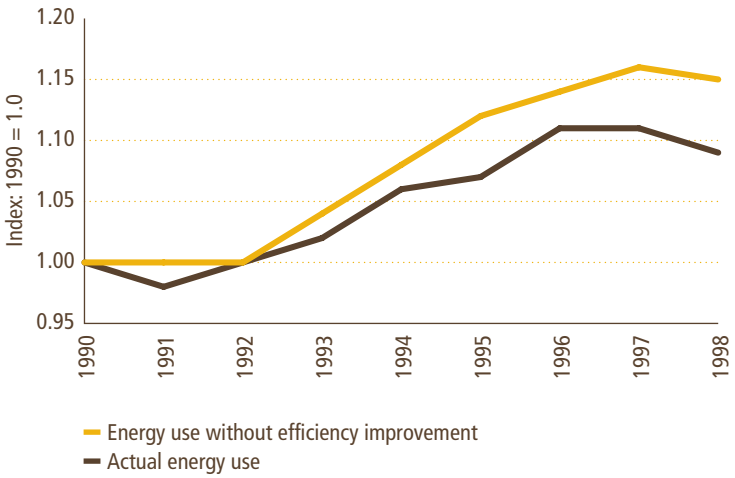
A third factor – weather – lowered secondary energy use by 1.2 percent (88 petajoules); the winter of 1998 was warmer than the winter of 1990, resulting in a lower demand for heating in the residential and commercial and institutional sectors.

If only these three factors had been in effect, secondary energy use would have increased by 17.2 percent. However, improvements in energy efficiency worked to decrease energy use by 6.1 percent (430 petajoules). As a result, energy use increased by only 9.2 percent. This change in energy use during 1990 to 1998, with and without changes in energy efficiency, is shown in Figure 2. The difference in energy use due to energy efficiency – the energy saving – represents a reduction in energy costs of almost $5 billion a year and a reduction in GHG emissions of about 25 megatonnes per year.

Changes in energy efficiency are estimated for each of the four major end-use sectors using the approach described above and presented in Chapters 3 to 6. The energy efficiency improvements were largest in the residential sector (12.5 percent), followed by the transportation (5.5 percent), industrial (5.3 percent), and commercial and institutional sectors (2.1 percent).

NRCan's programs contributed to a portion of the energy savings due to energy efficiency, as shown in Figure 2. The OEE is undertaking analysis to determine the portion of this energy saving that could be attributed to its programs. It is difficult, however, to separate the effects of NRCan's programs from those of other programs or normal marketplace changes. Moreover, many of the improvements in energy efficiency that have resulted from NRCan program initiatives undertaken between 1990 and 1999 have not had enough time to significantly affect total energy efficiency. Products entering the market in the past few years constitute only a fraction of today's capital stock of energy-using equipment. It will take many years for recent energy efficiency improvements in new appliances and equipment to be fully revealed in the average efficiency of the Canadian stock of appliances and equipment. For example, new refrigerators sold in Canada are now 31-percent more energy efficient than those sold in 1990, primarily as a result of government regulations. However, it will take 15 years or more (the typical life of a refrigerator) before Canadian energy intensity figures fully reflect the 31-percent improvement. For these reasons, the following chapters do not, in most cases, quantify the energy use or GHG impact of NRCan's programs from 1990 to 1999. Rather, they examine a number of progress indicators to determine whether these programs are changing consumers' behaviour and advancing the adoption, or likely future adoption, of new technologies to improve energy use and reduce GHG emissions.

FIGURE 2
Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998



Chapter 3

Residential Sector

Energy Use and Greenhouse Gas Emissions

The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling, heating water and operating appliances and lights. This sector accounts for 16.8 percent (1288 petajoules) of secondary energy use and 15.3 percent (69 megatonnes) of greenhouse gas emissions.

The majority of Canadian dwellings are single detached houses, followed by apartments, single attached dwellings and mobile homes (see Figure 3). Because single detached and attached houses predominate, most NRCan residential building programs focus on these dwellings.

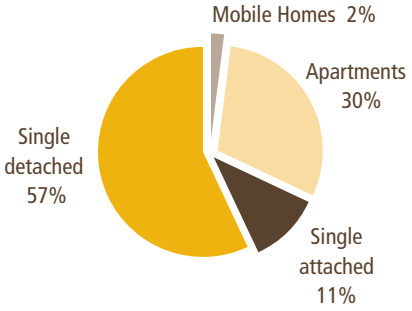
Space and water heating make up 81 percent of residential energy use, followed by the shares devoted to operating appliances, lighting and space cooling (see Figure 4).

Between 1990 and 1998, residential energy use decreased by 2.4 percent or 31 petajoules (from 1319 to 1288 petajoules). GHG emissions from the residential sector declined by 0.7 percent from 1990 to 1998. A 2.4-percent decrease in energy use combined with a 0.7-percent decrease in GHG emissions reflects an increase in GHG intensity. This was due to a decrease in the carbon intensity of the sector's energy use combined with a more-than-offsetting increase in the carbon intensity of the electricity-generating industry.

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

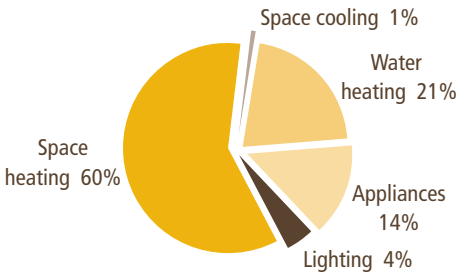
- *activity* – the increase in the number of households and the size of dwellings (the principal measures of residential activity) increased energy use by 16.2 percent (214 petajoules);

FIGURE 3
Canadian Households by Type of Dwelling, 1998



Total: 11 690 029 Households

FIGURE 4
Residential Energy Use by Purpose, 1998

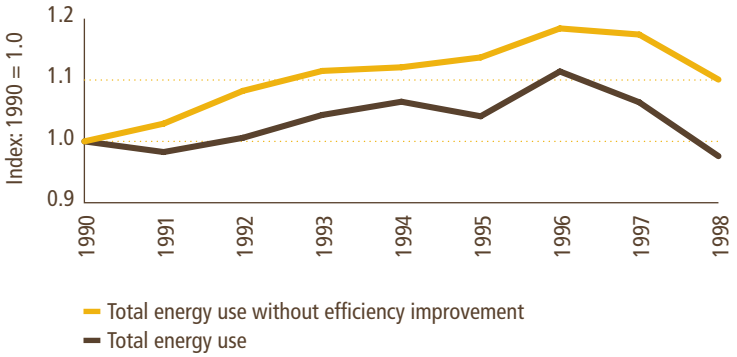


Total: 1288 Petajoules

- *weather* – warmer weather in 1998 compared to 1990 led to a decrease in space heating requirements. This decreased energy use by 5.2 percent (68 petajoules);
- *structure* – the percentage shares of energy end-uses changed over the period such that they increased energy use by 1.2 percent (16 petajoules); and
- *energy efficiency* – improvements in energy efficiency worked to decrease energy use by 12.5 percent (165 petajoules).

Growth in residential energy use was driven in large part by growth in activity. This increase was more than offset by significant improvements in energy efficiency, as well as changes in weather. Structural changes had a minor impact on residential energy use.

FIGURE 5
Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998



The change in residential energy use during 1990 to 1998, as well as the energy savings due to energy efficiency, is shown in Figure 5.

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.

New Houses

NRCan promotes energy efficiency in new houses through the following initiatives:

- R-2000 HOME Program;
- *Model National Energy Code for Houses*; and
- Building Energy Technology Advancement (BETA) Plan – Residential Buildings.

R-2000 HOME Program

The R-2000 HOME Program encourages Canadians to build houses that are more energy efficient and environmentally responsible. To this end, NRCan encourages home builders to voluntarily build houses to the R-2000 Standard – a technical performance standard that exceeds the requirements for energy efficiency and environmental responsibility in current Canadian building codes. To ensure that every R-2000 home meets the required energy performance standard, NRCan trains and licenses home builders and other professionals across Canada in R-2000 construction techniques and practices and provides third-party quality assurance by certifying every R-2000 home. Ongoing research by NRCan, in collaboration with industry partners, ensures that the R-2000 Standard maintains its leading-edge position in the housing technology market. NRCan promotes the R-2000 Standard to builders, consumers and the construction industry.

NRCan manages the R-2000 HOME Program and more than 30 industry partners across Canada – such as energy utilities, home builders' associations, manufacturers, product suppliers and financial institutions – deliver it at the provincial level. As well, private sector sponsors market the R-2000 HOME Program in return for the publicity associated with the R-2000 name. The scope of the R-2000 HOME Program grows with the changing needs of consumers to address such issues as indoor air quality, healthier homes, flex-housing and technological advancement.

Achievements 1999–2000

- NRCan worked with the Canadian Home Builders' Association and other industry stakeholders to update the R-2000 energy efficiency standard to reflect current technologies and to maintain the standard's international reputation as the leading edge for energy-efficient housing. Key changes include an increase in energy efficiency, without raising building costs, and a simplified method for pre-approving standard building designs of production house builders to the R-2000 Standard.
- NRCan established a partnership with the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) and the Cement Association of Canada to develop R-2000 training modules for builders by 2001.
- Preliminary results from a Health Canada study, comparing the health of R-2000 home dwellers with those living in control homes, revealed a significant (30 percent) reduction in respiratory complaints among R-2000 occupants. The study was extended to further verify results.
- NRCan held a national "Dinner of Champions" to recognize the many individuals who over the past two decades have helped to improve the energy efficiency of new houses in Canada by championing R-2000. In addition, NRCan instituted R-2000 Awards of Excellence in Manitoba, Ontario, Nova Scotia and New Brunswick.

Model National Energy Code for Houses

The *Model National Energy Code for Houses* (MNECH) aims to increase energy efficiency by specifying minimum performance standards for new Canadian houses. It provides this customized energy standard by allowing for regional climate and energy and construction cost variations. Published by the Canadian Commission on Buildings and Fire Codes in 1997, its development was supported by NRCan in collaboration with energy utilities, provincial and territorial governments, and the National Research Council Canada (NRC). NRCan encourages the adoption and implementation of this model code by relevant housing authorities (i.e., provinces, territories and municipalities). The department also monitors and analyses the impact of this code.

Achievements 1999-2000

- During consultations under the National Climate Change Process (see page 4), the provisions of the MNECH provided a basis for considering measures to improve the energy efficiency of the Canadian housing stock.

Building Energy Technology Advancement (BETA) Plan – Residential Buildings

The Building Energy Technology Advancement (BETA) Plan – Residential Buildings provides technology development and transfer and quality assurance to promote energy-efficient and environmentally responsible technologies for new and existing housing. Priority is given to emerging technologies that can be used in new construction or retrofit projects such as residential space- and water-heating systems, ventilation and windows; and the development of software for identifying cost-effective retrofit opportunities. The BETA Plan – Residential Buildings also provides technical advice to the EnerGuide for Houses program, the R-2000 HOME Program and the *Model National Energy Code for Houses*.

Achievements 1999–2000

- NRCan began the Advanced Integrated Mechanical Systems (AIMS) project, a joint industry–government initiative to help manufacturers develop and test a new generation of natural gas systems that integrate ventilation and space and hot-water heating, and improve indoor air quality while reducing homeowner costs and GHG emissions. Six companies were selected to develop AIMS products, which will be tested in 120 Canadian homes over the next two winters.
- In cooperation with Canada Mortgage and Housing Corporation, NRCan developed and delivered a seminar on exporting housing materials and products to Japan. This provided building and housing products professionals with recent information on the Japanese market, including more stringent regulatory standards regarding energy efficiency and healthy housing.
- NRCan organized the 6th Canada/Japan Housing R&D workshop in Prince Edward Island in August 1999, which was well received. This helped lead to the finalization of an agreement between NRCan and Japan's Building Research Institute to continue close cooperation and exchanges on technical innovation in housing.
- NRCan delivered a series of Super E™* training sessions to Super E member companies and to non-member companies to further build industry expertise and capacity for exporting Canadian energy-efficient housing. Six Canadian companies are now members of the Super E program, some because of requests from their Japanese clients. To date, about a dozen Super E houses have been built in Japan, and an agreement signed during the Prime Minister's Team Canada Mission to Japan in 1999 provides for the construction in Japan of up to 70 Super E homes over the next three years.

*SuperE™ is a trademark of Her Majesty the Queen in Right of Canada as represented by the Minister of Natural Resources.

Residential Sector: New Houses

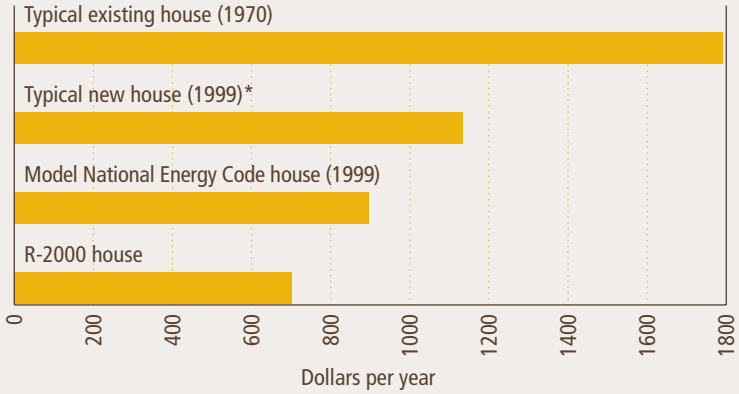
Progress Indicators

The three program initiatives described above help reduce energy consumption in new residential units. For example, a new house in Ottawa that meets the model energy code costs about 21 percent less to heat than a conventional new house, whereas an R-2000 house costs about 38 percent less to heat (see Figure 6).

The proportion of R-2000 houses among new housing starts across Canada in the 1990s has declined substantially since 1993, from almost one percent to about one sixth of that level. This decrease is due in part to the fact that energy utilities in New Brunswick and Ontario discontinued their financial incentives in support of R-2000 (see Figure 7).

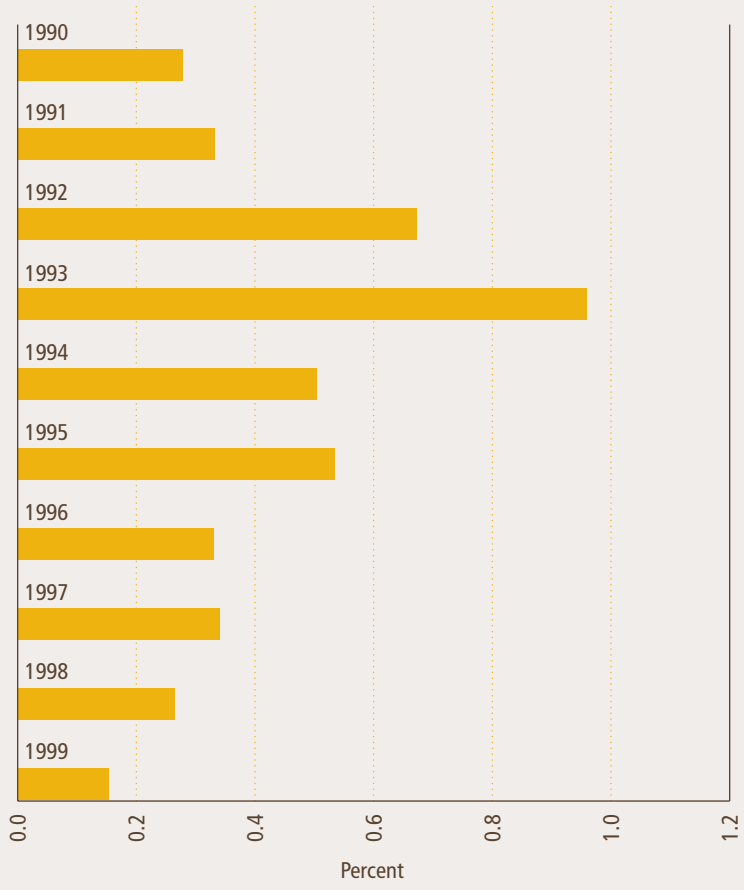
Because the R-2000 HOME Program demonstrates readily available, energy-efficient building practices and technologies, it is more influential than the actual number of R-2000 houses would suggest. Mainstream home builders have increasingly adopted R-2000 practices and technologies and now incorporate some R-2000 energy efficiency principles in many (if not most) new houses. In recent years, new houses in Canada have contained heat recovery ventilators, which arose directly from R-2000 research (all R-2000 houses have controlled ventilation to ensure good indoor air quality). The increasing airtightness of new houses, a key feature of R-2000 construction, is another indicator of improved overall energy efficiency. Air leakage is an important element in heat loss, which is why airtightness has a direct effect on residential energy efficiency. R-2000-certified houses must not exceed 1.5 air changes per hour, and they average slightly more than 1 air change per hour. Since the R-2000 HOME Program began in 1981, the average number of air changes per hour in all newly constructed houses has decreased from more than 5 to 3 (see Figure 8), and the number continues to drop.

FIGURE 6
Annual Heating Costs for Houses Constructed to Different Standards, 1999



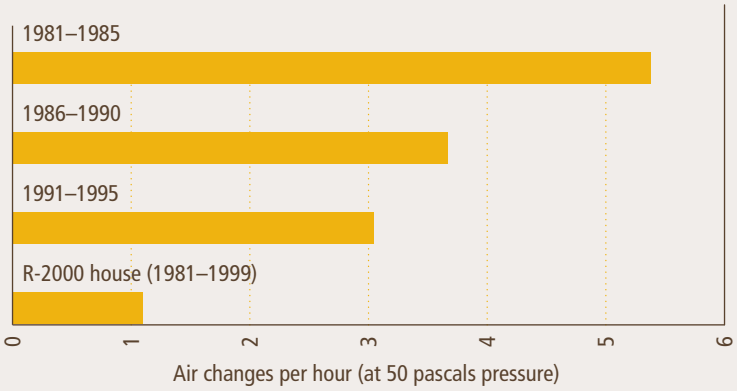
*198-m^2 single detached house heated with natural gas, Ottawa

FIGURE 7
R-2000 Share of National Housing Completions, 1990 to 1999



Progress Indicators (continued)

FIGURE 8
National Trends in Air Leakage in Houses by Construction Period



Existing Houses

NRCan promotes energy efficiency improvements in existing houses through the following initiatives:

- EnerGuide for Houses;
- Reno$ense; and
- BETA Plan – Residential Buildings (see page 20).

EnerGuide for Houses

The EnerGuide for Houses program encourages Canadians to improve the energy efficiency of their homes, especially when undertaking home renovation and maintenance projects. At the request of the homeowner, a qualified energy evaluator gathers energy-related information during a site inspection and undertakes a computerized analysis of the house's energy efficiency. The evaluator gives the homeowner a report that includes an estimate of the house's annual energy requirements, recommended energy efficiency improvements, and a label with an energy efficiency rating, the EnerGuide Rating, which can be used to

- plan energy improvements and renovations;
- qualify for home improvement loans;
- obtain a second rating after the renovations to measure the improvement in energy performance;
- qualify home buyers for "green mortgages" by financial institutions; and
- compare the EnerGuide ratings of different houses, when selling or buying a home.

This initiative raises consumer awareness of the benefits of energy efficiency, such as cost savings, improved comfort and indoor air quality, durability and the resale value of a house. Third parties deliver this initiative under licence from NRCan. They hire and train energy assessors and quality control personnel and provide local marketing and delivery. NRCan provides national coordination, technical support, quality assurance, software tools and training, generic information materials and national marketing.

Achievements 1999–2000

- NRCan expanded the EnerGuide for Houses program to cover 80 percent of the Canadian population. The department also increased the program's delivery capacity in Newfoundland, Nova Scotia, Quebec, Ontario and Saskatchewan.
- During the year, the program evaluated 9100 houses. A client satisfaction study revealed that over 80 percent of homeowners whose homes were evaluated implemented at least one of the recommended energy efficiency improvements.
- NRCan signed Marketing and Licensing Agreements with over 30 new partners to promote the EnerGuide for Houses evaluation services.
- An NRCan evaluation of a number of new houses in Ontario, based on data from the EnerGuide for Houses initiative, revealed that the energy performance of new tract-built housing varies widely and has potential for energy efficiency improvements.

Reno$ense

To tap into Canada's $20-billion-a-year home renovation market, the Reno$ense program encourages Canadians to incorporate energy efficiency into these projects. In collaboration with private sector sponsors, NRCan distributes information on the benefits of, and directions for, energy efficiency improvements through print and television campaigns, point-of-purchase displays and promotions, and utility mailings.

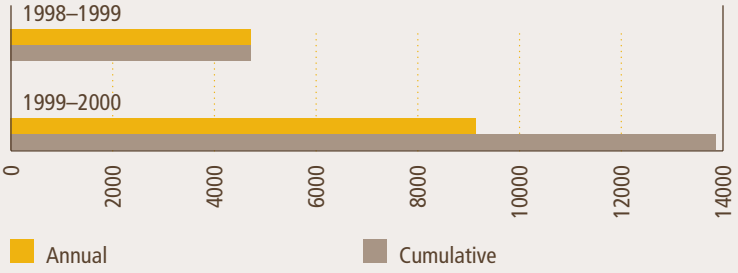
Achievements 1999–2000

- In partnership with the retail and manufacturing sectors, Tree Canada and The Weather Network/MétéoMedia, NRCan undertook a collaborative "Energy Fitness" campaign to promote energy efficiency improvement in home renovation.
- NRCan persuaded partners to contribute funding – ten times that of NRCan – in order to distribute over 600 000 copies of the 20-page "Energy Fitness Guide for Your Home" across Canada.
- NRCan created an electronic version of a very popular publication, *Keeping the Heat In* (the OEE's comprehensive guide to home energy retrofits), to make it available on the OEE Web site.

Residential Sector: Existing Houses

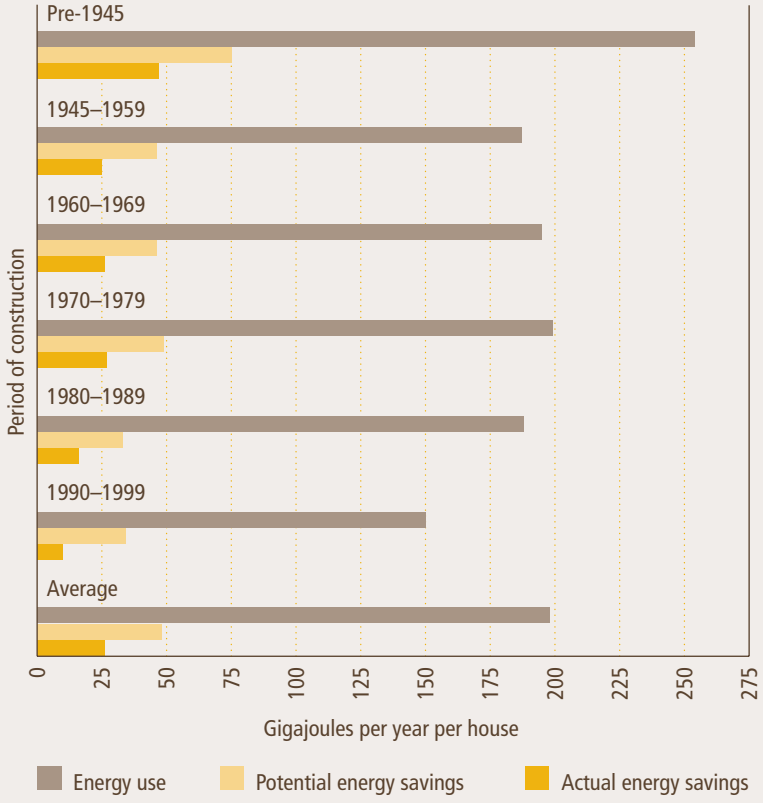
Progress Indicators

FIGURE 9
Homes Evaluated Under EnerGuide for Houses Program



In its second year of operation, the EnerGuide for Houses program evaluated almost twice as many houses (over 9100) as it did in its first year (almost 4700) (see Figure 9). These houses were built at different times with different construction methods. They represent different levels of energy use, potential for energy savings and actual energy savings realized in conjunction with the program (see Figure 10). On average, the potential energy savings of the houses was 25 percent of their energy use, while the actual or realized energy savings following the evaluation was over 13 percent of their energy use.

FIGURE 10
Energy Use and Energy Savings – EnerGuide for Houses Program



Equipment

NRCan promotes energy-efficient equipment through the following initiatives:

- *Energy Efficiency Regulations*; and
- EnerGuide for Equipment and HVAC.

The BETA Plan provides technical support for the EnerGuide initiative.

Energy Efficiency Regulations

Under the authority of the *Energy Efficiency Act*, NRCan sets *Energy Efficiency Regulations* for selected types of energy-using equipment, to eliminate less energy-efficient products from the market. The Regulations prohibit imports of or interprovincial trade in prescribed products that fail to meet minimum energy performance levels. The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. NRCan funds and participates in nationally accredited standards-writing committees administered by CSA International to foster the development of these standards.

Achievements 1999–2000

- NRCan drafted and undertook public consultations on an amendment to the Regulations requiring more stringent energy performance for refrigerators, combination refrigerator-freezers and freezers.

EnerGuide for Equipment and HVAC

The purpose of the EnerGuide for Equipment and HVAC program is to encourage consumers to purchase energy-efficient products (household appliances, room air conditioners and HVAC equipment). This is done by disseminating information through a label on the annual energy consumption of the product and comparing it with competing products of the same class and size.

EnerGuide labels for major household appliances describe energy performance as the number of kilowatt hours (kWh) that an appliance consumes in a year (see Figure 11). EnerGuide labels for room air conditioners describe energy performance as an energy-efficiency ratio (see Figure 12). Both labels give consumers consistent, verifiable energy efficiency information they can use when shopping for appliances.

The EnerGuide appliance label has two significant features. First, it states the annual energy consumption for the product, based on standardized test procedures prescribed in the Regulations. The annual consumption figure enables the buyer to calculate the operating cost of the product model. Second, for consumers who prefer a visual comparison, the label shows the performance range of products in a product class for a given year, using a bar with a pointer to indicate how the energy consumption of the model compares with that of other models of the same product.

NRCan selects products to bear the EnerGuide label in consultation with stakeholders. It implements marketplace monitoring and enforcement systems through audits on the frequency of labelling. NRCan also conducts public information campaigns to explain the EnerGuide label and the benefits of energy efficiency. Working with its partners, NRCan offers awareness programs for retail salespeople, supports media campaigns and staffs exhibits for major consumer home shows.

FIGURE 11
EnerGuide Label for Appliances

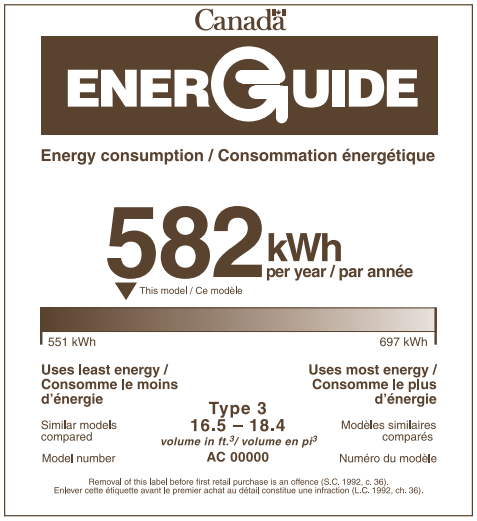
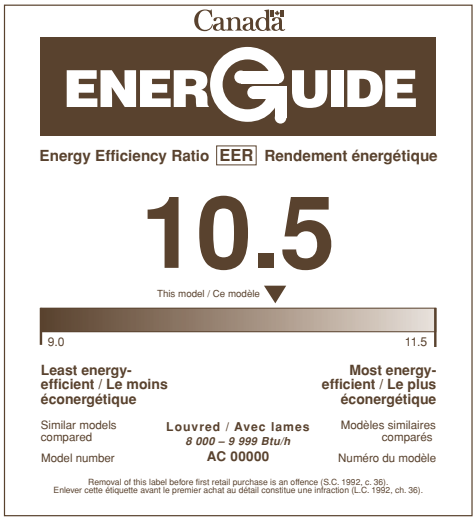


FIGURE 12
EnerGuide Label for Air Conditioners



NRCan's EnerGuide label is delivered under two systems:

- mandatory – through regulations; and
- voluntary – through agreement with product manufacturers.

Regulations under the *Energy Efficiency Act* include labelling requirements for eight major household appliances, as follows:

- electric clothes dryers;
- clothes washers;
- dishwashers;
- electric ranges;
- freezers;
- integrated stacking washer-dryers;
- refrigerators and combination refrigerator-freezers; and
- room air conditioners.

NRCan's voluntary HVAC labelling system is delivered in partnership with the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI). Manufacturers of HVAC equipment feature an EnerGuide rating in their product brochures. The EnerGuide rating indicates the yearly energy consumption of a product and how this compares with ratings for its competitors, based on standardized testing. HRAI members provide awareness training to their dealers and contractors and report to NRCan on the energy efficiency of HVAC products. NRCan provides training materials and other products and services for dealer education programs and a recognition program for manufacturers.

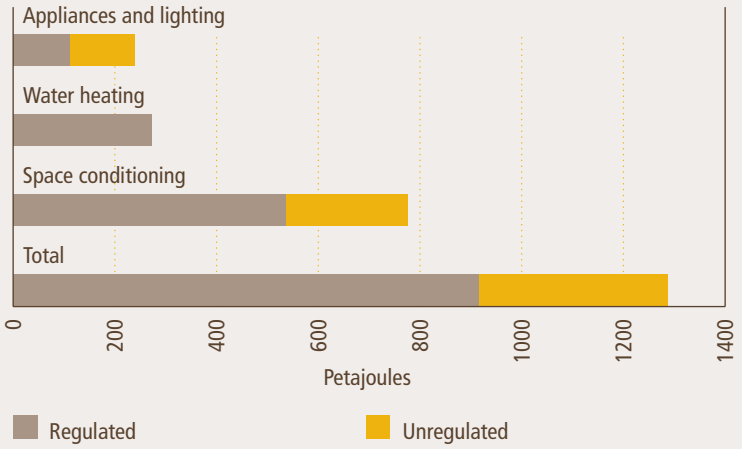
Achievements 1999–2000

- NRCan participated in a steering committee, along with Union Gas, Enbridge Consumers Gas and the Ontario Ministry of Energy, Science and Technology, which carried out a study on the desirability and feasibility of a national labelling/communications program for gas fireplaces and residential and commercial water heaters and boilers. The study concluded that an EnerGuide labelling program would be feasible for gas fireplaces, and that a national communications program should be established to promote the sale and use of more energy-efficient water heaters and boilers.
- NRCan participated in a CSA International technical committee which provided a final review of a draft gas fireplace test standard. This standard will provide the basis for an EnerGuide label for gas fireplaces.
- NRCan, in co-operation with the HRAI and the Canadian Oil Heat Association, prepared and distributed to industry members a workplan for the adoption of the EnerGuide rating system for oil furnaces, whereby manufacturers and dealers would include the information on the back of their product brochures.
- NRCan began an integrated advertising campaign to position EnerGuide as a tool to make wise energy choices when shopping for appliances, cars, heating and cooling equipment, or when auditing a home for energy efficiency. The slogan for this campaign is "Before you decide: EnerGuide."
- NRCan officials began discussions with their counterparts in the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy on the introduction of the international ENERGY STAR® program in Canada. ENERGY STAR is a collaboration between the U.S. Department of Energy, the EPA, utilities and many national and international companies, which is designed to raise awareness about the environmental impact of energy use. Products receiving the ENERGY STAR designation exceed minimum performance standards, and are promoted for their energy and environmental benefits. Many products in stores in Canada carry the ENERGY STAR logo, since many companies sell the same products in the United States.

Residential Sector: Equipment

Progress Indicators

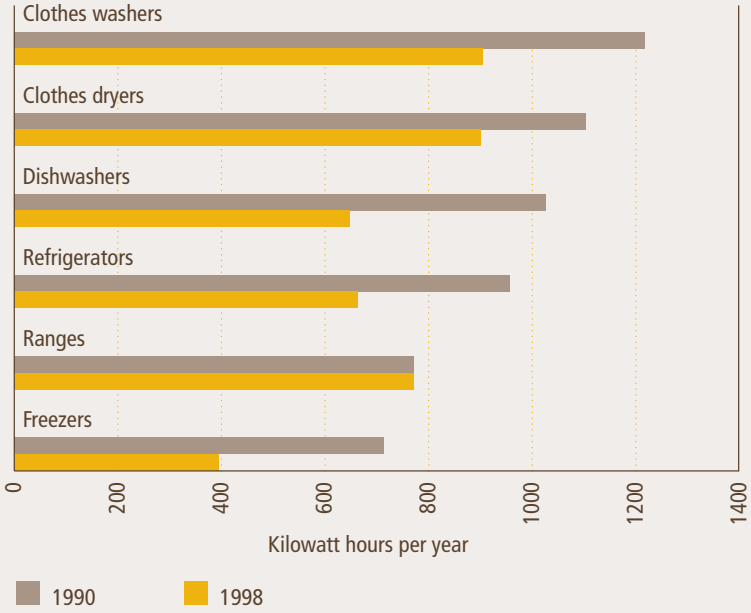
FIGURE 13
Share of Residential Energy Consumption Subject to Energy Efficiency Regulations, 1998



The Regulations apply to equipment that accounts for 71 percent of total residential energy consumption, almost all of the energy consumed in water heating, 69 percent of energy used in heating, ventilation and air conditioning (HVAC), and 46 percent of the energy used to operate appliances and lighting (see Figure 13).

The Regulations have significantly affected the energy efficiency of appliances. The energy consumption of new appliances has decreased by substantial amounts, ranging from 18 percent (clothes dryers) to 45 percent (freezers) (see Figure 14).

FIGURE 14
Average Energy Consumption of New Appliances, 1990 and 1998



Progress Indicators (continued)

The Regulations also greatly influenced the average efficiency of natural gas furnaces. Since 1990, low-efficiency natural gas furnaces have disappeared from the market (see Figure 15), while mid-efficiency furnaces have increased their market share from 16 to 62 percent and high-efficiency furnaces have increased their market share from 22 to 38 percent. The minimum efficiency specified in the Regulations is 78 percent, while the maximum attainable with current technology is 96 percent. The (sales-weighted) average Annual Fuel Utilization Efficiency (AFUE) for natural gas furnaces in 1999 was 85.3 percent.

By helping consumers compare products, the EnerGuide for Appliances initiative gives manufacturers an incentive to increase energy efficiency. Thirty-one percent of refrigerators with top-mounted freezers manufactured in 1998 had energy consumption ratings at least 10 percent better than the minimum standard (see Figure 16). Similar analyses for dishwashers and clothes washers show that 35 percent of these products have energy consumption ratings at least 10 percent better than the minimum standard. More than 25 percent of all standard dishwashers show EnerGuide ratings at 26 percent better than the minimum standard. These figures highlight the synergistic relationship between the Regulations and labelling initiatives. Without EnerGuide labels, manufacturers would have little incentive to provide more energy-efficient products.

FIGURE 15
Natural Gas Furnace Sales by Efficiency Level, 1990 and 1998

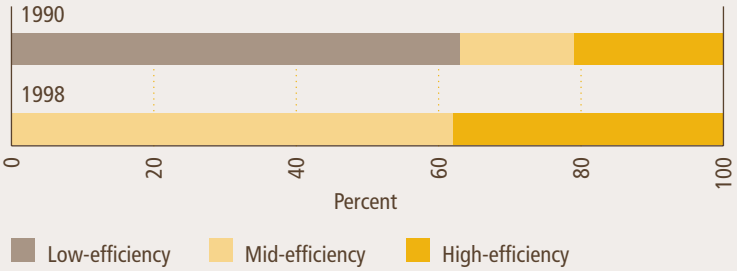
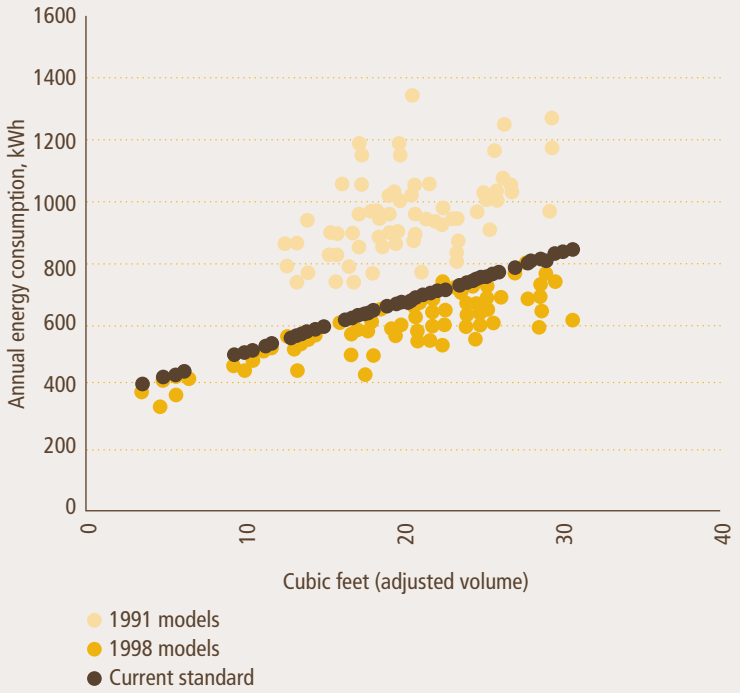


FIGURE 16
Energy Use of Refrigerators, 1991 and 1998



Chapter 4

Commercial and Institutional Sector

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.

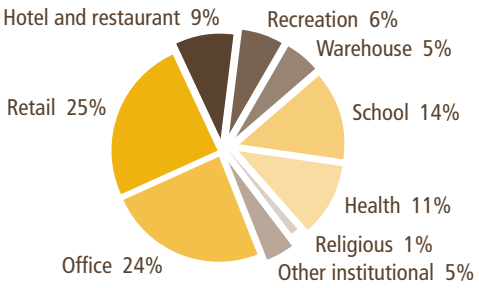
In 1998, the commercial and institutional sector accounted for 12.3 percent (944 petajoules) of secondary energy use and 12.2 percent (54 megatonnes) of GHG emissions.

This sector comprises many building types (see Figure 17). Retail and office space account for nearly half of commercial and institutional sector energy demand. Schools, health care facilities, and hotels and restaurants account for another 34 percent of that demand. 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 18). Each of the remaining five uses of energy in this sector accounts for between 5 and 15 percent of its energy demand.

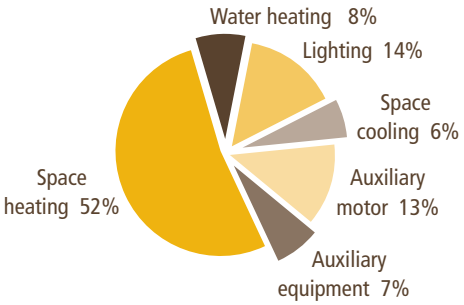
Between 1990 and 1998, commercial and institutional energy use increased by 12.3 percent or 77 petajoules (from 867 to 944 petajoules). However, GHG emissions from the sector rose by 13.1 percent in the same period. The main factor causing emissions to increase more quickly than energy use was the increase in the CO_2 intensity of electricity production.

FIGURE 17
Commercial and Institutional Energy Use by Building Type, 1998



Total: 936 Petajoules
(excludes 8 petajoules for street lighting)

FIGURE 18
Commercial and Institutional Energy Use by Purpose, 1998

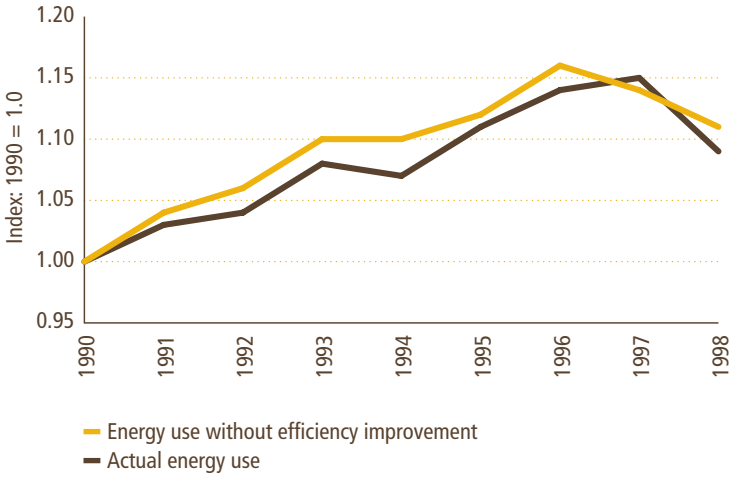


Total: 936 Petajoules

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

- *activity* – an increase of 118 petajoules in energy use;
- *weather* – a decrease of 20 petajoules;
- *energy efficiency* – a decrease of 18 petajoules; and
- *structure* – an increase of 3 petajoules.

FIGURE 19
Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998



If only activity, weather and structure had been in effect, commercial and institutional energy use would have increased by 11.6 percent (101 petajoules). However, improvements in energy efficiency worked to decrease energy use by 2.0 percent (18 petajoules). As a result, energy use increased by only 8.8 percent. This change in energy use during 1990 to 1998, as well as the energy savings due to energy efficiency, is shown in Figure 19.

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

Three initiatives address energy efficiency in new commercial and multi-use apartment buildings.

These are

- *Model National Energy Code for Buildings* (MNECB);
- Commercial Building Incentive Program (CBIP); and
- BETA Plan – Large Buildings.

Model National Energy Code for Buildings

The *Model National Energy Code for Buildings* (MNECB) aims to increase energy efficiency by specifying minimum performance standards for new Canadian buildings. It provides these customized energy standards by allowing for regional climate and energy and construction cost variations. Published by the Canadian Commission on Buildings and Fire Codes in 1997, its development was supported by NRCan in collaboration with energy utilities, provincial and territorial governments, and the National Research Council Canada (NRC). NRCan encourages the adoption and implementation of this model code by relevant building authorities (i.e., provinces, territories and municipalities). The department also monitors and analyses the impact of this code.

Achievements 1999–2000

- During consultations under the National Climate Change Process (see page 4), the provisions of the MNECB provided a basis for considering measures to improve the energy efficiency of the Canadian building stock.

Commercial Building Incentive Program

CBIP provides financial incentives to builders and developers to incorporate energy-efficient technologies and practices into the design and construction of new commercial, institutional and multi-unit residential buildings. CBIP seeks to encourage a permanent change in the way such buildings are designed. It is intended to offset the extra cost of designing energy-efficient buildings and thus encourage designers and developers to consider efficiency options in their designs of commercial and institutional buildings. To qualify for the incentive, buildings must be at least 25 percent more efficient than buildings that meet the requirements of the MNECB. CBIP provides a one-time grant based on the difference in estimated annual energy costs between an approved CBIP design and an MNECB design. In addition to financial incentives, CBIP provides design software and guidelines, case studies and training for architects and engineers.

Achievements 1999–2000

- NRCan made available on its Web site all CBIP program information. This includes six technical guidelines (with 2300 downloads for the office building guideline alone); six case studies (with 4200 downloads); and an on-line screening tool.
- NRCan trained more than 850 professionals in several types of sessions: day-long general workshops in Ottawa, Toronto, London, Montréal, Québec, Moncton, Vancouver and Saskatoon; sector-specific workshops for health care facilities in Ottawa, Toronto and London; and technical workshops on ground-source heat pumps to meet CBIP program criteria in Toronto, Montréal, Moncton and Vancouver.
- NRCan provided incentive payments for 34 building designs (up from 12 in the first year of the program) at an average payment of $30,000. The average design was 30 percent more efficient than the *Model National Energy Code for Buildings*.
- A school to be built in Gillam, Manitoba, achieved the highest design performance – 62 percent better than the *Model National Energy Code for Buildings*. Rebuilding a former supermarket into a new Mountain Equipment Co-op retail store in Ottawa achieved an energy efficiency 56 percent better than the MNECB, and featured extensive use of recycled material.
- To assist in a preliminary evaluation of buildings submitted for CBIP incentives, NRCan released in 1999 a user-friendly Web-based screening tool that provides an estimate of the expected savings, calculated based on the CBIP rules. Designers, engineers and building developers can quickly assess whether their building design qualifies for CBIP funding. The screening tool is based upon detailed energy simulations for different building typologies in different climate zones across Canada. The ease of access and use made it a very successful tool with potential CBIP applicants, and a long-term upgrade of the screening tool is underway.

Building Energy Technology Advancement (BETA) Plan – Large Buildings

NRCan's Building Energy Technology Advancement (BETA) Plan – Large Buildings supports the development, commercialization and industry adoption of energy-efficient, environmentally responsible technologies for large commercial buildings as well as high-rise residential structures. Its S&T activities are designed to identify the benefits and costs associated with introducing environmentally friendly, energy-efficient technologies. The C-2000 Program is one component of the BETA Plan – Large Buildings. It aims to accelerate the adoption of new technologies by demonstrating how energy efficiency, indoor environment and the environmental impact of commercial buildings can be improved through an integrated approach to design and renovation. The BETA Plan – Large Buildings provides technical advice to the Commercial Building Incentive Program.

Achievements 1999–2000

- The Green Building Challenge (GBC) is an international initiative under the BETA Plan – Large Buildings to develop and test new methods of assessing the environmental performance of buildings. In 1999–2000, Spain became the 18th country to join the GBC. As well, a Canadian team began work on a national presentation including tests on three buildings at the Sustainable Building 2000 conference held in Maastricht, Netherlands, in October 2000.
- NRCan released two versions of EE4, a bilingual building simulation software program. EE4 is used by architects and engineers to demonstrate compliance with the *Model National Energy Code for Buildings* and CBIP. The software was downloaded from the NRCan Web site by 350 users, and NRCan conducted training sessions in Vancouver, Montréal, Québec, Moncton and Ottawa.
- As part of its C-2000 Program, NRCan conducted a public demonstration of the program's integrated design process at the annual Construct Canada exhibition. The demonstration illustrated the energy efficiency benefits of using the integrated design process versus conventional design methods in four building projects, ranging from a new 33 000-m^2 informatics centre at the University of Toronto to the renovation of a 13-storey apartment building. As well, construction began on four new C-2000 projects in Regina, Ottawa, Montréal and Halifax.
- NRCan signed a Memorandum of Understanding (MOU) with the Korea Institute for Energy Research (KIER), which has been contracted by South Korea's ministry of energy to prepare a strategy for implementing green buildings. NRCan prepared a paper to guide KIER in the implementation of the initiative and developed a plan to help achieve the transfer of three Canadian products to Korea – Solarwall® solar heating systems, transparent insulation and light pipe technologies.

Commercial and Institutional Sector: New Buildings

Progress Indicators

Since provinces and territories have jurisdiction over construction regulations, the *Model National Energy Code for Buildings* (MNECB) only comes into force if it is incorporated into provincial or municipal building codes. By March 2000, the City of Vancouver had formally committed to adopting the model code, and the Province of Ontario had specified it as one of two options to demonstrate good practice required for all new buildings in the province. Commercial buildings that meet the model code would use 15 percent less energy than those built to current standards (see Figure 20).

To qualify for incentives under CBIP, a developer must construct a building that is at least 25 percent more efficient than the level set out in the MNECB (see Figure 20). During CBIP's first two years of operation, recipients of CBIP incentives realized energy consumption levels 30 to 35 percent lower than set out in the MNECB (see Figures 21 and 22).

Under the C-2000 Program, NRCan invited private industry to develop an advanced commercial building to meet stringent energy efficiency design criteria. C-2000 buildings use about 55 percent less energy than conventional buildings (see Figure 20).

FIGURE 20
Energy Use in Commercial Buildings, 1998

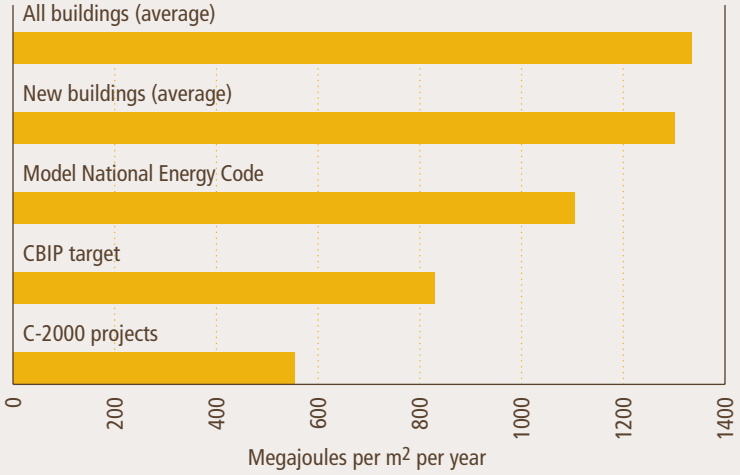


FIGURE 21
Energy Consumption of CBIP Buildings

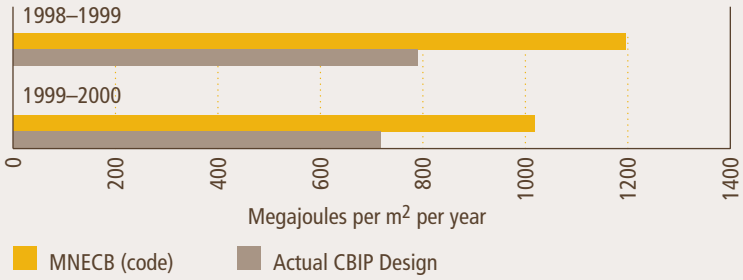
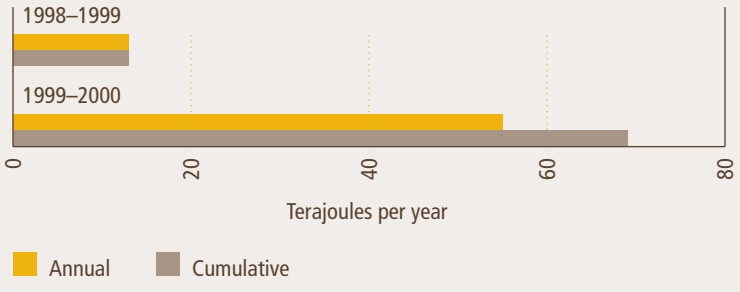


FIGURE 22
Energy Savings from CBIP



Existing Buildings

NRCan encourages energy efficiency improvements in a wide range of commercial and public sector facilities through the

- Energy Innovators Initiative (EII);
- Federal Buildings Initiative (FBI); and
- Federal Industrial Boiler Program (FIBP).

Energy Innovators Initiative

The EII promotes energy efficiency initiatives, upgrades and building retrofits in the commercial and institutional sector. The initiative recruits Canadian organizations to enrol as Energy Innovators and make a corporate commitment to energy efficiency using an Energy Management Plan. An Energy Innovator can ask to have its plan, which includes its commitment to reduce greenhouse gas (GHG) emissions from its operations, registered with Canada's Climate Change Voluntary Challenge and Registry Inc. (VCR Inc.).

The EII helps organizations plan and implement comprehensive energy efficiency improvements by providing a wide range of products and services, including the following:

- planning and tracking advice;
- models for energy-efficient design;
- how-to guides, technical fact sheets and case studies of easy-to-replicate projects;
- a source list of qualified energy service companies (ESCos);
- assistance to explore project financing and project implementation options;
- workshops and employee awareness programs;
- access to an energy management training service; and
- access to an international database on up-to-date energy efficiency technologies.

Through an approach called "savings financing," public and private sector organizations can use energy savings to pay for the projects they implement. Under an energy performance contract with an ESCo, they can obtain financing for an energy efficiency project and the ESCo guarantees the energy savings used to repay the project financing.

In addition, EII offers a pilot retrofit incentive, expanded partnerships and benchmarking.

The pilot retrofit incentive is available to Energy Innovators implementing comprehensive energy efficiency pilot retrofits. NRCan contributes up to 25 percent of project costs to a maximum of $250,000. Participants agree to replicate their pilot project in at least 25 percent of similar facilities that they own or occupy.

NRCan works in partnership with key sectoral associations such as the Hotel Association of Canada and the Association of Canadian Community Colleges. These partnerships help to recruit Energy Innovators, stimulate energy management plans and projects and develop sector-specific tools.

Benchmarking and best-practice guides allow organizations to measure their efficiency against similar organizations and identify where to obtain better performance.

Achievements 1999–2000

- NRCan recruited to the Initiative three health care organizations from Quebec, which comprise 281 hospital facilities with a combined energy bill of $65 million per year.
- Sixteen Innovators received a VCR Inc. Champion Reporting Level Status for their energy management action plans – nine Gold Level, three Silver Level and four Bronze Level.
- EII approved $5.9 million in pilot retrofit incentive payments to qualifying Energy Innovator organizations. These organizations undertook to invest $148 million in energy efficiency retrofits which are expected to reduce energy costs by about $14 million per year.
- M&M Meat Shops Limited was the first national franchise chain to receive approval for retrofit incentives which will reduce energy use by 25 percent in 161 of its 280 stores.
- The Hotel Association of Saskatchewan undertook a successful benchmarking program of 50 hotels in the province.

Federal Buildings Initiative

The Government of Canada is the largest energy consumer in the country. Federal building use is by far the largest source of energy demand, accounting for more than 80 percent of federal energy use. The Government of Canada owns or leases about 23 million square metres of floor space, with 90 percent of it concentrated in five departments.

The Federal Buildings Initiative (FBI) provides energy management products and services to assist federal departments to implement comprehensive energy efficiency improvements. The initiative supports partnerships with energy management firms that provide a turnkey service which includes engineering, third-party private sector financing, comprehensive training packages and performance guarantees.

Achievements 1999–2000

- Energy efficiency retrofit projects involving an estimated 5500 buildings have been initiated under and registered with the FBI.
- By March 2000, National Defence had implemented about $90 million of FBI-type energy efficiency improvement projects in 14 of its bases in all regions of the country. These projects are guaranteed to save $10 million in energy costs per year.

Federal Industrial Boiler Program

The Federal Industrial Boiler Program (FIBP) assists its clients to increase energy efficiency, reduce nitrogen oxide (NO_x) emissions and extend the useful life of existing heating and cooling systems and auxiliary equipment. FIBP encourages its clients to consider energy-efficient and environmentally responsible technologies when replacing or modifying industrial heating and cooling plants.

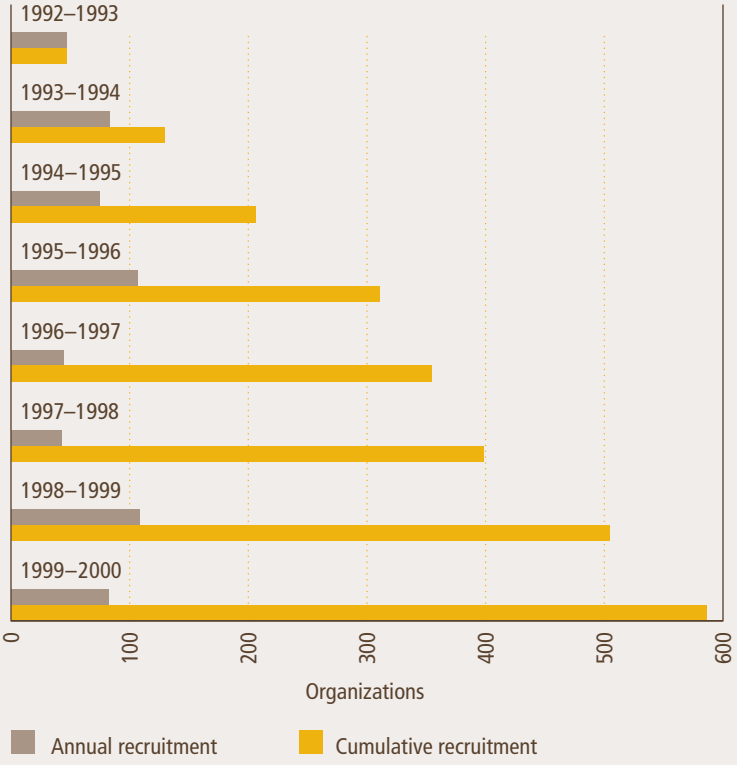
FIBP services are available to all federal departments and agencies, Crown corporations, provincial and municipal departments and the private sector. The Government of Canada owns 52 central heating plants, housing more than 270 boilers that consume more than 8000 terajoules of fuel annually. Services delivered under the FIBP help government departments and other clients adopt heating technologies that could reduce NO_x emissions by 50 percent, increase energy efficiency by up to 15 percent and reduce operating costs by 20 percent compared with conventional practices.

Achievements 1999–2000

- Since 1997, NRCan has provided the Department of Foreign Affairs and International Trade with technical and project management services as it retrofits and upgrades its embassies around the world. In 1999–2000, NRCan conducted a site survey of the mechanical and electrical systems at the Canadian Embassy in Beijing, China and developed recommendations for improvements.
- With joint funding from the Ontario Ministry of the Environment, Enbridge Consumers Gas and Union Gas, FIBP prepared and published a guide to efficiency improvement and emissions reduction for boilers and heaters.
- On behalf of Correctional Services Canada (CSC), NRCan analysed NO_x emissions at several CSC central heating plants. A study at the Kent Institution near Chilliwack, British Columbia, determined that the replacement of a boiler burner could reduce NO_x emissions by 40 percent (283 kg/year), and improvements to the operation of the boiler plant could reduce costs by 4 percent ($3,000/year).
- An NRCan analysis of a CSC heating plant at the Leclerc Institution in Laval, Quebec, indicated that the equipment is approaching the end of its life cycle. The department developed a plan to replace three of the four boilers with high-efficiency boilers and low-NO_x burners. These would reduce NO_x emissions to the level specified in the Canadian Council of Ministers of the Environment guidelines.

Progress Indicators

FIGURE 23
Recruitment of Energy Innovators (Commercial and Institutional), 1992–1993 to 1999–2000



As of March 2000, a total of 584 commercial, institutional and municipal organizations had been recruited as Energy Innovators. They represent 25.3 percent ($2.4 billion) of the total energy bill of the commercial and institutional sector. Eighty-two new organizations joined the program in 1999–2000 (see Figure 23).

Since its introduction in April 1998, the Energy Innovators pilot retrofit incentive has had a significant impact on energy retrofit activity (see Table 2). The incentive contributed $8.6 million of federal funds to stimulate a 24-fold investment ($206 million) by Energy Innovators. The resulting projects are expected to reduce energy costs by $19 million per year and reduce GHG emissions by 161 kilotonnes per year.

TABLE 2
Energy Innovators Pilot Retrofit Incentive, 1998–1999 to 1999–2000

	1998–1999	1999–2000
Federal incentives	$2.7 million	$5.9 million
Private sector investment	$58.4 million	$147.6 million
Energy savings	$4.9 million	$14.1 million

The investment and savings are estimated and include both pilot and replication.

Progress Indicators (continued)

Under the program, Energy Innovators have implemented 248 energy-saving projects, of which 52 occurred in 1999–2000 (see Figure 24).

In 1999–2000, energy efficiency investments by government departments under the FBI increased by $50 million, bringing the total since the program began to $180 million (this figure comprises private sector investment plus interest during repayment). The investments are expected to yield energy savings of $24 million per year. Figure 25 summarizes the investments and associated energy savings of FBI projects, focusing on the activity undertaken by the five leading departments.

FIGURE 24
Energy-Saving Projects Under Energy Innovators Initiative, 1992–1993 to 1999–2000

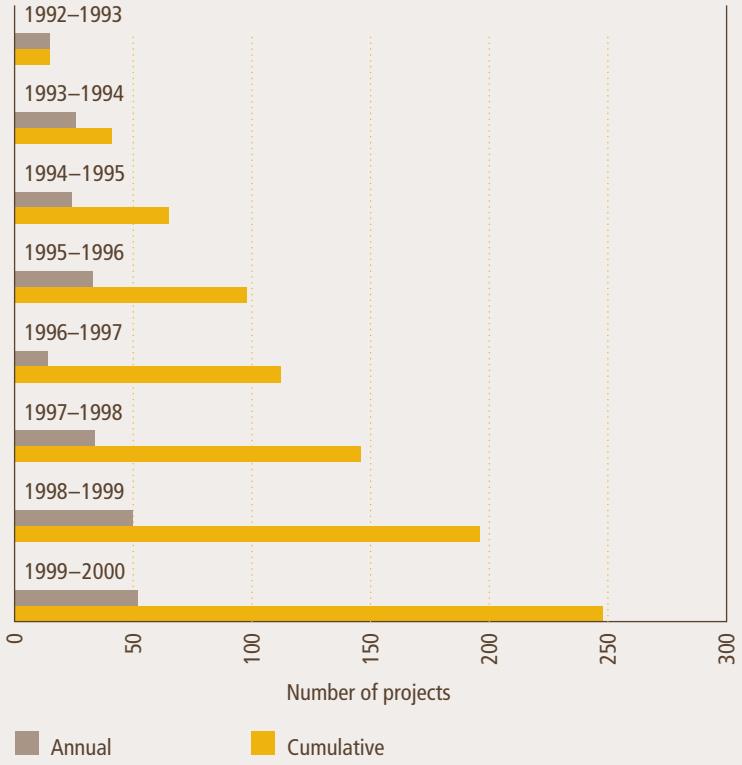
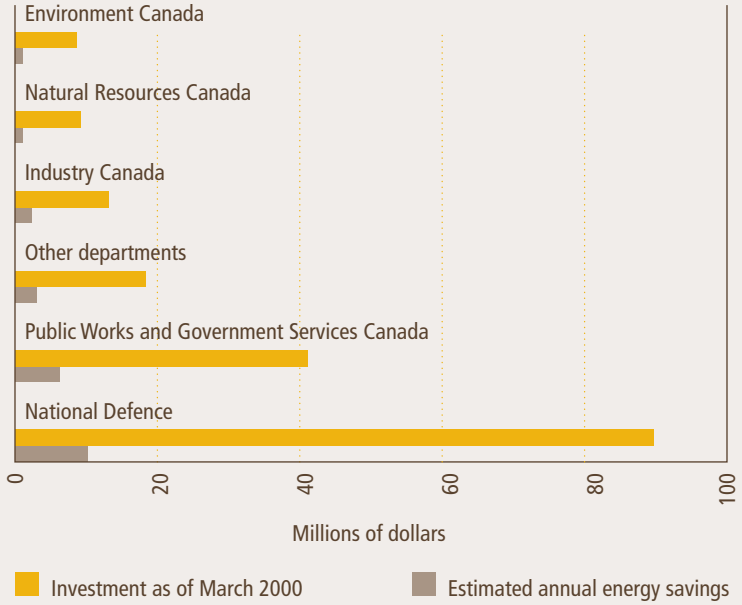


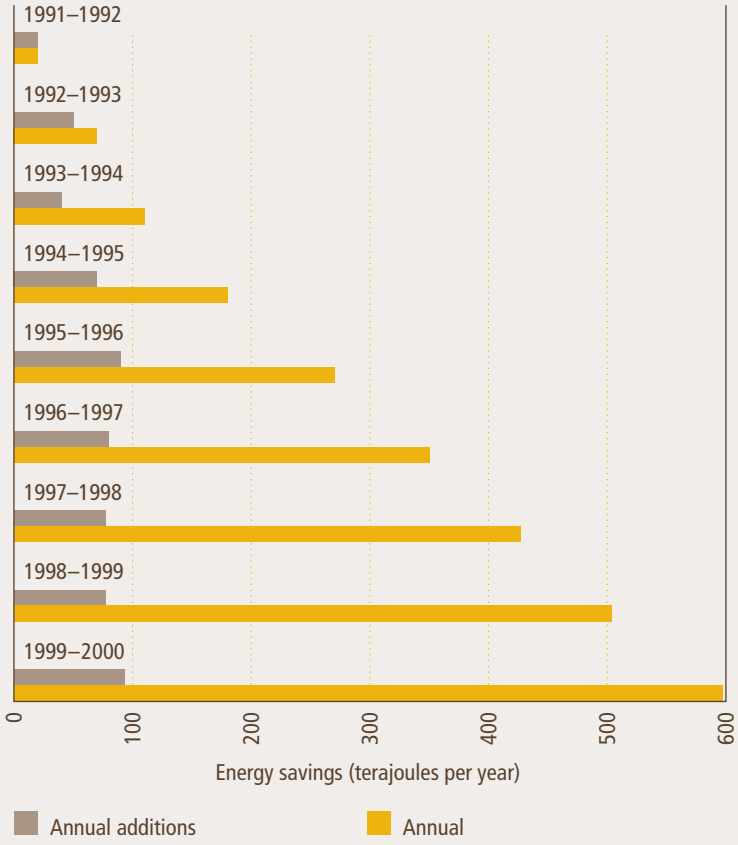
FIGURE 25
FBI Investment and Energy Savings



Progress Indicators (continued)

FIBP projects implemented in 1999–2000 saved 93 terajoules per year (see Figure 26). Since 1991–1992, the energy savings from this program have risen to 597 terajoules per year and the cumulative energy savings since the program began are about 2.5 petajoules.

FIGURE 26
Energy Savings from FIBP, 1991–1992 to 1999–2000



Equipment

NRCan uses the following initiatives to encourage the development and use of energy-efficient equipment in commercial and institutional buildings:

- *Energy Efficiency Regulations*; and
- Refrigeration and Intelligent Buildings Program.

Energy Efficiency Regulations

Under the authority of the *Energy Efficiency Act*, NRCan sets *Energy Efficiency Regulations* for selected types of energy-using equipment, to eliminate less energy-efficient products from the market. The Regulations prohibit imports of or interprovincial trade in prescribed products that fail to meet minimum energy performance levels. The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. NRCan funds and participates in nationally accredited standards-writing committees administered by CSA International to foster the development of these standards.

Refrigeration and Intelligent Buildings Program

The Refrigeration and Intelligent Buildings Program develops and commercializes technologies in the areas of ground-source heat pumps, refrigeration, photovoltaics and intelligent buildings (using the latest advanced computerized control systems for buildings).

Achievements 1999–2000

- NRCan began to develop Diagnosis Agent for Building Operator (DABO) software to simplify the maintenance and optimization of centralized control systems. It will allow real-time predictions of energy consumption, detect and diagnose building heating, ventilation, air-conditioning and refrigeration system defects, and optimize the design and maintenance of energy systems.
- Quebec's Agence de l'efficacité énergétique and the Association des arénas du Québec agreed to NRCan's proposal to undertake an energy efficiency program for obsolete and inefficient refrigeration systems in the province's ice arenas. The program will provide technological innovation, technological assistance and training. NRCan signed agreements to provide expertise to firms working on the project.
- NRCan demonstrated its prototype "virtual building test bench" to Seneca College in Toronto for possible use in its building operator training course. The college has agreed to work with NRCan to fully develop the prototype into a teaching tool.
- NRCan signed an agreement under which it will test and work to improve a thermal management system for electric vehicles. Optimizing the energy efficiency of the vehicle's heating and cooling unit would help increase the vehicle's range and decrease its costs in cold climates.

Commercial and Institutional Sector: Equipment

Progress Indicators

FIGURE 27
Influence of Regulation on Energy Use of Two Fluorescent Lamp Types, 1996

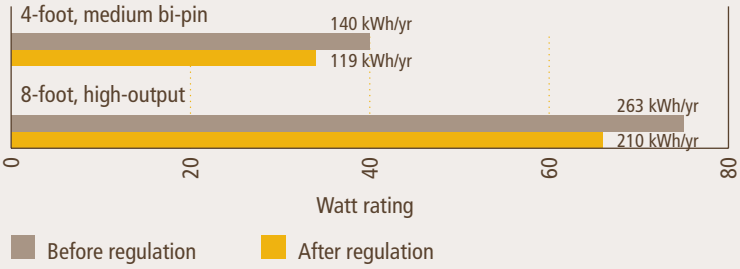


TABLE 3
Savings Arising from Canadian Energy Efficiency Lighting Regulations

Annual sales of lamps affected by regulations	$33 million
Estimated direct savings of electricity used for lighting in 2000	39 petajoules
Estimated net energy savings in 2000*	10 petajoules
Estimated net reduction in GHG emissions in 2000	5.5 megatonnes

* The estimate of net energy savings is lower than the estimate of direct savings of electricity because the direct savings of electricity are partially offset by an increase in space-heating demand required because more efficient lighting emits less heat. When this effect is taken into account, estimated energy savings are less. The net effect varies by region and building.

The original *Energy Efficiency Regulations*, which took effect in February 1995, covered two commercial energy-using products, electric motors (discussed in Chapter 5, "Industrial Sector") and fluorescent lamp ballasts. Minimum performance requirements for fluorescent lamps took effect on February 1, 1996 and for incandescent reflector lamps on April 1, 1996. The fluorescent lamp regulations reduced annual energy use by 20 percent for the 2.4-m (8-ft.), high-output lamp and by 15 percent for the 1.2-m (4-ft.), medium bi-pin lamp, two of the most popular fluorescent lamps (see Figure 27).

NRCan estimates that these regulations will result in net energy savings of 10 petajoules and a net reduction in GHG emissions of 5.5 megatonnes in 2000 (see Table 3). This reduction in emissions is equivalent to the annual GHG emissions of more than 90 000 homes.

Chapter 5

Industrial Sector

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 39 percent (3027 petajoules) of secondary energy use and 34 percent (155 megatonnes) of GHG emissions.

Within the industrial sector, energy is consumed primarily in the petroleum refining, iron and steel, upstream mining, aluminum, organic chemicals, pulp, newsprint and other paper industries. Together, these sectors accounted for 65 percent of total industrial energy demand in 1998 (see Figure 28).

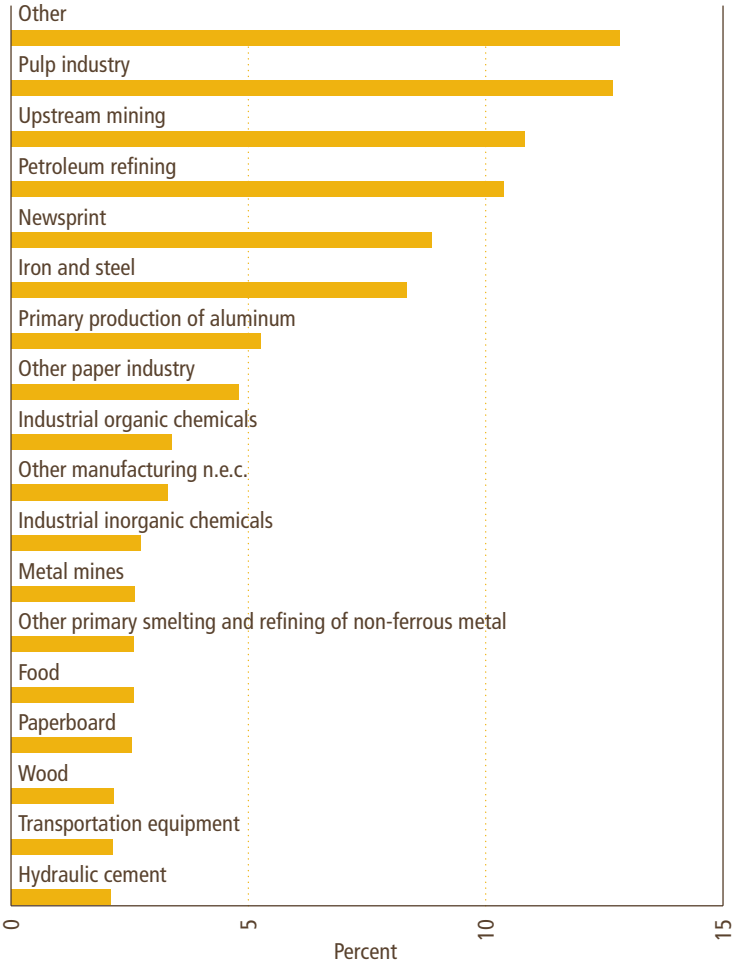
In most industries, energy purchases account for only a small proportion of total expenditures. However, for some relatively energy-intensive industries – lime, cement, magnesium and aluminum – this share is higher than 15 percent (see Figure 29).

After decreasing slightly from 1990 to 1991, as a result of the recession, industrial energy use had increased by about 10 percent (272 petajoules) by 1998 (from 2754 to 3027 petajoules) (see Figure 30). Two main factors increased industrial energy use – activity and structure:

- *activity* – increases in physical industrial output and gross domestic product (GDP) contributed to an increase in energy use of 16.5 percent (455 petajoules);
- *structure* – the change in the mix of activity toward more energy-intensive industries (such as pulp and paper, iron and steel, aluminum and mining) resulted in a 2.2 percent increase in energy use (62 petajoules).

If only these two factors had been in effect, industrial energy use would have increased by 18.7 percent (517 petajoules). However, improvements in energy efficiency worked to decrease energy use by 5.3 percent (145 petajoules). As a result, energy use increased by only 10 percent. This change in energy use during 1990 to 1998 as well as the energy savings due to energy efficiency are shown in Figure 30.

FIGURE 28
Industrial Energy Use by Subsector, 1998



n.e.c. = not elsewhere classified

Whereas energy use between 1990 and 1998 increased by 10 percent, industrial GHG emissions increased by only 9.1 percent.

NRCan delivers initiatives to increase energy efficiency in the following subsectors of the industrial sector:

- Industrial Processes and Technologies; and
- Equipment.

FIGURE 29
Cost of Energy to Industry as Percentage of Total Production Cost, 1997

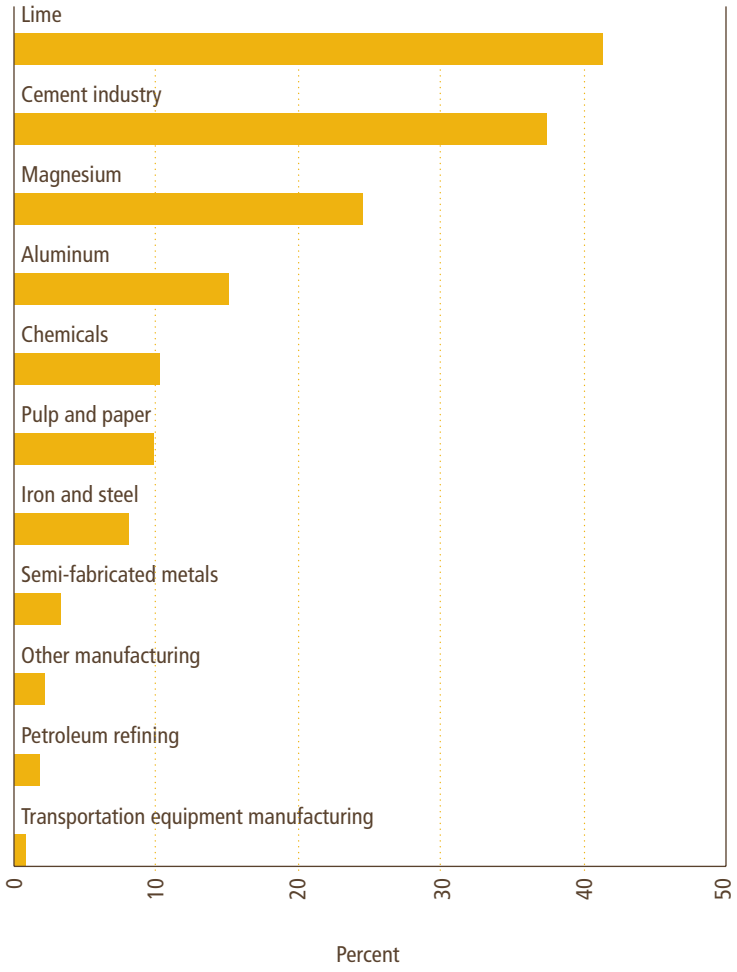
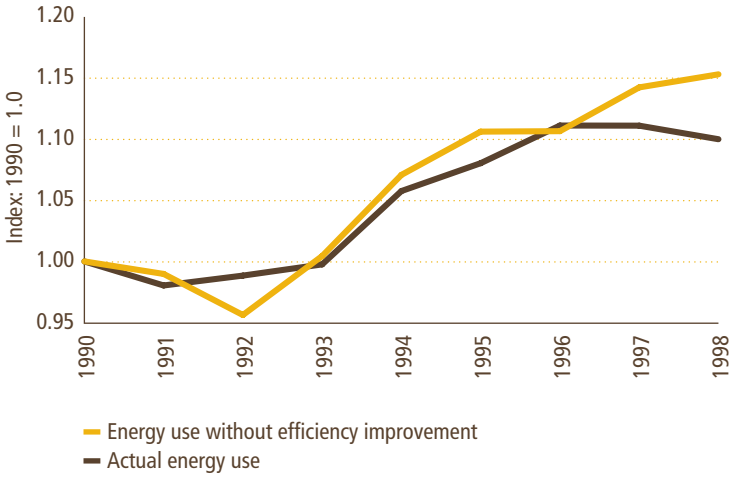


FIGURE 30
Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998



Industrial Processes and Technologies

NRCan promotes energy efficiency in the industrial sector through the following initiatives:

- Industrial Energy Efficiency (IEE);
- Industry Energy Research and Development (IERD) Program;
- Emerging Technologies Program;
- Industrial Process Integration Program;
- Industrial Process Engineering Program;
- Advanced Combustion Technologies Program (ACTP);
- Energy Technologies for High-Temperature Processes;
- Processing and Environmental Catalysis Program (PECP); and
- Minerals and Metals Technologies Initiative.

NRCan also provides technical advice to Canada Customs and Revenue Agency (CCRA) on applications by companies to depreciate their assets under Class 43.1 of the *Income Tax Act*. This class provides an accelerated capital cost allowance to manufacturing and process industries for certain types of energy-efficient or renewable energy equipment. NRCan advises on whether the equipment in question meets or would meet the technical conditions spelled out in regulations.

Industrial Energy Efficiency

The IEE provides a framework for a voluntary industry–government alliance to achieve greater energy efficiency in Canada's manufacturing and mining sectors. It uses a two-tiered approach – it operates at the industrial sector level through the Canadian Industry Program for Energy Conservation (CIPEC) and, at the company level, through the Industrial Energy Innovators Initiative (IEII).

CIPEC has task forces for a majority of industrial sectors to determine their potential for energy efficiency improvements, establish targets for improvement, create action plans for reaching these targets, and track and report on progress. These task forces also provide a forum for stakeholders to identify common needs in areas such as energy management planning, technical information, financing, training and employee awareness. NRCan works with the task forces to develop appropriate services to satisfy these needs.

Once CIPEC task forces establish targets and action plans, the IEII helps to transform these commitments into company action. To become an Industrial Energy Innovator, a company commits to

- develop and implement a target and action plan for energy efficiency improvement;
- appoint a corporate energy efficiency champion; and
- track its improvements in energy efficiency and report on them annually against its action plan.

NRCan provides tools and services for Innovators such as employee awareness kits, best practices guides, technical information and workshops on energy management.

CIPEC encourages Industrial Energy Innovators to register their action plans with VCR Inc., which provides a public record of an organization's commitments, action plans and results on energy efficiency and greenhouse gas (GHG) emissions.

Achievements 1999–2000

- For the years 1990–1999, CIPEC sectors achieved an average annual aggregate energy intensity improvement of 2.0 percent. Their direct GHG emissions from energy use declined to 1.9 percent below the 1990 level.
- In October 1999, industries participating in CIPEC extended their commitment to improve their average annual energy intensity by 1 percent per year for the period 1990–2000 for five more years until 2005.
- Participation in CIPEC increased:
  - two new task forces were created (increasing the total from 21 to 23) – the Western Canada and the Quebec regional task forces of General Manufacturing; and
  - three new trade associations joined CIPEC (increasing the total from 31 to 34) – the Canadian Association of Man-Made Vitreous Fibre Manufacturers, the Canadian Meat Council and the Food and Consumer Products Manufacturers Council of Canada.
- A total of 98 industrial companies sent 212 employees to energy management workshops sponsored by NRCan.
- In order to help industrial companies improve their energy efficiency, NRCan developed and released a video and poster on compressed air savings.

Industry Energy Research and Development (IERD) Program

The IERD program encourages and supports 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 research and development 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.

Achievements 1999–2000

- NRCan is working with Gamma Engineering Ltd. of Whitby, Ontario, to design, develop and construct a new system to service hot metal ladles in steel mills. The new system would save energy through on-line replacement of nozzles and plugs in the hot ladle, rather than taking the ladle off-line, cooling it, replacing the plugs and nozzles and reheating it before placing it back in service.
- Nautel Ltd. of Hackett's Cove, Nova Scotia, is developing, with NRCan assistance, 50- and 100-kW solid-state radio frequency (RF) amplifiers, as well as the associated "matching network" for industrial drying purposes. Current RF drying methods are based on vacuum-tube technology, but vacuum tubes are becoming obsolete and are less energy efficient than solid-state devices.
- NRCan supported Sigmabond Technologies Corporation of Toronto, Ontario, in its development of a new copper/aluminum electrical connection foil produced by explosive welding and subsequent rolling. The purpose of the foil is to provide a clean metallic interface between these two dissimilar metals, which can reduce energy losses and eliminate galvanic corrosion for industrial electrical power users that need to connect copper and aluminum conductors in their facilities.
- NRCan worked with Menex Technologies Inc. of Edmonton, Alberta, in the development of a more efficient gas wellhead flow controller. The new controller is designed to continually optimize well production in order to reduce costs, increase safety and recover 10–15 percent more gas.

Emerging Technologies Program (ETP)

The ETP supports the identification and demonstration of new and emerging energy-efficient technologies. The 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. Program clients from across Canada represent a wide range of industrial sectors and company sizes.

Achievements 1999–2000

- In the first of a series of projects intended to demonstrate the benefits of artificial intelligence (AI) in different applications in Canadian industry, NRCan supported the application of AI systems at the Millar Western Pulp Mill in Meadow Lake, Saskatchewan. The systems are designed to optimize the pulp bleaching process and the scheduling of pulp grade changes, which will reduce chemical use, energy use and waste generation.
- NRCan helped SSI Special Services Inc. of Red Deer, Alberta, to develop, certify and demonstrate a novel system for the rapid and safe control of gas and oil well blow-outs. Current practice involves placing blow-out control devices in well piping manually, which is slow, dangerous and wastes energy resources while the well is being brought under control. To address these problems, the company is developing an automated system for handling and placing these devices in well piping.

- NRCan worked with Orenda Aerospace Corporation in field trials of a Mashproekt GT2500 gas turbine using biomass-derived liquid pyrolysis fuels. The trials showed that an industrial gas turbine of this class can be operated entirely on liquid biomass-derived fuel with efficiencies very close to those realized with diesel fuel, and with significantly lower SO_2 and NO_x emissions.
- NRCan supported a project at the Seymour Reservoir in Vancouver, British Columbia, to evaluate four new ultrafiltration membrane systems. These systems offer the potential to produce high-quality drinking water in an energy-efficient manner.

Industrial Process Integration Program

The program supports the development and adoption of process integration in various industries. It focuses on the following:

- combined heat-and-power optimization methodologies;
- total site optimization methodologies;
- water-pinch optimization methodologies in the agri-food, pulp and paper and textile industries; and
- the building of an international-calibre Canadian capacity in process integration.

Achievements 1999–2000

- NRCan developed and transferred to Cascades Inc. a software program that allows the systematic optimization of industrial water networks in order to reduce water consumption and, consequently, wastewater generation and energy use. Cascades will use the software in its 45 pulp and paper mills. A network optimization study done at a Cascades Inc. paperboard mill demonstrated the possibility of an 80-percent reduction in water consumption, the complete reuse of mill effluent and the reduction of up to 25 300 tonnes/year of GHG emissions.
- NRCan initiated a process integration study at the Cartons St–Laurent paperboard mill in La Tuque, Quebec, to identify energy and water reduction opportunities in the paper machines section of the mill. The first phase will gather detailed mass and energy balances data using a methodology developed by NRCan. The second phase will propose various alternative water and steam network configurations.
- NRCan, Quebec's Agence de l'efficacité énergétique and a textile dyeing company agreed to co-operate in the use of process integration methods to reduce water, energy and chemical consumption in a textile dye house in Quebec. Other team members include an engineering firm specializing in treating wastewater using membrane technologies and a consulting engineering firm specializing in textiles. If the project proves successful, an energy efficiency program based on process integration will be developed for the textile industry as a whole.
- In co-operation with the Association des industries forestières du Québec (AIFQ), NRCan worked on the development of an energy efficiency program in the pulp and paper industry through the application of process integration methodologies.

Industrial Process Engineering Program

The program aims to improve the energy intensity of existing dryers and to develop new drying technologies. The program focuses on building a Canadian capacity to

- improve the existing dryer base;
- commercialize the pulse fluid bed and jet-spouted bed dryers in the agri-food industry;
- develop and commercialize intelligent control systems for dispersion-type dryers;
- assess opportunities for advanced controls in the drying industry; and
- assess the potential of new residue upgrading technologies.

Achievements 1999–2000

- The U.S. Patent and Trademark Office accepted NRCan's U.S. patent application for the pulse fluid bed dryer (PFBD) technology. The PFBD technology employs a valve distributor that periodically directs the fluidizing air stream to different sections of the bed's plenum chamber. Advantages over conventional fluid beds include the ability to fluidize materials with broad particle size ranges and particles of uneven shape, and to operate with lower pressure drop, shallow beds and a lower flow rate, resulting in a more economic and energy-efficient operation.
- In collaboration with a vegetable producer, a Quebec government department and a manufacturer of industrial dryers, NRCan worked on organizing the first industrial showcase for its innovative PFBD industrial drying technology. The project is designed to allow the vegetable producer to market 30 tonnes of carrots a day that would otherwise be wasted.
- NRCan completed the development of the jet-spouted bed dryer (JSBD). The JSBD is an energy-efficient industrial drying technology well suited for food and food processing residues. It was decided to build the first pilot-scale demonstration unit at the Food Development Centre in Manitoba.
- Bousquet Frères Limitée of Sainte-Julie, Quebec, manufactures and sells natural gas heating/ventilation units ranging from 250 000 to 1 500 000 Btu/h based on a concept developed by NRCan. NRCan worked to help the company develop the production drawings and the technical/commercial brochure for a new 7 500 000-Btu/h unit based on the same technology.

Advanced Combustion Technologies Program

The Advanced Combustion Technologies Program helps 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. The program's research focuses on optimizing the performance of stationary 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.

The program's facilities include seven pilot-scale industrial boilers and furnaces, laboratories for equipment testing, laser diagnostics and fuel characterization, as well as emissions monitoring capabilities and strong computer modelling capabilities.

The program serves clients from a variety of sectors, including electrical utilities and other operators of stationary combustion facilities; oil, coal and natural gas producers; pulp and paper producers; combustion equipment manufacturers; software developers; industry associations; federal and provincial government departments and standards-writing organizations.

Achievements 1999–2000

- NRCan carried out verification tests on a patented Chinese technology known as "One Furnace, Two Functions" at the department's vertical combustor pilot plant. This technology improves the utilization of ashes from a coal-fired power plant by adding an ash modification component which simultaneously allows the boiler to produce steam and high-quality cement clinker. It might also improve combustion performance by lowering the proportion of unburnt carbon in ashes and reducing SO_2 emissions.

- NRCan provided technical assistance on the design, construction and operation of the first prototype of a 300-kW straw gasifier, which will be used for space heating at a manufacturing plant in Arborg, Manitoba. The unit was designed to operate on flax and wheat straw, both of which are readily available in Manitoba and Saskatchewan. Work began on a patent application for the feed system.
- NRCan developed a proposal to demonstrate an industrial-scale gasification plant in rural China that would supply the energy needs of 2000 families and selected small industries. The project would examine the feasibility of using rice straw and other greenhouse-gas-neutral waste biomass materials and assess the feasibility of producing fertilizer and bio-oil in addition to fuel gas, steam and electricity.
- NRCan presented a series of technical seminars on oil-heating systems to more than 250 members of the Canadian Oil Heat Association. The seminars concentrated on advances in oil-heating technology and how to make existing oil-heating installations more efficient and environmentally friendly.

Energy Technologies for High-Temperature Processes

The Energy Technologies for High-Temperature Processes program is designed primarily to improve the energy efficiency, productivity and operating costs of Canadian metallurgical processes. It includes initiatives to improve coke technologies; enhance coal selection, storage, transportation, handling and utilization; and study the injection of biomass and waste materials into blast furnaces.

Achievements 1999–2000

- National Steel, one of the largest steelmakers in the United States, asked NRCan to evaluate several coals to determine the one most suitable for blast furnace injection. As a result of the increased productivity and energy efficiency of their furnaces using the recommended coal, the company began to request all of its blast furnace coal suppliers to provide NRCan with combustibility studies of their product.
- Ten different coals were evaluated by NRCan to select the one best suited for Falconbridge Ltd. to use in the process of reducing nickel-bearing laterite ore for production of ferronickel. The evaluation looked at coal reactivity and coal tar aromaticity by combined thermogravimetric and infrared analysis. A number of other analyses were conducted, including the chemistry and fusibility of ash, to compare fuel properties. Based on the results of the study, Falconbridge will undertake demonstration stage work in Germany on the use of coal as a reductant in a fluidized bed reactor which will lead to a more energy-efficient production process.
- NRCan completed a project comparing the combustibility of western Canadian coals with foreign coals for blast furnace injection. Canadian coals performed well, with good burnout despite relatively low volatile matter content, less slag formation because of their lower sulphur content and less energy needed for pulverizing. As well, Canadian chars were found to burn as efficiently as foreign ones at the tuyere tip and in the blast furnace raceway.
- NRCan began a laboratory column study aimed at better understanding the movement of moisture in coal and its effect on coal deterioration. The examination of a number of factors is required to better understand the process, including coal particle size, bulk density, initial moisture content and the effect of rain on drainage – i.e., the effect of flowing water versus stagnant water. The laboratory column study is a first step and will be followed by a more detailed study in real coal stockpiles at mine sites or ports. Improved storage and handling of coal can reduce environmental impacts and improve combustion efficiency by maintaining a higher energy content of the fuel.

Processing and Environmental Catalysis Program (PECP)

The PECP seeks to solve industrial process problems and research 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. The program targets energy efficiency in chemical processing and works with consortia to

- develop catalytic systems for NO_x removal from engine emissions;
- convert natural gas to liquid fuels, fuel components, petrochemicals and synthesis gas;
- develop a process to derive high-quality transportation fuels from low-value, biomass-derived oils;
- convert low-grade heat to electricity to increase industrial energy efficiency; and
- develop high-temperature ceramic membranes for hydrogen separation and purification.

Clients include oil and gas companies, petrochemical companies, original engine manufacturers, waste oil renderers and specialty ceramic manufacturers.

Achievements 1999–2000

- NRCan proved the concept of a novel technology to convert low-grade heat to electricity using pyroelectric conversion. The technology will increase the energy efficiency of industrial processes by exploiting the energy contained in low-temperature process streams that are currently discarded. Estimates show the potential for a 10-percent reduction in energy consumption for a typical pulp and paper operation using this new technology.
- NRCan is one of seven partners in the Consortium on the Conversion of Natural Gas, an international R&D program. The department realized significant achievements through the consortium this year, including the development of an innovative process for direct conversion of natural gas to value-added oxygenated products, a process that saves energy and is also a net producer of energy. NRCan also developed a robust active catalyst for the production of synthesis gas – the building block for a suite of fuels and chemicals – from natural gas. The catalyst will decrease the energy requirements for synthesis gas production.
- The department also successfully developed, through the consortium, a methodology for the preparation of high-performance dense-phase ceramic membranes for hydrogen separation, which has achieved the highest reported performance in terms of permeation rates and separation. This development has the potential for a range of applications in the petrochemical and fuel cell industry. Hydrogen separation at high temperatures saves process energy since it does not require cooling prior to separation.
- NRCan developed a microemulsion process which allows bio-oils produced from the fast pyrolysis of biomass to be mixed with diesel to produce a stable fuel. The use of biofuels in diesel engines offers improved efficiency and lower GHG emissions. The potential of this development for industrial applications has attracted strong interest in Europe and NRCan is working with the European Union to develop markets for the bio-oil blends in Europe and North America.
- The department has proven a novel concept for an energy-efficient process to remove sulphur from diesel fuels. This "lower temperature" process can be applied to waste oil streams as well as conventional diesel fuel.

Minerals and Metals Technologies Initiative

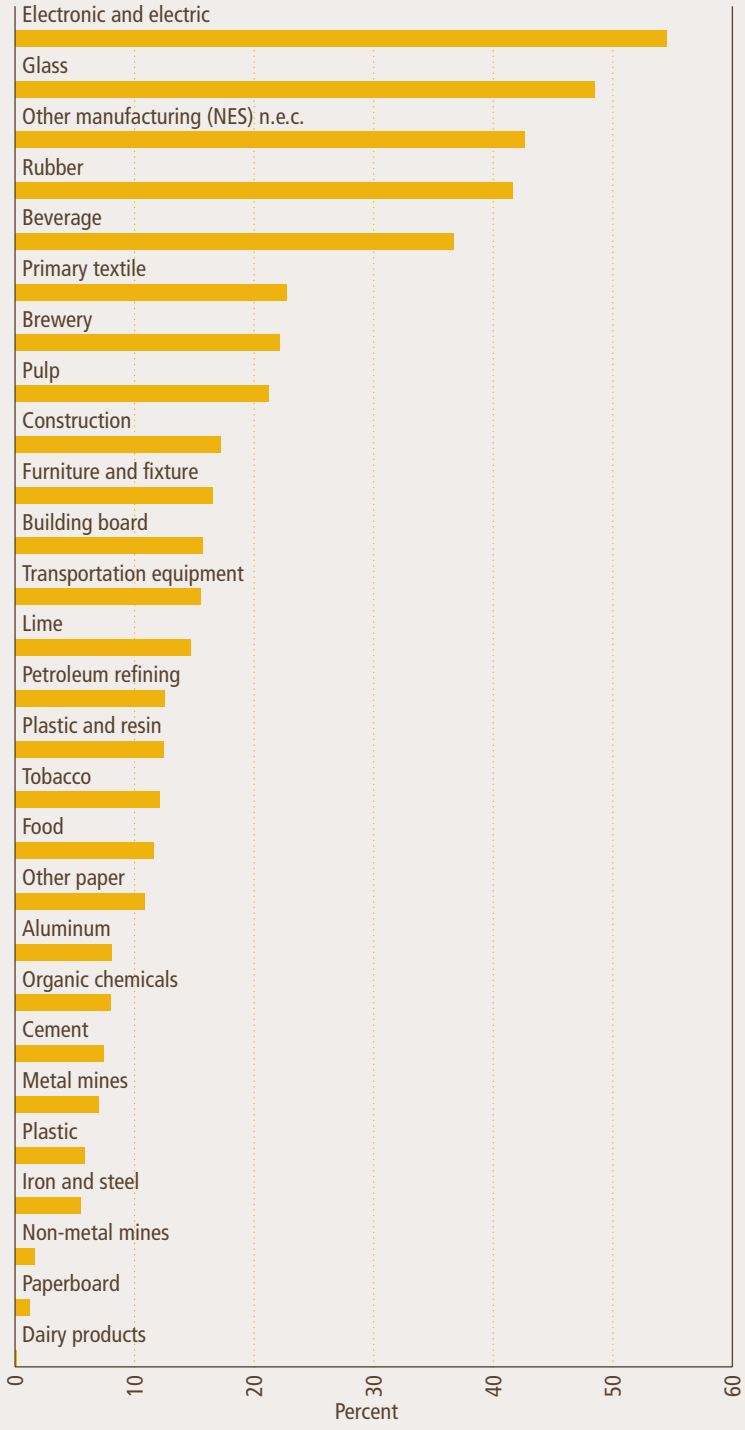
The Minerals and Metals Technologies Initiative helps Canada's minerals and metals industries improve energy efficiency and reduce energy costs. Many of the initiative's research projects involve increasing the use of recyclable materials or improving or eliminating industrial processes that use excessive energy. Activities include technology development and pilot-scale demonstration projects with industry that focus on information dissemination, technology transfer and product commercialization. Partners include Canadian companies – especially foundries – provincial governments, energy utilities and industrial, trade and standards associations.

Achievements 1999–2000

- A consortium including NRCan optimized the design of the CANDRILL, a water-powered rock drill which has been developed for Canadian conditions. Tests indicate that CANDRILL, when compared to compressed air equivalents, could offer improved energy efficiency (up to 30 percent) along with double the penetration rates, reduced vibration, less dust and elimination of oil emissions. Final trials of the CANDRILL are scheduled for the spring of 2000 and commercialization for January 2001.
- NRCan continued to promote and introduce energy efficiency to the mining industry through ventilation automation and optimization. Ventilation is typically responsible for 40 percent of an underground mine's total energy use. In 1999–2000, NRCan assisted four mines in achieving more efficient ventilation.
- NRCan co-led a North American underground mining vehicle fuel cell consortium, which was launched in 1999–2000. The consortium includes mining companies, equipment manufacturers, research organizations, government regulatory agencies and trade unions. Their goal is to replace diesel with hydrogen fuel cells as the energy source for underground mine production vehicles. This could resolve a number of industry issues, including the need to lower production costs through reduced ventilation as well as lower natural gas use for mine air heating/electricity consumption.
- NRCan's International Centre for Sustainable Development of Cement and Concrete (ICON) continued to promote the use of high-volume fly ash concrete (HVFC). Fly ash, a by-product of coal burning in power plants which normally goes to landfill, can be substituted for a portion of the Portland cement in concrete. HVFC technology saves energy and reduces GHG emissions, since manufacturing cement for concrete is very energy intensive and releases about one tonne of GHG per tonne of cement. The use of HVFC technology can also increase the durability of concrete. During the year, NRCan participated in demonstration projects of this technology – in particular, the structural framework of the Liu Centre for Global Studies at the University of British Columbia uses concrete made from a high-volume (50 percent) fly ash system designed by NRCan.
- NRCan provided secretariat support to an industry steering committee leading the Canadian Lightweight Materials Research Initiative (CLiMRI), a government–industry partnership aimed at developing materials and manufacturing processes for fuel-efficient vehicles (a key factor in improving vehicle efficiency is vehicle weight – for every 10-percent reduction in vehicle weight, there is a 6 to 8-percent improvement in fuel efficiency). The CLiMRI research program started in April 1999 with an initial set of 11 projects. In addition to NRCan, the National Research Council Canada and five universities perform the research, supplemented by the work of private sector R&D centres.

Progress Indicators

FIGURE 31
Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 1998



n.e.c. = not elsewhere classified

During 1990 to 1998, 27 of the 39 industrial sectors improved their energy efficiency. The most notable efficiency gains were made by the electronic and electric, glass, other manufacturing, rubber and beverage sectors, which realized efficiency gains of 37 to 55 percent (see Figure 31).

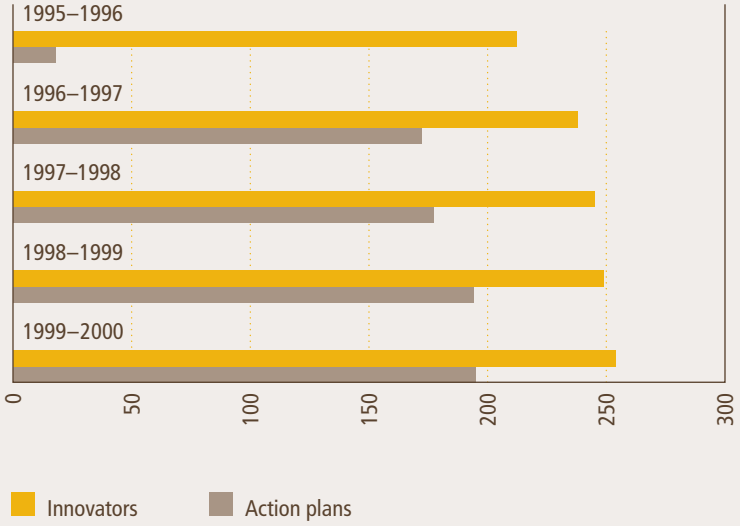
CIPEC reports on approximately 90 percent of total industrial energy demand through 21 task forces. Although not all companies in every industrial subsector are aware of CIPEC, each task force reports progress for its entire subsector, as defined by Statistics Canada's Standard Industrial Classification (SIC) system. Data from the Industrial Consumers of Energy (ICE) Survey enable the CIPEC task forces to compare their performance with their energy efficiency improvement targets. Where possible, CIPEC measures energy efficiency as energy use per physical unit of production. Where physical denominators are not available, an economic denominator is used.

Progress Indicators (continued)

Most task forces have committed to energy efficiency improvements of 1 percent per year from 1990 to 2005. Exceptions are breweries (3 percent), textiles (2 percent), cement (0.7 percent) and electronic and electric (1.25 percent). During 1990–1999, the energy intensity of the then-21 CIPEC task forces improved on average by 2.0 percent per year.

By March 2000, the IEEI had recruited 254 industrial companies as Industrial Energy Innovators, representing about 74 percent of industrial energy use (see Figure 32). By March 2000, 195 participants had prepared action plans describing their energy efficiency projects.

FIGURE 32
Industrial Energy Innovators and Action Plans, 1995–1996 to 1999–2000



Equipment

Energy Efficiency Regulations

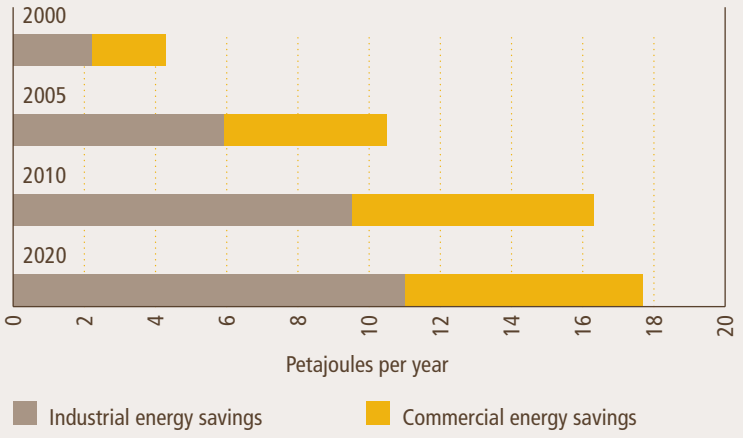
Under the authority of the *Energy Efficiency Act*, NRCan sets *Energy Efficiency Regulations* for selected types of energy-using equipment, to eliminate less energy-efficient products from the market. The Regulations prohibit imports of or interprovincial trade in prescribed products that fail to meet minimum energy performance levels. The Regulations incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. NRCan funds and participates in nationally accredited standards-writing committees administered by CSA International to foster the development of these standards.

Achievements 1999–2000

- NRCan conducted analyses of energy savings and undertook consultations on possible performance standards for electric distribution transformers, both dry and liquid. Stakeholders verified the analyses and suggested alternate approaches to realize these energy savings. In the case of liquid type transformers, electric utilities and manufacturers proposed a voluntary approach through their Environmental Commitment and Responsibility Program. In the case of dry transformers, considerable support was expressed for mandatory standards and NRCan began to draft a regulation to that effect.

Industrial Sector: Equipment
Progress Indicators

FIGURE 33
Energy Savings from Motor Regulations, 2000 to 2020



Amendments to the *Energy Efficiency Regulations* in 1997 raised the efficiency standard for industrial motors by about 5 percent. NRCan estimates that the aggregate annual energy savings from the amendment to the motor efficiency regulations will be 16.3 petajoules in 2010 (see Figure 33). The estimated reduction in GHG emissions resulting from these savings will be more than 2 megatonnes in 2010. More than half of the projected energy savings are expected to come from the industrial sector.

Chapter 6

Transportation Sector

Energy Use and Greenhouse Gas Emissions

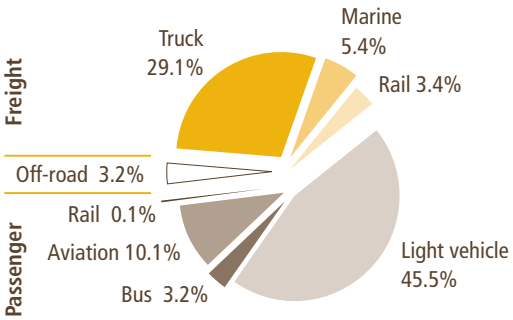
The transportation sector consists of three subsectors: passenger, freight and off-road. Passenger and freight transportation account for 59 and 38 percent respectively of transportation energy use, with off-road representing only 3 percent. The passenger subsector is composed of three modes: road, rail and air. The freight subsector comprises road, rail and marine. Road transport uses the most energy, accounting for 78 percent of total transportation energy use – 83 percent of passenger energy use and 77 percent of freight energy use (see Figure 34). All NRCan transportation energy-use programs focus on the energy used in road transportation.

Transportation energy use increased by over 16 percent (304 petajoules) from 1990 to 1998 (see Figure 35). Passenger transportation energy use increased by almost 10 percent (116 petajoules) while freight transportation energy use increased by over 26 percent (171 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 tonnes-kilometres for freight transportation). This increased transportation energy use by almost 16 percent (293 petajoules). The freight and passenger segments contributed to this increase by 46 percent and 54 percent respectively; and
- *structure* – shifts between modes of transport were significant in the freight segment, resulting in an increase of over 7 percent in transportation energy use (134 petajoules).

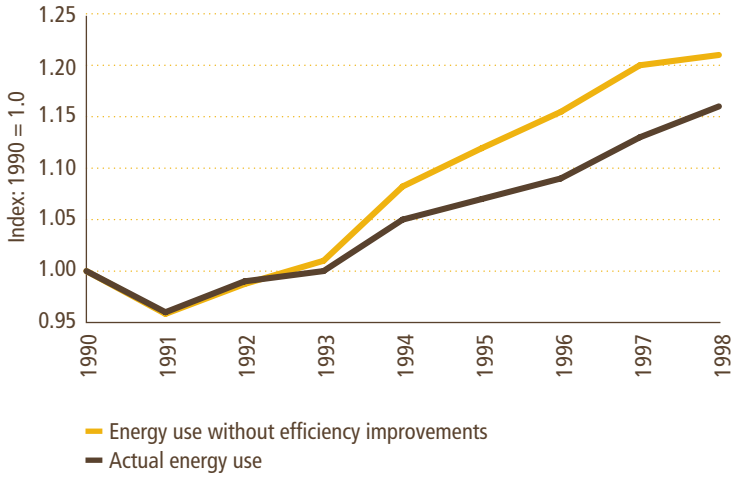
If only these two factors had been in effect, transportation energy use would have increased by almost 23 percent (426 petajoules). However, improvements in energy efficiency worked to decrease energy use by 5.5 percent (103 petajoules). As a result, energy use increased by only 16 percent. This change in energy use during 1990 to 1998, as well as the energy savings due to energy efficiency, is shown in Figure 35.

FIGURE 34
Transportation Energy Use by Mode, 1998



Total: 2182 Petajoules

FIGURE 35
Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998



The transportation sector accounts for over 28 percent (2182 petajoules) of secondary energy use and over 34 percent (157 megatonnes) of GHG emissions. From 1990 to 1998, transportation energy use increased by over 16 percent, and GHG emissions also increased by over 16 percent. The change in GHG intensity of transportation energy use was negligible.

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

- personal vehicles;
- commercial fleets;
- transportation research and development; and
- alternative transportation fuels.

Personal Vehicles

NRCan promotes the production and purchase of more energy-efficient vehicles and more energy-efficient use and maintenance of these vehicles through

- the Vehicle Fuel Efficiency Initiative;
- EnerGuide for Vehicles; and
- Auto$mart.

Vehicle Fuel Efficiency Initiative

The Vehicle Fuel Efficiency Initiative is a voluntary initiative with vehicle manufacturers to improve motor vehicle fuel efficiency. The initiative encourages manufacturers to voluntarily meet standards for company average fuel consumption (CAFC) for new automobiles and light trucks sold in Canada. In addition, under a Memorandum of Understanding (MOU) with domestic and international vehicle manufacturers, NRCan and the manufacturers pursue opportunities to improve both new vehicle and on-road vehicle fuel efficiency through changes to both vehicle technology and the behaviour of vehicle owners and operators. This initiative is managed by NRCan and Transport Canada in cooperation with motor vehicle manufacturers.

Achievements 1999–2000

- NRCan initiated discussions in August 1999 with the U.S. Department of Energy (DOE) to assess the possibility of a North American voluntary fuel economy program. By January 2000, NRCan and the DOE agreed to cost-share a research study to examine several options for, and the impacts of, a new voluntary North American vehicle fuel efficiency program.
- NRCan developed a database on new fuel efficiency technology introduced by vehicle manufacturers to provide information for new vehicle fuel efficiency policy analysis.
- NRCan updated and segmented its Vehicle Information System to produce a trend analysis of new vehicle fuel efficiency in a report entitled *Canadian New Light-Duty Vehicles: Trends in Fuel Consumption and Characteristics*.

EnerGuide for Vehicles

The EnerGuide for Vehicles initiative informs consumers about the fuel efficiency of new light-duty vehicles to help them choose the most fuel-efficient vehicle that meets their needs. Under a voluntary agreement, vehicle manufacturers affix an EnerGuide fuel consumption label to new passenger cars, vans and light-duty trucks. The standardized label shows the vehicle's city and highway fuel consumption ratings and estimated annual fuel cost. The annual *Fuel Consumption Guide*, which is available at vehicle dealerships, most motor vehicle agency offices and on the Internet, provides the same information for all light-duty motor vehicles. The annual EnerGuide Awards for the Most Fuel-Efficient Vehicles help make consumers aware of the model year's most fuel-efficient vehicles in each size class. The program works in close collaboration with Auto$mart, sharing the same Web site and toll-free publication line.

Achievements 1999–2000

- The program raised awareness and increased the use of the program's goods and services:
  - traffic to Web pages (*Fuel Consumption Guide*, EnerGuide label and Most Fuel-Efficient Vehicles) reached 105 471 user sessions, an increase of 390 percent over 1998–1999;
  - requests through the toll-free line led to the distribution of 95 046 publications;
  - the program received extensive media coverage (over 110 separate articles or ads) in the form of free advertisement placement, media stories and editorials, for a total reach of over 24 million Canadians; and

- in responses to an NRCan survey,
  - 29 percent were aware of the *Fuel Consumption Guide*;
  - 27 percent were aware of the EnerGuide label for vehicles; and
  - 38 percent were aware of the awards given to the most fuel-efficient vehicles.
- A survey of car dealers in late 1999 showed that the majority of vehicle manufacturers introduced the new EnerGuide label, which was required after January 1999. However, only 64 percent of vehicles on car dealer lots and 47 percent of vehicles in car dealer showrooms displayed the label. A strategy to reinforce compliance under the agreement was prepared toward year-end, for discussion with the Canadian Automobile Dealers Association (CADA) and the vehicle manufacturers.
- The *Fuel Consumption Guide* continued to grow in popularity, with over 500 000 copies of the 2000 edition requested compared to 470 000 copies for the 1999 edition and 450 000 for the 1998 edition.
- The EnerGuide Awards generated over 40 free media stories. The six winning manufacturers developed showroom, newspaper, magazine, radio and TV advertisements for their winning vehicles.

Auto$mart

Auto$mart encourages and assists motorists to buy, drive and maintain their vehicles in energy-efficient ways that save fuel and money, and it emphasizes how such efforts also reduce vehicle emissions. Its main tool is the *Auto$mart Guide*, which offers useful information and tips on purchasing, operating and maintaining personal vehicles. The initiative also provides fuel efficiency training for new drivers, provides information packages to support the initiatives of local governments, industry and associations to promote fuel efficiency, and it offers information on opportunities to use alternative fuels.

Achievements 1999–2000

- A total of 116 new driving instructors registered with the program, bringing the total instructors who incorporate Auto$mart material into their curriculum to 882. The instructors taught almost 235 000 novice drivers in 1999–2000, raising the total number of students who have received training on vehicle fuel efficiency to over half a million since 1997.
- NRCan's awareness and promotional activities involved distributing about 200 000 publications (60 percent of these were the *Car Economy Calculator*), registering over 104 422 user sessions on its Web pages and reaching 23 million Canadians through 369 free regional media coverage articles.
- The Auto$mart and EnerGuide for Vehicles programs together received over 10 000 calls on the toll-free information line, an increase of 250 percent over the previous year.
- A major focus for the Auto$mart program was the development of a community-based single issues campaign. Such a public education campaign would be delivered by local government and environmental groups through fuel efficiency messages dealing with a single issue, such as reduced idling. During the year, NRCan developed a strategic framework for the campaign, conducted initial market research, consulted with potential partners – municipal environmental coordinators and local environmental associations – and tested public messages.

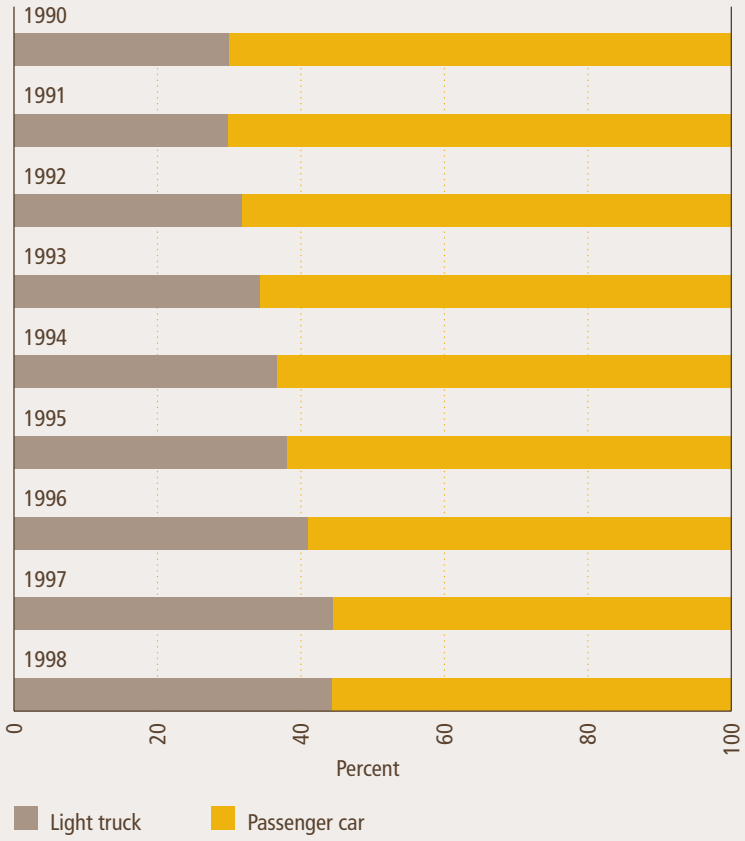
Progress Indicators

TABLE 4
Vehicle Vintage and Characteristics*

Year/vintage	1970s and earlier	1980s vintage	1990s vintage
Weight (tonnes)	2.0	1.5	1.6
Horsepower	135.0	100.0	140.0
Weighted average economy (L/100 km)	16.4	10.6	10.1

* Average new car from each model year

FIGURE 36
Market Shares of New Light Trucks and Passenger Cars, 1990 to 1998



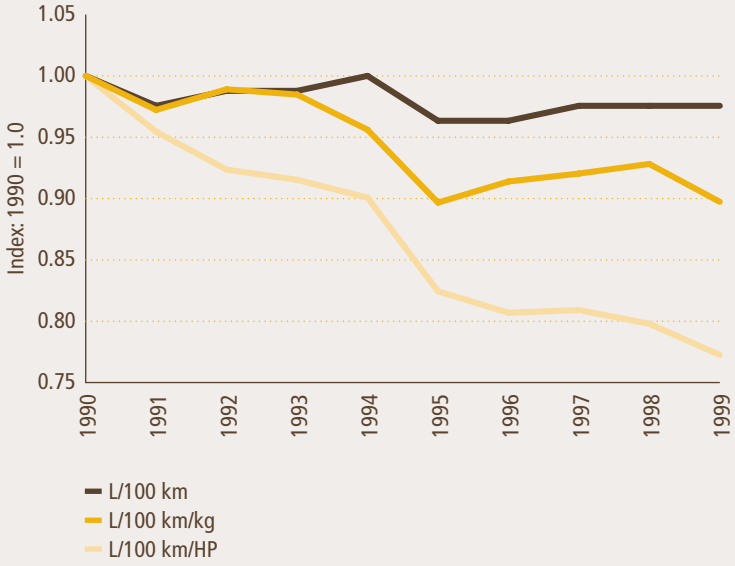
The conventional measure of transport fuel consumption is litres of fuel burned per 100 kilometres travelled (L/100 km). The most rapid fuel consumption improvements, measured in these units, occurred in the late 1970s and early 1980s, mainly because the newer vehicles weighed less and were less powerful than cars built in the 1970s. Vehicles built in the 1990s tend to be more powerful and, to a lesser degree, heavier, and this trend seems to have slowed new vehicle fuel efficiency improvements (see Table 4).

From 1990 to 1998, the energy intensity of the light-duty vehicle market (cars and light trucks) declined, as more efficient vehicles came on the market. The average fuel consumption of new light-duty vehicles (cars and light trucks combined) improved by 3.0 percent from 1990 to 1998, and the average on-road fuel consumption of the total stock of light-duty vehicles in Canada increased by 4.5 percent. These improvements occurred in the face of a trend toward heavier, more powerful vehicles in the 1990s. For example, the share of light trucks in the new light-duty vehicle market increased from 30 percent in 1990 to 44 percent in 1998 (see Figure 36).

Progress Indicators (continued)

Fuel consumption measurements typically assume fairly stable service characteristics; that is, features for safety, comfort or performance. Vehicle characteristics, however, have changed considerably. As a result, fuel efficiency improvements can be detected by using other indicators than the generally used measure of fuel economy (L/100 km). Two alternative ways to measure fuel efficiency are to standardize for weight and to standardize for power. These fuel consumption indicators have shown more rapid improvement than the L/100 km indicator. Whereas the fuel consumption (L/100 km) of new cars decreased by 2.4 percent from 1990 to 1999, the fuel consumption measured in terms of L/100 km/kg over the same period decreased by 10.3 percent; measured in terms of L/100 km/HP, it decreased by 22.7 percent (see Figure 37). The negative impact of greater vehicle weight and power was more than offset by improved fuel efficiency.

FIGURE 37
New Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 1999



Commercial Fleets

The Government of Canada has two initiatives to increase energy efficiency and the use of alternative transportation fuels:

- FleetWise, for the Government of Canada; and
- FleetSmart, for the private sector and other levels of government.

FleetWise

The FleetWise program helps the managers of federal fleets to improve their operational (including energy) efficiency and accelerate the use of alternative fuels to meet

- the federal objective of reducing 1995 levels of vehicle GHG emissions by 30 percent by 2000;
- the Greening of Government energy and environmental goals; and
- the vehicle acquisition requirements of the *Alternative Fuels Act* and Treasury Board Secretariat's Motor Vehicle Policy.

The initiative provides fleet managers with an assessment of fleets at little or no cost and technical advice on using alternative transportation fuels (ATF) and acquiring alternative fuel vehicles. As well, it campaigns to encourage vehicle operators to select alternative fuels. Four departments participate in planning and reporting on the initiative: Treasury Board Secretariat, NRCan, Environment Canada and Public Works and Government Services Canada (PWGSC). NRCan is responsible for implementing the initiative.

Achievements 1999–2000

- NRCan renewed the Q-Tool database which provides a single, comprehensive source of ATF vehicle prices, regional rebates and incentives and dealers in Canada. National Defence began to use the database in its On-Track vehicle acquisition program, to assess the cost-effectiveness and operational suitability of ATF vehicles being considered for purchase.

FleetSmart

FleetSmart aims to improve the fuel efficiency of, and the use of ATFs in, non-federal vehicle fleets. It provides information materials, workshops, technical demonstrations and training programs to help fleet operators assess and pursue opportunities to increase energy efficiency in their operations. NRCan delivers FleetSmart in partnership with fleet and industry associations and other levels of government.

Achievements 1999–2000

- NRCan distributed the FleetSmart Tool Kit to 114 new clients, bringing the program's client base to a total of 1068 organizations representing more than 123 000 commercial vehicles.
- NRCan continued to expand the network for its main training program – SmartDriver for Heavy Vehicles. During the year, it enrolled 134 driving school instructors (for a total of 179), 105 fleet trainers (for a total of 141), 21 training consultants (for a total of 29), and 20 partners, such as provincial safety councils and trucking associations (for a total of 27).
- NRCan conducted three FleetSmart workshops in partnership with provincial trucking associations.
- NRCan established partnerships with the Forest Engineering Research Institute of Canada and the Canadian Owner-Operator's Co-operative to develop training programs for their members.
- NRCan and the Federation of Canadian Municipalities agreed to develop a comprehensive program to reduce energy use in municipal fleets by the fourth quarter of 2000.

Transportation Sector: Commercial Fleets

Progress Indicators

Since the FleetWise initiative was launched in October 1995, the fleet of federal, on-road civilian vehicles has decreased by about 2400 vehicles – almost 10 percent. At the same time, the annual fuel consumption of the fleet declined by over 10 million litres (gasoline equivalent) – almost 12 percent. The annual consumption per vehicle decreased by 70 litres or almost 2 percent (see Figure 38).

During the last three fiscal years (1997–1998 to 1999–2000), the Government of Canada purchased 473 ATF vehicles (see Figure 39). During this period, the share of these vehicles in the federal fleet increased slowly to 3 percent, as older ATF vehicles have been replaced.

FIGURE 38
Federal Fleet Size and Fuel Consumption, 1995–1996 to 1999–2000

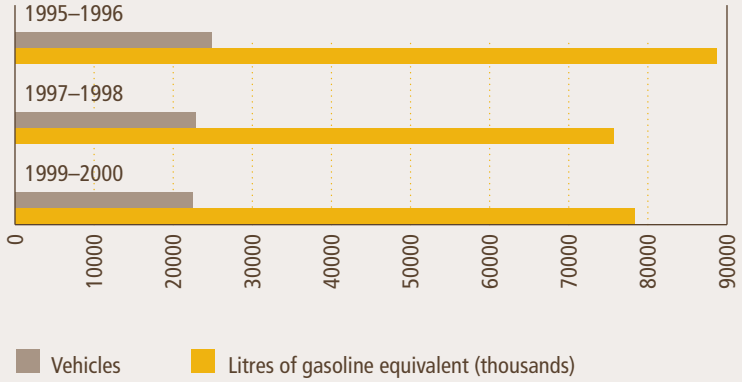
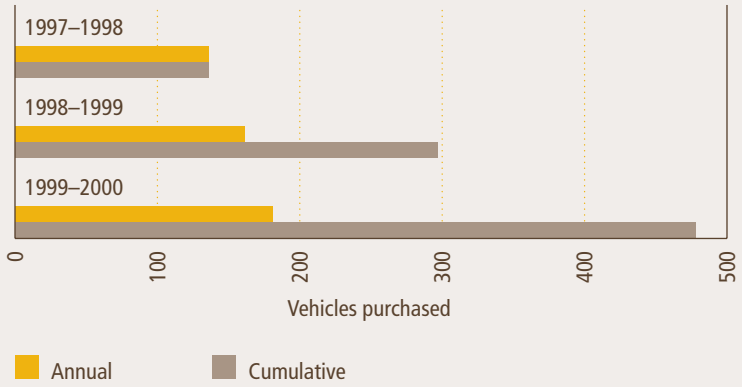


FIGURE 39
Purchases of ATF Vehicles for Federal Fleet



Transportation Research and Development

NRCan promotes energy efficiency and the use of ATFs and ATF vehicles through the Transportation Energy Technologies Program.

Transportation Energy Technologies Program

The program works 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 areas include

- the development of alternative fuels and advanced propulsion systems (gaseous fuels, alcohols, hydrogen, fuel cells, electric vehicles and hybrids and related systems);
- advanced energy storage systems (lightweight cylinders, adsorption technologies and flywheels);
- emissions control technologies (for diesel and alternative fuel engines, lean-burn catalysts and enhanced combustion-chamber design);
- vehicle transportation system efficiency (advanced materials and processes, auxiliaries and regenerative breaking systems); and
- fuelling infrastructure (fuelling station hardware, hydrogen systems and battery charging systems).

The program works in co-operation with stakeholders in the domestic and international transportation industries, including original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial governments, research organizations, universities, other federal departments, the U.S. Department of Energy and the International Energy Agency.

Achievements 1999–2000

- NRCan helped organize and sponsor a number of vehicle "challenge" events for students to raise awareness about more climate-friendly vehicles and vehicle fuels, including
  - the Electrathon, in which participants compete to build an electric vehicle that travels the greatest distance in one hour on one set of batteries;
  - the Future Car Challenge, an attempt to attain 3.55 L/100 km (80 m.p.g.) from a mid-size vehicle;
  - Sunrayce, in which participants build and then race solar-powered vehicles; and
  - the Ethanol Vehicle Challenge, where participants convert a gasoline-powered car to run on E85 (85 percent ethanol and 15 percent gasoline).
- The department co-sponsored, with Environment Canada and the U.S. Department of Energy, the 15th annual Windsor Workshop, which was held in Toronto and provided a forum for dialogue on R&D projects in ATFs. More than 160 people attended from around the world to report on technological developments and to give their views on how the segments of the transportation sector (fuels, vehicles, regulatory/fiscal instruments) should share the burden in meeting GHG emissions reduction targets.
- With the help of NRCan's sponsorship of R&D, two Proton Exchange Membrane (PEM) fuel cell systems of less than 1 kW were deployed to power an Antarctic environmental acquisition site. The patented system design removes the limitations of traditional batteries operating in cold conditions.

- With NRCan support, Advanced Engineering Technology (AET) developed the fast, economical Ignition Quality Tester (IQT) technology to determine the cetane level of diesel fuel. AET applied for approval for the device from the American Society of Testing and Materials. If approved, the IQT may be the first practical alternative to the standard engine test due to its potential for low-cost, real-time evaluations of diesel fuel cetane quality.
- With NRCan support, Spincraft developed a hybrid diesel-electric boat. By using a combination of electric and diesel power, the 19-foot (5.8-metre), eight-passenger boat overcomes the limited running time of a purely battery-powered boat. It substantially reduces fuel consumption and noise without affecting the comfort of passengers, and emits 85 percent fewer GHGs than a similar boat powered by a diesel or gasoline engine.

Alternative Transportation Fuels

NRCan promotes the development and use of ATFs and ATF vehicles through the Future Fuels Market Analysis Initiative and the Natural Gas for Vehicles Incentives Program.

Future Fuels Market Analysis

This initiative encourages the development, production and use of alternative and future vehicle and fuel technologies. The fuels include propane, natural gas, alcohols, electricity and hydrogen. The initiative provides support to fleet operators in the public and private sectors through economic and market studies, emissions and safety assessments, market demonstrations, communications and awareness activities, and general and technical information about fuel options in Canada. The initiative periodically sponsors workshops with the industry and other governments to review market, technical and policy issues.

Natural Gas for Vehicles Incentives Program

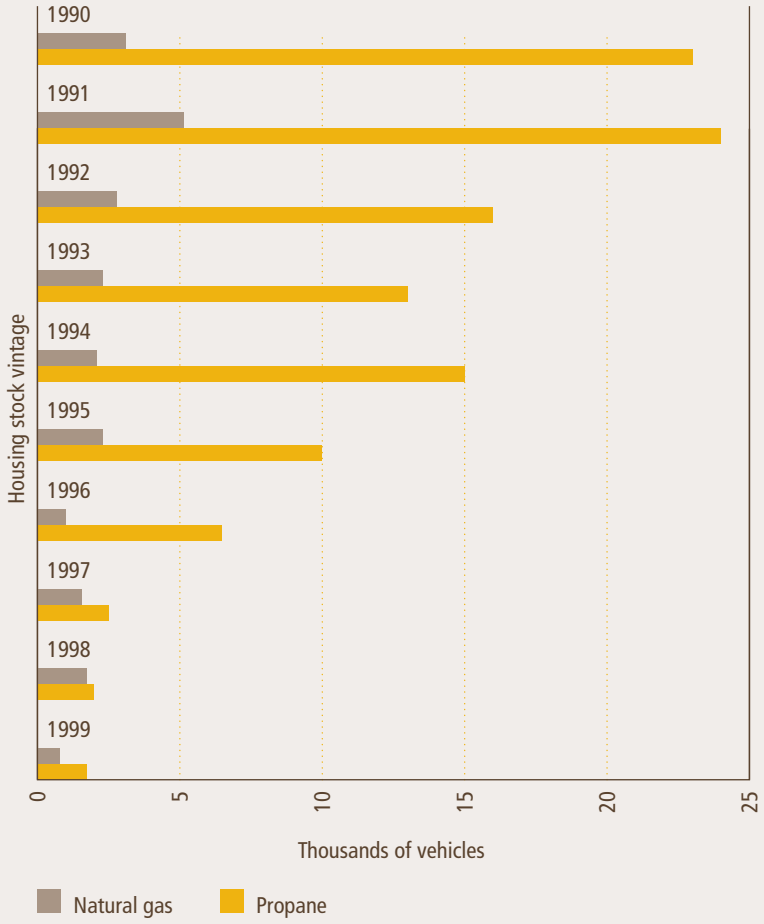
The Natural Gas for Vehicles Incentives Program applies to regions of Canada served by Alberta natural gas. This program was renewed in February 1999 and will run until January 31, 2002. The program provides contributions of $2,000 for each factory-built natural-gas vehicle, $500 for road vehicles converted to use natural gas, a contribution to help foster new refuelling outlets, marketing and awareness activities, and co-funded R&D. The incentives are sourced from the Market Development Incentive Payments (MDIP) fund, which was created in the early 1980s with receipts from Alberta's upstream natural gas producers for the purpose of expanding markets for Alberta natural gas.

Achievements 1999–2000

- Contributions were provided to almost 1000 converted vehicles and 63 new vehicles.

Progress Indicators

FIGURE 40
Conversion of Vehicles to Natural Gas and Propane, 1990 to 1999



The annual level of conversions of motor vehicles from gasoline to propane declined from 24 000 in 1991 to 1750 in 1999 (see Figure 40). This decline is attributable to several factors, including the restructuring of major propane distribution companies through mergers, technical difficulty in converting newer vehicles to propane, the decline in the price difference between gasoline and propane, and significant volatility in propane prices.

The annual rate of conversions of gasoline-powered vehicles to natural gas also declined, from about 5100 in 1991 to 800 in 1999. This is attributable to a decline in the price differential between gasoline and natural gas and technical difficulties in converting vehicles manufactured after 1995. However, the volume of natural gas sold through public and private stations has been stable in recent years. Part of the reason for this is that the market is moving increasingly to high-usage fleets, with transit buses making up approximately one third of the national demand.

Progress Indicators (continued)

The number of fuelling stations selling ethanol-blended gasoline increased from 266 in 1990 to 1140 by March 2000 (see Figure 41). The increase resulted from the introduction of ethanol blends into the Ontario and Quebec markets. Ethanol-blended gasoline is now sold from British Columbia to Quebec.

Propane is the most widely available ATF. Use of this fuel peaked in 1992 and decreased by about one third by 1999. Natural gas use has changed little from 1992 to 1999, while the use of alcohol fuels increased eightfold since 1991 (see Figure 42).

FIGURE 41
Number of Stations Selling Ethanol-Blended Fuels, 1990 to 2000

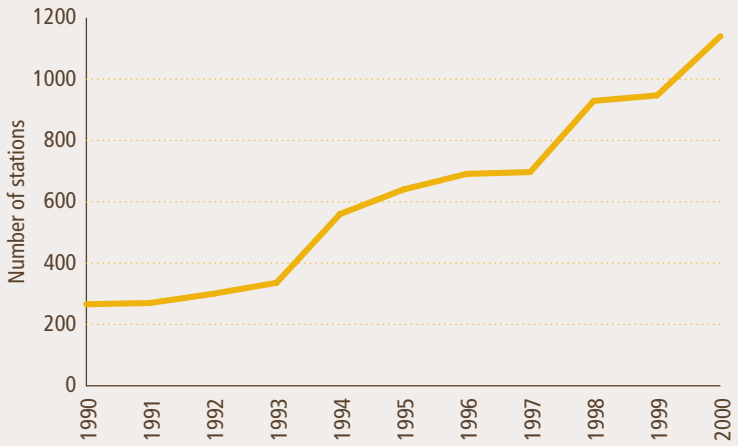
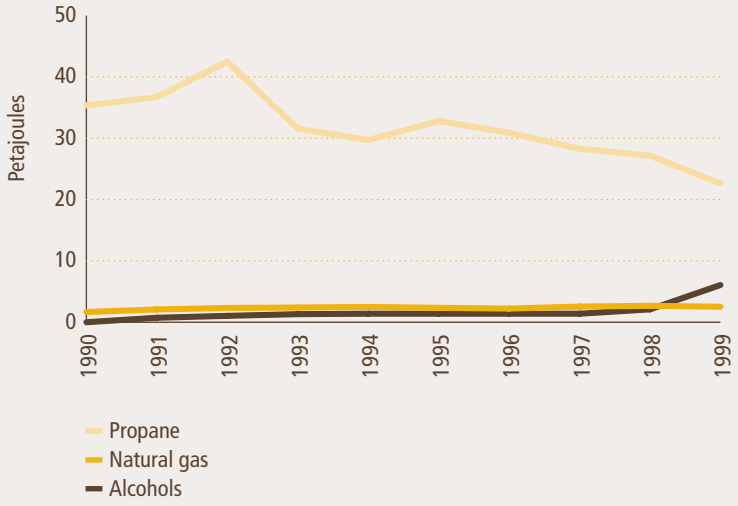


FIGURE 42
Use of Alternative Transportation Fuels, 1990 to 1999



Chapter 7

Renewable and Community Energy

Introduction

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

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 5).

Renewable Energy Use

In 1998, renewable energy sources accounted for about 18 percent of Canada's primary energy use, 1922 out of 10 826 petajoules (see Table 6. As some of these numbers are soft estimates, it would be advisable to use them with discretion). Most of the renewable energy used in Canada comes from either hydro-electricity or wood biomass sources.

TABLE 5
Renewable Energy Markets and Technologies Used in Canada

Electricity	*Thermal Energy*
Hydro-electricity	Biomass (e.g., round wood, 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 6
Estimates of Primary Energy Production from Renewable Sources, 1998

	Petajoules
Hydro	1255
Tidal	0.1
Biomass	
industrial pulp and paper (IPP) electricity from wood waste and spent pulping liquor	100
IPP electricity from wood waste	37.5
electricity from landfill sites	7.2
electricity from municipal solid waste (MSW)	0.5
municipal waste incinerators	12.5
biogas from sewage plants	n/a
IPP heat from wood waste	393
residential space heating	95
commercial/institutional heating	n/a
thermal energy from landfill sites	2.4
thermal energy from MSW	12
ethanol from biomass	4.1
energy crops plantations	–
agriculture wastes	n/a
Earth energy systems	1.5
Wind electric	1.2
Wind mechanical	n/a
Solar thermal (water and air)	0.2
Solar photovoltaic	0.01
Total renewable energy	**1922.2**

– number too small to include
n/a not available

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.

Hydro-electricity constitutes about 11 percent of Canada's primary energy, and most of this is generated from large-scale facilities. It is the dominant source of electricity in Canada, accounting for nearly two thirds of total electricity generation. Small-scale hydro-electric projects, with a capacity of 20 megawatts or less, constitute about 2 percent of Canada's electricity-generating capacity (more than 1500 megawatts). Small-scale hydro has good potential for increased production.

Biomass

Bioenergy is produced from biomass, which may be wood, wood waste from manufacturing processes, agricultural products and wastes, or municipal wastes. Biomass energy contributes around 6 percent of Canada's primary energy, for industrial process heat, electricity generation or residential space heating. Biomass in the form of biofuels, such as corn and other agricultural products, is used to generate ethanol for transportation purposes.

While industrial wood waste is used to produce heat for industrial process and space heating, some wood waste is used to generate electricity. The pulp and paper industry has about 1000 megawatts of electricity-generating capacity, which is fuelled in part by these residues.

Home heating from 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 two million Canadian households use wood for home heating. Canadians usually prefer round wood, but alternatives include wood chips and wood pellets.

Another potential bioenergy source is biocrops – crops that are planted and harvested specifically as a source of energy (e.g., poplars and willows in short-rotation plantations). Other bioenergy sources are wood waste generated during tree harvesting and waste from agricultural crops, such as straw, chaff, corn cobs and bean residues.

Earth Energy

As a result of the sun heating the surface of the planet, the temperature of the earth one or two metres below the surface remains fairly constant – between 5 and 10 degrees Celsius. 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 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 (EES).

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 very large wind resource potential because of its large size and its 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.

The first sizable wind farm developed in Canada is at Cowley Ridge, near Pincher Creek, Alberta. Facilitated by Alberta's *Small Power Research and Development Act* of 1988, it was built in the early 1990s and has a capacity of about 20 megawatts. The electricity is sold to TransAlta Utility Corporation under a long-term contract. Several other wind energy facilities across Canada, mostly single-turbine facilities, contribute a further 5 megawatts of capacity.

Le Nordais, a 100-megawatt wind farm on the Gaspé Peninsula in Quebec, completed in 1999, comprises 134 turbines generating 750 kilowatts each. The electricity is sold to Hydro-Québec under a long-term contract. Canada's wind-generated supply of electricity totals more than 300 gigawatt-hours, or 1.2 petajoules a year.

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

Solar Energy

Three main technologies use energy from the sun:

- with passive solar technologies, 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 much 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.

Initially used to power spacecraft and satellites, photovoltaic systems convert sunlight directly into electricity, using solar cells made from semiconductor materials. The installed capacity of photovoltaic systems in Canada in 1999 was about 5.8 megawatts, with an estimated annual production of 4.6 gigawatt-hours of electricity. The bulk of this capacity is "off grid" (not connected to an electrical transmission system) where the price of photovoltaics is competitive with conventional stand-alone power systems or extensions of a grid to a given location. Typical applications include telecommunication 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 fewer than 90 grid-connected photovoltaic systems, and they have a combined capacity of 297 kilowatts. A Greenpeace initiative in the Toronto area during 1999 led to the installation of forty-five 200-watt photovoltaic systems.

Renewable Energy Programs

NRCan delivers several initiatives to increase the use of small-scale renewable energy in Canada:

- Renewable Energy Deployment Initiative (REDI);
- Renewable Energy Information and Awareness Program;
- Renewable Energy Market Assessment Program;
- Green Power Initiative;
- Renewable Energy Technologies Program;
- Renewable Energy and Hybrid Systems for Remote Communities Program; and
- Energy from the Forest Program (ENFOR).

NRCan also provides technical advice to the CCRA on applications by companies to depreciate their assets under Class 43.1 of the *Income Tax Act*. This class provides an accelerated capital cost allowance to manufacturing and process industries for certain types of energy-efficient or renewable energy equipment. NRCan advises on whether the equipment in question meets or would meet the technical conditions spelled out in regulations.

Renewable Energy Deployment Initiative

The Renewable Energy Deployment Initiative (REDI) aims to stimulate demand for renewable energy systems for space and water heating and cooling. REDI targets four systems: solar water-heating systems, solar air-heating systems, ground-source heat pumps (earth energy systems) and high-efficiency, low-emission biomass combustion systems. REDI promotes these systems in the business, federal and non-business markets, mainly through

- *financial incentives* – Businesses and Government of Canada departments are eligible for an incentive of 25 percent of the purchase and installation costs of a qualifying system, to a maximum contribution of $50,000 per installation;
- *marketing* – NRCan, in partnership with the renewable energy industry, develops marketing strategies and assessments, and promotional, advertising and information campaigns;
- *infrastructure development* – NRCan helps the industry develop and deliver training programs, produce design tools, update and develop standards for renewable energy systems, and create a nationwide network of renewable energy technology specialists.

Achievements 1999–2000

- In December 1998, NRCan issued a Request for Letter of Interest for a pilot project for solar domestic water-heating systems in the residential market. This request was sent to electric and gas utilities, municipalities, builders' associations and other organizations. As a result, contribution agreements were signed with the Earth Festival Society for the installation of 80 solar domestic water-heating systems in the Comox Valley region of British Columbia and with Peterborough Green-Up for the installation of 30 systems in Peterborough County, Ontario.

- In the fall of 1999, the Federation of Canadian Municipalities (FCM), on behalf of NRCan, conducted a comprehensive survey to obtain technical information on municipal buildings across Canada. The survey also obtained information on awareness of REDI, municipal purchasing practices and renewable energy barriers in the sector. The data collected from this survey will be used by the FCM to develop a marketing strategy for REDI-type technologies.
- In December 1999, REDI and NRCan's Renewable Energy and Hybrid Systems for Remote Communities (RERC) Program (see page 73) established a partnership with the Arctic Energy Alliance (AEA) to promote renewable energy technologies (RETs) in the Northwest Territories. The AEA will provide training and workshops to Northerners, identify potential renewable energy projects, undertake project feasibility analysis using RETScreen®* and facilitate applications by project proponents for REDI funding.
- NRCan initiated discussions with the Geothermal Heat Pump Consortium, Inc. to assist the department in establishing a partnership with a broad range of stakeholders to transform the Canadian market for ground-source heat pump technologies. The consortium is a U.S.-based marketing coalition for ground-source heat pumps or geoexchange systems.

Renewable Energy Information and Awareness Program

The goals of this program are to expand the use of renewable energy technologies and stimulate the growth of the renewable energy industry. Its activities focus on examining the information needs of market participants (i.e., potential users of renewable energy and the renewable energy industry) and preparing specialized information to show how renewable energy technologies can economically and reliably help meet Canada's energy needs.

Achievements 1999–2000

- NRCan introduced several new publications during the year, including
  - *Solar Water Heating Systems – Buyer's Guide;*
  - *Stand-Alone Wind Energy Systems – Buyer's Guide*;
  - *Heating Your Building with Solar Energy – Efficient, Simple and Cost-Effective*; and
  - several case studies to promote the use of ground-source heat pump technologies in arenas, schools and federal buildings.
- During the year, NRCan distributed more than 200 000 publications on renewable energy technologies.

Renewable Energy Market Assessment Program

The objectives of this initiative are to review renewable energy resources and use, and to determine the potential of commercially available technologies for meeting Canada's energy needs and environmental goals. Its activities include compiling data on demand and supply constraints, evaluating market prospects for existing and new technologies, and developing strategies to increase the capacity of the renewable energy industry to meet demand in identified markets.

Achievements 1999–2000

- In March 2000, NRCan held a workshop with the biomass industry to review a draft document entitled *Small Commercial Biomass Combustion Systems: Market Study and Plan*, which was started by SGA Energy Consulting during 1999. More than 20 industry, government and non-government representatives attended the workshop in Ottawa. Their comments were incorporated into the study and plan.

*RETScreen is a registered trademark of the Minister of Natural Resources Canada.

- Enermodal Engineering of Kitchener, Ontario, under contract with NRCan, completed a study entitled *Potential for Solar Heating of Outdoor Residential Pools to 2020*. The study assessed the market for solar pool heating in Canada and compared the economics of solar pool heaters with conventional fossil fuel and electric heaters. The study concluded that solar pool heating systems can compete with most conventional pool heating systems.
- In 1999, NRCan contracted Bay Consulting Group to examine solar thermal technologies for hot water and air heating in the commercial, institutional and industrial sectors. The study is to identify market barriers and opportunities, and to develop a marketing strategy for promoting these technologies in the above-mentioned sectors.

Green Power Initiative

Under the Green Power Initiative, NRCan purchases electricity generated from renewable energy sources and encourages other federal departments to do the same. NRCan has pledged to purchase 15 to 20 percent of its electricity from new green power sources by 2010, wherever it makes economic sense. NRCan made its first green power purchase in Alberta in 1998.

Achievements 1999–2000

- A July 1999 public opinion survey (funded in part by NRCan) on consumer attitudes found that most Canadians think it is important to develop green power, mainly to reduce air pollution, ensure an adequate supply of energy, and prevent climate change. A majority of Canadians would also be willing to pay more for green power, according to the survey.

Renewable Energy Technologies Program

The Renewable Energy Technologies Program supports efforts by Canadian industry to develop renewable energy technologies, including 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.

NRCan champions and supports technology development and field trials in partnership with the renewable energy industry. 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.

Achievements 1999–2000

- The 600-kW Tacke wind turbine achieved the production milestone of 5000 MWh. Erected in 1995 with NRCan support, the turbine has operated successfully for over four years, providing clean, reliable energy to Ontario's power grid.
- NRCan created an Internet-based Small Hydro Database which contains information on small hydro development programs worldwide and identifies potential small hydro sites in various countries.
- The Hangzhou International Centre (HIC) in China is the headquarters for the International Network on Small Hydro Power (IN-SHP), which fosters co-operation among developing countries, developed countries and the private sector for small hydro deployment in developing countries. NRCan, which has supported IN-SHP since its inception in 1995, provided training to one of HIC's permanent staff members.

- NRCan negotiated a license agreement with the ADEPT Group Inc. of Los Angeles, California, to commercialize the CETC cetane enhancer technology, which allows a high-cetane-specification diesel fuel additive to be produced from waste biomass oils and animal fats, such as waste frying oils and grease, using conventional petroleum refining technology.
- NRCan released version 1 of the Solar Wall International Feasibility Tool (SWIFT) software, designed by the department, Conserval Engineering and Enermodal Engineering. SWIFT helps design solar air-heating systems and prepares quick, accurate feasibility studies. Key features include hourly weather data for more than 300 cities and the capability to design industrial, commercial and process air-heating (specifically crop-drying) systems. Industry in Canada, the U.S., Japan and several European countries has begun using SWIFT.

Renewable Energy and Hybrid Systems for Remote Communities Program

The Renewable Energy and Hybrid Systems for Remote Communities Program accelerates the deployment of renewable energy technologies in remote Canadian communities that are not connected to the main electricity grid or to natural gas networks. The program provides community decision makers with information, data and analysis to help assess the feasibility of renewable energy systems, to select the most cost-effective technologies and to implement projects.

The program also seeks to develop, implement and promote cost-effective photovoltaic (PV) technologies for domestic and international markets.

Achievements 1999–2000

- RETScreen is a software tool NRCan developed to assess potential renewable energy projects. The software, which can be applied for as little as one tenth the cost of conventional analyses, has 10 000 users in 130 countries around the world. NRCan improved RETScreen by adding an on-line weather database to provide weather data from ground monitoring stations in over 1000 locations around the world. The department also signed an agreement with NASA to give RETScreen users access to satellite weather data to better evaluate potential projects where ground monitoring station weather data are not available.
- NRCan signed an agreement with the United Nations Environment Programme to increase international awareness of RETScreen and enhance its international applicability, in particular, by jointly developing a GHG emissions mitigation model for the software.
- NRCan gave presentations and seminars on RETScreen to a variety of organizations and groups, such as the World Bank, the International Energy Agency, students in the international energy management program of the École des hautes études commerciales (HEC) in Montréal and participants in workshops presented by the Institut de l'énergie et de l'environnement de la Francophonie.
- In collaboration with several partners, NRCan used RETScreen to help identify high potential cost-effective renewable energy projects in Canada's 300 remote communities. Out of the 51 studies, 27 were identified as having near-term commercial viability, and work began to further analyse some of these projects.
- In partnership with Automation Tooling Systems Inc., NRCan approved funding for a project to develop advanced solar PV module manufacturing equipment. The goal is to lower the manufacturing cost of these modules and promote the use of this environmentally friendly means of producing electricity. The project is designed to develop an automated manufacturing process for PV modules and a more labour-intensive manufacturing process for export to developing countries – initially China.

Energy from the Forest Program (ENFOR)

ENFOR, managed by the Canadian Forest Service (CFS), undertakes R&D on forest biomass for energy through the private sector, universities or CFS research centres. The goal of this research is to improve the understanding of the role of biomass production for energy and to improve biomass productivity in conventional forest stands and plantations. Two primary sources of forest biomass for energy are under study: forest residues, including harvest residues; and energy plantations, involving short-rotation intensive culture in quick-growing trees, such as willow and poplar.

The forest also plays a role in the global carbon cycle, which is linked to climate change. ENFOR seeks to better understand the role of Canada's forests in reducing atmospheric CO_2 emissions. It also investigates the broad environmental effects of harvesting and using forest biomass for energy, focusing on sustaining forest productivity and improving the sequestration and storage of atmospheric carbon in forest ecosystems.

Achievements 1999–2000

- Under the International Energy Agency (IEA) Bioenergy Agreement, the CFS continued to collaborate in international projects on the production of forest biomass, the use of conventional forestry for biomass production, GHG balances of bioenergy systems, and the socio-economic aspects of bioenergy production. These projects form an integrated approach to the production and use of bioenergy while contributing to the reduction of GHG emissions and strengthening the economic base of rural communities. The major products of this collaboration have been a series of workshops, seminars and publications. This sharing of knowledge and technology has facilitated the establishment of many demonstration plantations and infrastructure (boilers, conversion plants) for the generation of electricity from biomass feedstock. Generating plants have been established in the Netherlands, Sweden and the U.K.
- NRCan completed a major study on biomass residue recovery from hardwood harvesting operations. The report sets out the quantities of biomass produced by harvesting operations, the cost of recovering these residues, the level of environmental concern by the public over areas where forestry operations take place, and the amount of interest in using this biomass for bioenergy or other purposes. The report also discusses the potential for job creation and the economic spinoff associated with biomass recovery from conventional harvesting operations.
- NRCan developed a framework document for the implementation of bioenergy based on the products developed by previous programs, and consideration of the opportunities for and barriers to increased use of biomass for energy. Both national and international activities were considered. The framework outlines the impact of national and international commitments on energy policy to guide decisions and activities for increased bioenergy use in the Canadian energy context.
- NRCan completed the evaluation and harvest of a willow biomass plantation farm. The report assessed the potential insect and disease conditions and their impact on biomass production, and provided estimates of biomass yields for five promising clones of willow.
- NRCan concluded a study on increasing biomass production from poplar for energy purposes. The study examined methods which would increase productivity per hectare, reduce the need to exploit natural forests and improve productivity under low-light conditions.

Progress Indicators

Wind power is a viable option for supplying renewable energy, particularly in remote, off-grid communities. In addition, there has been an increase in the number of large wind turbines connected to the grid, particularly in Alberta and Quebec. As of March 2000, installed capacity had increased to approximately 125 megawatts, reflecting additions to capacity at the Le Nordais project in the Gaspé region of Quebec (see Figure 43).

During the second year of REDI, NRCan approved nine applications from Canadian businesses for renewable energy systems representing investments of almost $500,000 (see Table 7).

FIGURE 43
Canadian Wind Power Capacity, 1990 to 2000

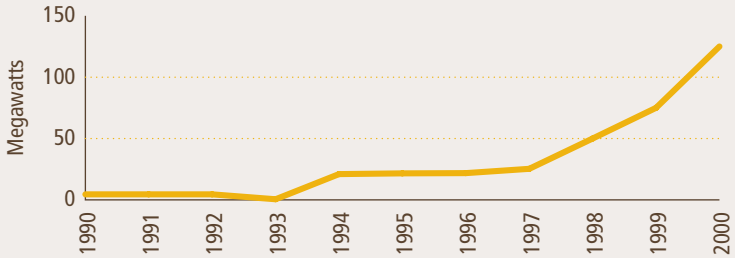


TABLE 7
Completed REDI for Business Projects, 1999–2000

Business name	Building type	Province	Type of system	NRCan contribution	Project cost
Bombardier Inc.	Manufacturing plant	Quebec	Solarwall™	$16,981	$67,922
Serge Venne Inc.	Farm building	Quebec	Solar water heating	$6,039	$24,159
Nyco–Wynd Estates	Club house/pool	British Columbia	Solar water pool heating	$2,370	$9,480
Ferme J.M. Roy et Fils	Farm building	Quebec	Solar water heating	$1,249	$4,995
ABB Inc.	Manufacturing plant	Quebec	Solarwall™	$37,026	$148,104
Havre Familial	Family camp	Quebec	Solar water heating	$4,795	$19,178
La Casa Appartements	Apartment building	Quebec	Biomass	$2,444	$9,774
Chenil Elandees Kennel	Kennel	Quebec	Solar water heating	$2,215	$8,866
Everest Equipment Inc.	Manufacturing plant	Quebec	Solar air heating	$46,791	$187,164
Total				**$119,910**	**$479,642**

Community Energy Systems

The Community Energy Systems program works in partnership with Canadian communities and businesses to help them meet their energy needs with greater energy efficiency and increased use of renewable energy. The program identifies and develops opportunities to use district heating and cooling, combined heat and power (cogeneration), waste-heat recovery, thermal storage and local sources of renewable energy, particularly biomass. The program provides planning and implementing services for projects in both urban centres and remote communities, development of software for system design, and analysis of the improved performance of district cooling systems. It also promotes and fosters the adoption of integrated energy systems. The program's laboratory, which houses an ice-slurry-based district cooling system, develops and tests district energy technologies.

Achievements 1999–2000

- NRCan helped assess, design, troubleshoot or manage, or provide advice on, district heating and cooling systems in 13 communities across Canada, from downtown Toronto to Pelly Crossing, Yukon, to Oujé–Bougoumou, Quebec, whose district energy system has attracted international attention since receiving the United Nations Award for Sustainable Communities.
- District energy system projects delivered by NRCan in three northern communities – Fort McPherson, Northwest Territories; Arviat, Nunavut; and Watson Lake, Yukon – received support from the Technology Early Action Measures (TEAM) of the Climate Change Action Fund (CCAF) for their potential to reduce fuel consumption and GHG emissions. These projects will reduce each community's annual fuel consumption by up to 12 percent, thereby reducing GHG emissions by 2665 tonnes.
- The department became an advisor on district energy to the U.S. Department of Energy, which has proposed the adoption of a district energy program based on the "Canadian Model."
- NRCan signed an agreement with the Regional Municipality of Ottawa–Carleton (RMOC) to install a 75-kW microturbine at a RMOC waste disposal site to test the potential of recovering flared methane and using it as fuel for the turbine, in order to reduce landfill methane emissions.
- The department proved the ability of microturbines to destroy odour-causing compounds by installing a microturbine at a City of Winnipeg wastewater treatment plant whose hydrogen sulphide emissions had caused complaints. The foul air stream was mixed with the microturbine combustion air intake, eliminating the odour and producing both power and heat.

Chapter 8

Intergovernmental Co-operation

Introduction

This chapter describes NRCan's intergovernmental co-operation with respect to EAE during the reporting period at three levels: provincial/territorial, municipal and international. Other examples of intergovernmental co-operation are set out in Chapter 1 and in Chapters 3 to 7 in the *Achievements* sections of specific EAE program initiatives.

Federal–Provincial and Federal–Territorial Co-operation

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

General Co-operation

Co-operation took place through two main mechanisms:

Letters of Co-operation

- NRCan had Letters of Co-operation (LOCs) on EAE with Manitoba Conservation and Quebec's Agence de l'efficacité énergétique during the reporting period. These LOCs are mechanisms to ensure efficient consultation and exchange of information between the two governments, co-ordinate EAE activities in the provinces and create opportunities for joint projects.

  A management committee established under each LOC meets twice a year to review policy and program developments, progress on joint program initiatives and areas for further co-operation.
- NRCan and Quebec's Agence de l'efficacité énergétique signed an LOC on energy efficiency and alternative transportation fuels in May 1999. The two parties held two general meetings during the period and program managers discussed specific files on a regular basis. The LOC played a considerable role in facilitating the following:
  - managing the licensing agreement for the EnerGuide for Houses program (which is delivered by the Agence in Quebec);
  - negotiating a contribution agreement regarding projects submitted to NRCan by public organizations in Quebec. Discussions in 1999–2000 focused on a project by a school board under the Commercial Building Incentive Program (CBIP). The agreed-upon co-operation framework is being considered for application to some other NRCan energy sector programs; and
  - negotiating an agreement between NRCan (CANMET Energy Diversification and Research Laboratory at Varennes, Quebec) and the Agence on a project in an arena in Montréal to design, implement and monitor advanced refrigeration technologies.
- Similarly, the LOC between NRCan and Manitoba Conservation (signed in September 1996) facilitated, for example, the conclusion of the licensing agreement for the R-2000 HOME program (delivered by Manitoba Conservation).

National Advisory Council on Energy Efficiency

- NRCan created the National Advisory Council on Energy Efficiency (NACEE) in April 1998 to advise and guide the OEE on the most effective way to achieve its mission. During 1999–2000, NACEE members included representatives from four provinces – Manitoba, New Brunswick, Quebec and Saskatchewan – who had the opportunity to comment on the OEE's business plan and programs.

Co-operation at the Program Level

R-2000 HOME Program

- In 1999–2000, the R-2000 HOME program was delivered in seven provinces (Alberta, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario and Saskatchewan) and in the Yukon. Provincial home builders' associations, except in Manitoba and the Yukon, participated in the delivery of the program. There were three types of co-operation during the period:
  - Representatives from most provinces and the Yukon participated as members of regional R-2000 Advisory Committees.
  - In New Brunswick, Newfoundland, Nova Scotia and Saskatchewan, the provincial governments and NRCan supported the program through financial or in-kind contributions.
  - In Manitoba and the Yukon, the provincial and territorial governments delivered the program under a licensing agreement with NRCan. Ten houses in Manitoba and two houses in the Yukon were registered under the R-2000 program.

EnerGuide for Houses

- Several provinces and the Yukon participated in the EnerGuide for Houses Advisory Committee.
- The Yukon Housing Corporation and Quebec's Agence de l'efficacité énergétique are the delivery agents of the program in their jurisdictions, under licensing agreements with NRCan. During the reporting period, 192 home evaluations were conducted in the Yukon and over 200 in Quebec.

Commercial Building Incentive Program

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

Energy Innovators

- A number of provincial and territorial departments as well as health and education organizations (including 26 school boards) registered as Energy Innovators during the period. In the same vein, several health and education organizations received financial assistance under the Energy Innovators Plus program.

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.

Green Power Initiative

- 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. Subsequently, NRCan entered into discussions with SaskPower and Maritime Electric on the purchase of green power for federal facilities in their provinces.

Residential Wood Combustion

- NRCan is a member of the Intergovernmental Working Group on Residential Wood Combustion co-chaired by Environment Canada and the Newfoundland Department of Environment and Labour. The Federal Smog Plan calls for four initial joint actions pertaining to residential wood combustion:
  a) assess the effectiveness of pilot wood stove change-out programs and consider options for a national program;
  b) 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;
  c) support public education on cleaner wood burning with advanced technologies and sustainable wood use; and
  d) develop a federal regulation on residential wood combustion, focusing on cleaner-burning appliances.

Other examples of federal–provincial co-operation are set out in the *Achievements* section of the following program initiatives:

- EnerGuide for Appliances and HVAC;
- Federal Industrial Boiler Program;
- Refrigeration and Intelligent Buildings Program; and
- Industrial Process Integration Program.

Federal–Municipal Co-operation

- A number of municipalities received financial incentive contributions in 1999–2000 under CBIP.
- A number of municipalities registered as Energy Innovators during the period and some received financial assistance under the Energy Innovators program.
- A working group of seven municipalities (Saanich, City of North Vancouver, District of North Vancouver, Edmonton, North Battleford, Montréal and Gander) was formed in 1999–2000 to oversee the development of a tool kit for municipal fleet managers. This tool kit, part of the new Municipal Vehicle Energy Use Reduction Program being developed under the FleetSmart program, will provide information on energy management planning, vehicle specifications, alternative fuels, preventive maintenance, computerized productivity tools and driver training.

Other examples of federal–municipal co-operation are set out in the *Achievements* section of the following program initiatives:

- Auto$mart;
- Renewable Energy Deployment Initiative (REDI); and
- Community Energy Systems.

International Co-operation

NRCan also co-operates with several international organizations and foreign governments. Canada benefits from this co-operation in two ways:

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

International Energy Agency

Canada is a member of the IEA, an autonomous agency linked with the Organisation for Economic Co-operation and Development (OECD).

NRCan serves on a number of committees that review policies and undertake studies on energy efficiency and related issues. These committees include the Standing Group on Long-Term Co-operation (SLT) and the Energy Efficiency Working Party (EWP), which reports to the SLT. The SLT develops policy analyses to promote conservation and the efficient use of energy, while the EWP/SLT carries out more detailed studies on specific energy efficiency issues.

Asia–Pacific Economic Co-operation

Since the first meeting of the Energy Ministers of Asia-Pacific Economic Co-operation (APEC) in August 1996, NRCan has played a leading role in efforts to ensure that efficiency test standards for energy-using appliances do not become barriers to trade within the APEC region. Acting on the ministers' directions, NRCan has chaired the APEC Energy Working Group's Steering Group on Energy Standards since 1996. In 2000, the workplan of this working group was incorporated into the workplan of the Expert Group on Energy Conservation and Renewable Energy.

During the reporting period, the group accomplished the following:

- assessed options for a multilateral testing laboratory program, so that suppliers could have their products' performance tested only once, at a regionally recognized laboratory;
- conducted a study to determine regional differences in test standards and the merits of establishing a regional notification system on the use of standards;
- identified priority products to harmonize test standards and technical procedures for achieving this;
- analysed options to communicating the needs of APEC economies more effectively in international standards-making processes;
- identified the need for a co-ordinator dedicated to standards information within APEC; and
- committed to engage local standards organizations in the energy efficiency standards activities of the Working Group.

Also under the APEC Energy Working Group, NRCan participates in the Expert Group on New and Renewable Technology Co-operation. Activities of the working group during the reporting period included exchanging information on new and renewable energy technology programs, technologies and research and development (R&D) strategies; fostering co-operation in priority areas; conducting technology transfer seminars; analysing projects for APEC funding; and monitoring progress in the accepted projects. On the domestic side, NRCan provided information to interested Canadian parties in the private sector and government on opportunities for collaboration, potential opportunities for technology transfer and information exchange, and on upcoming APEC seminars such as the APEC R&D and Technology Transfer Seminar in Bangkok, Thailand.

Hemispheric Energy Initiative

The Hemispheric Energy Initiative (HEI) is the energy component of the action plan arising from the Summit of the Americas and supporting the Hemispheric Energy Ministers Meetings. The aim of the HEI is

to advance sustainable development and use of energy in the hemisphere. The HEI has eight "outcomes," one of which is promotion of energy efficiency in the hemisphere. NRCan leads on one component of this outcome – promotion of energy efficiency in equipment and buildings.

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 International Energy Agency tasks and supporting technical and trade oriented workshops and conferences.

Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET)

Canada co-operated with 12 OECD countries to distribute information about energy-efficient technologies through CADDET. With a range of printed, electronic and on-line material, CADDET is an international information network to help managers, engineers, architects and researchers find out about energy-saving techniques that have worked in other countries.

United States

Motor Vehicle Fuel Efficiency and Fuels

- In March 1996, NRCan and the U.S. Department of Energy (DOE) signed a Memorandum of Understanding (MOU) concerning road transportation, energy efficiency and alternative fuels. The MOU provides a formal mechanism for negotiating and harmonizing North American policy on fuel efficiency. With this MOU, NRCan and the DOE have agreed to formalize contact, as both nations consider options in responding to their respective climate change commitments.

District Energy

- NRCan and the Chittenden County Regional Planning Commission in Vermont co-produced a municipal guide to district energy. The guide targets smaller cities, towns and communities that are interested in alternative energy and is applicable in both Canada and the United States.

Other examples of Canada–United States co-operation are set out in the *Achievements* section of the following program initiatives:

- EnerGuide for Equipment and HVAC;
- Transportation Energy Technologies Program; and
- Renewable Energy Deployment Initiative (REDI).

Mexico

- NRCan signed an 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 both countries by
  - improving the design and delivery of EAE programs implemented or sponsored by NRCan and the Mexican national commission for energy savings (*Comisión Nacional para el Ahorro de Energía* or CONAE); and
  - enhancing trade, investment and exchanges (technical and other) related to energy-efficient products, energy management services and alternative energy goods and services.

China

- NRCan and China's Ministry of Water Resources signed an MOU in May 1997, under which they have jointly undertaken extensive work. Some projects undertaken in 1999–2000 include a demonstration of small hydro control systems, a joint venture between Powerbase (Ontario) and the Hangzhou International Centre, and training for Chinese technicians to install and maintain control systems.

Japan

- NRCan participated in the 6th Annual Canada-Japan Housing Workshop and the Canada-Japan R-2000 meeting in Summerside, Prince Edward Island, in August 1999.

Appendix 1

NRCan's Efficiency and Alternative Energy Initiatives and Expenditures, 1999–2000 (millions of dollars)

General Programs **7.7**
Public Information
Community Energy Systems
National Energy Use Database

Energy Efficiency – Equipment **2.9**
Energy Efficiency Regulations
EnerGuide for Equipment and HVAC

Energy Efficiency – Buildings **22.3**
R-2000 HOME Program
Model National Energy Codes for Houses and Buildings
Buildings Energy Technology Advancement Plans
EnerGuide for Houses
Reno$ense
Commercial Building Incentive Program
Energy Innovators Initiative
Federal Buildings Initiative
Federal Industrial Boiler Program
Refrigeration and Intelligent Buildings Program

Energy Efficiency – Industry **27.1**
Industrial Energy Efficiency
Industry Energy Research and Development Program
Emerging Technologies Program
Industrial Process Integration Program
Industrial Process Engineering Program
Advanced Combustion Technologies Program
Energy Technologies for High-Temperature Processes
Processing and Environmental Catalysis Program
Minerals and Metals Technologies Initiative

Energy Efficiency – Transportation **3.9**
Vehicle Fuel Efficiency
EnerGuide for Vehicles
Auto$mart
FleetWise
FleetSmart

Alternative Energy – Alternative Transportation Fuels **8.4**
Transportation Energy Technologies Program
Future Fuels Market Analysis
Natural Gas for Vehicles Incentives Program

Alternative Energy – Renewable Energy Sources **19.4**
Renewable Energy Deployment Initiative
Renewable Energy Information and Awareness Program
Renewable Energy Market Assessment Program
Green Power Initiative
Renewable Energy Technologies Program
Renewable Energy and Hybrid Systems for Remote Communities Program
Energy from the Forest Program

Total **91.6**

Figures do not add to total, 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 Emission 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 D of NRCan's *Energy Efficiency Trends in Canada 1990 to 1998*.

FIGURE 2: Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Actual energy use	1.00	0.98	1.00	1.02	1.06	1.07	1.11	1.11	1.09
Energy use without efficiency improvement	1.00	1.00	1.00	1.04	1.08	1.12	1.14	1.16	1.15

FIGURE 3: Canadian Households by Type of Dwelling, 1998 (percent)

Single detached	56.79
Apartments	30.49
Single attached	10.58
Mobile homes	2.12

FIGURE 4: Residential Energy Use by Purpose, 1998 (percent)

Space heating	60
Water heating	21
Appliances	14
Lighting	4
Space cooling	1

FIGURE 5: Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total energy use	1.00	0.98	1.01	1.04	1.06	1.04	1.11	1.06	0.98
Total energy use without efficiency improvement	1.00	1.03	1.08	1.11	1.12	1.14	1.18	1.17	1.10

FIGURE 6: Annual Space Heating Energy Cost for Different Houses (dollars per year)

Typical existing house (1970)	1790
Typical new house (1999)	1134
Model National Energy Code house (1999)	897
R-2000 house	701

FIGURE 7: R-2000 Share of National Housing Completions, 1990 to 1999 (percent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
R-2000 Share	0.279	0.333	0.673	0.959	0.504	0.534	0.331	0.341	0.265	0.154

FIGURE 8: National Trends in Air Leakage in Houses by Construction Period
(air changes per hour [at 50 pascals pressure])

1981–1985	5.38
1986–1990	3.67
1991–1995	3.05
R-2000 house (1981–1999)	1.1

FIGURE 9: Homes Evaluated Under EnerGuide for Houses Program

	Annual	Cumulative
1998–1999	4686	4686
1999–2000	9145	13 831

FIGURE 10: Energy Use and Energy Savings – EnerGuide for Houses Program
(gigajoules per year per house)

Period of construction	Energy use	Potential energy savings	Actual energy savings
Pre-1945	254	75	47
1945–1959	187	46	25
1960–1969	195	46	26
1970–1979	199	49	27
1980–1989	188	33	16
1990–1999	150	34	10
Average	198	48	26

FIGURE 13: Share of Residential Energy Consumption Subject to Energy Efficiency Regulations, 1998 (petajoules)

	Regulated	Unregulated
Appliances and lighting	111	128
Water heating	270	2
Space conditioning	536	240
Total	**916**	**371**

FIGURE 14: Average Energy Consumption of New Appliances, 1990 and 1998
(kilowatt hours per year)

	1990	1998
Clothes washers	1218.0	904.95
Clothes dryers	1102.6	900.88
Dishwashers	1025.7	647.99
Refrigerators	956.2	664.00
Ranges	772.2	771.05
Freezers	713.8	395.37

FIGURE 15: Natural Gas Furnace Sales by Efficiency Level, 1990 and 1998 (percent)

	1990	1998
Low-efficiency	63	0
Mid-efficiency	16	62
High-efficiency	22	38

FIGURE 16: Energy Use of Refrigerators, 1991 and 1998

Source: Natural Resources Canada EnerGuide Database.

FIGURE 17: Commercial and Institutional Energy Use by Building Type, 1998
(petajoules)

Building type	Energy use
Retail	232.10
Office	226.87
School	127.50
Health	104.96
Hotel and restaurant	83.54
Recreation	59.68
Warehouse	49.90
Other institutional	40.52
Religious	11.09
Total	**936**

FIGURE 18: Commercial and Institutional Energy Use by Purpose, 1998 (petajoules)

Space heating	490.72
Lighting	134.84
Auxiliary motor	117.73
Water heating	71.51
Auxiliary equipment	66.02
Space cooling	55.30
Total	**936**

FIGURE 19: Commercial and Institutional Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998 (index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Energy use without efficiency improvement	1.00	1.04	1.06	1.10	1.10	1.12	1.16	1.14	1.11
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.14	1.15	1.09

FIGURE 20: Energy Use in Commercial Buildings, 1998 (megajoules per m^2 per year)

All buildings (average)	1335
New buildings (average)	1300
Model National Energy Code	1105
CBIP target	829
C-2000 projects	553

FIGURE 21: Energy Consumption of CBIP Buildings (megajoules per m^2 per year)

	1998–1999	1999–2000
Actual CBIP Design	789	718
MNECB (Code)	1196	1018

FIGURE 22: Energy Savings from CBIP (terajoules per year)

	1998–1999	1999–2000
Annual	13	55
Cumulative	13	69

FIGURE 23: Recruitment of Energy Innovators (Commercial and Institutional), 1992–1993 to 1999–2000 (organizations)

	Annual recruitment	Cumulative recruitment
1992–1993	47	47
1993–1994	82	129
1994–1995	75	204
1995–1996	104	308
1996–1997	44	352
1997–1998	43	395
1998–1999	107	502
1999–2000	82	584

FIGURE 24: Energy-Saving Projects Under Energy Innovators Initiative, 1992–1993 to 1999–2000 (number of projects)

	Annual projects	Cumulative projects
1992–1993	15	15
1993–1994	26	41
1994–1995	24	65
1995–1996	33	98
1996–1997	14	112
1997–1998	34	146
1998–1999	50	196
1999–2000	52	248

FIGURE 25: FBI Investment and Energy Savings
(millions of dollars)

	Investment as of March 2000	Estimated annual energy savings
Environment Canada	8.7	1.1
Natural Resources Canada	9.2	1.0
Industry Canada	13.1	2.3
Other departments	18.3	3.1
Public Works and Government Services Canada	41.0	6.3
National Defence	89.7	10.2

FIGURE 26: Energy Savings from FIBP, 1991–1992 to 1999–2000 (energy savings [terajoules per year])

	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000
Annual additions	20	50	40	70	90	80	77	77	93
Annual	20	70	110	180	270	350	427	504	597

FIGURE 27: Influence of Lighting Regulation on Energy Use of Two Fluorescent Lamp Types, 1996

	Before regulation–watt rating	After regulation–watt rating	Before regulation–kWh/yr	After regulation–kWh/yr
4-foot, medium bi-pin	40	34	140	119
8-foot, high-output	75	66	263	210

FIGURE 28: Industrial Energy Use by Subsector, 1998 (percent)

Other	12.812
Pulp industry	12.666
Upstream mining	10.810
Petroleum refining	10.377
Newsprint	8.852
Iron and steel	8.323
Primary production of aluminum	5.265
Other paper industry	4.803
Industrial organic chemicals	3.380
Other manufacturing n.e.c.	3.295
Industrial inorganic chemicals	2.719
Metal mines	2.603
Other primary smelting and refining of non-ferrous metal	2.586
Food	2.575
Paperboard	2.546
Wood	2.163
Transportation equipment	2.138
Hydraulic cement	2.087
Total	**100**

FIGURE 29: Cost of Energy to Industry as Percentage of Total Production Cost, 1997

Lime	41.35
Cement industry	37.47
Magnesium	24.48
Aluminum	15.08
Chemicals	10.25
Pulp and paper	9.81
Iron and steel	8.03
Semi-fabricated metals	3.27
Other manufacturing	2.12
Petroleum refining	1.77
Transportation equipment manufacturing	0.78

FIGURE 30: Industrial Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998 (index: 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Energy use without efficiency improvement	1.000	0.990	0.957	1.004	1.070	1.105	1.105	1.141	1.151
Actual energy use	1.000	0.981	0.989	0.998	1.057	1.079	1.110	1.110	1.099

FIGURE 31: Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 1998 (percent)

Electronic and electric	54.5
Glass	48.5
Other manufacturing (NES) n.e.c.	42.6
Rubber	41.6
Beverage	36.7
Primary textile	22.7
Brewery	22.1
Pulp	21.2
Construction	17.2
Furniture and fixture	16.5
Building board	15.7
Transportation equipment	15.5
Lime	14.7
Petroleum refining	12.5
Plastic and resin	12.4
Tobacco	12.1
Food	11.6
Other paper	10.8
Aluminum	8.1
Organic chemicals	8.0
Cement	7.4
Metal mines	7.0
Plastic	5.8
Iron and steel	5.5
Non-metal mines	1.6
Paperboard	1.2
Dairy products	0.1

FIGURE 32: Industrial Energy Innovators and Action Plans, 1995–1996 to 1999–2000

	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000
Innovators	212	238	245	249	254
Action plans	18	172	177	194	195

FIGURE 33: Energy Savings from Motor Regulations, 2000 to 2020 (petajoules per year)

	2000	2005	2010	2020
Industrial energy savings	2.2	5.9	9.5	11.0
Commercial energy savings	2.1	4.6	6.8	6.7

FIGURE 34: Transportation Energy Use by Mode, 1998 (petajoules per year)

Light vehicle	992.08
Freight truck	634.662
Aviation	220.56
Freight marine	118.268
Freight rail	75.127
Bus	69.71
Off-road	69.37
Rail	2.19
Total	**2181.95**

FIGURE 35: Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1998
(index: 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Energy use without efficiency improvements	1.00	0.96	0.99	1.01	1.08	1.12	1.15	1.20	1.21
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.16

FIGURE 36: Market Shares of New Passenger Cars and Light Trucks, 1990 to 1998 (model year) (percent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Light truck	29.85	29.72	31.70	34.22	36.58	38.04	40.98	44.43	44.27
Passenger car	70.15	70.28	68.30	65.78	63.42	61.96	59.02	55.57	55.73

FIGURE 37: New Car Fuel Efficiency, Normalized for Weight and Power, 1990 to 1999 (index: 1990 = 1.00)

	L/100 km	L/100 km/kg	L/100 km/HP
1990	1.000	1.000	1.000
1991	0.976	0.972	0.955
1992	0.988	0.989	0.924
1993	0.988	0.985	0.915
1994	1.000	0.956	0.901
1995	0.963	0.897	0.824
1996	0.963	0.914	0.807
1997	0.976	0.920	0.809
1998	0.976	0.928	0.798
1999	0.976	0.897	0.773

FIGURE 38: Federal Fleet Size and Fuel Consumption, 1995–1996 to 1999–2000 (litres of gasoline [equivalent] in thousands)

	1995–1996	1997–1998	1999–2000
Total fuel consumption	88 725	75 684	78 281
Vehicles	24 854	22 796	22 462

FIGURE 39: Purchases of ATF Vehicles for Federal Fleet (vehicles purchased)

	Annual	Cumulative
1997–1998	135	135
1998–1999	159	294
1999–2000	179	473

FIGURE 40: Conversion of Vehicles to Natural Gas and Propane, 1990 to 1999 (thousands of vehicles)

	Natural gas	Propane
1990	3.12	23.00
1991	5.15	24.00
1992	2.78	16.00
1993	2.29	13.00
1994	2.08	15.00
1995	2.30	10.00
1996	1.01	6.50
1997	1.57	2.50
1998	1.75	2.00
1999	0.80	1.75

FIGURE 41: Number of Stations Selling Ethanol-Blended Fuels, 1990 to 2000 (number of stations)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Number of stations	266	270	300	336	560	640	691	697	929	947	1140

FIGURE 42: Use of Alternative Transportation Fuels, 1990 to 1999 (petajoules)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Propane	35.36	36.71	42.49	31.56	29.70	32.81	30.89	28.27	27.16	22.63
Natural gas	1.66	2.09	2.33	2.40	2.49	2.35	2.22	2.55	2.68	2.52
Alcohols	0.00	0.73	1.04	1.32	1.39	1.39	1.39	1.39	2.10	6.07

FIGURE 43: Canadian Wind Power Capacity, 1990 to 2000 (megawatts)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Megawatts	4.5	4.5	4.5	0.5	21	21.6	21.8	25.3	50	75	125

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