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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 years ending March 31, 1998 and 1999, in accordance with section 36 of the Act.

Respectfully submitted,

Ralph Goodale
Minister of Natural Resources

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Minister's Foreword

Since I last presented a report under the *Energy Efficiency Act*, the climate change challenge has lent a sense of urgency and a sharper focus to all activities related to sustainable development in energy. Energy efficiency and alternative sources of energy have received increased attention from all sectors of society.

Canada, along with other developed nations, is responding to the climate change challenge, in part, by seeking to reduce greenhouse gas emissions. To reach our target of 6 percent below 1990 levels by 2008-2012, we must improve our energy performance. Canadians will need to use energy more efficiently and use energy sources that are less carbon-intensive.

This sixth report covers the period from April 1997 to March 1999 and details the progress that has been made toward improved secondary energy use. Natural Resources Canada's (NRCan) analysis indicates that energy efficiency improved by 6.2 percent during 1990 to 1997. This represents a saving of $5 billion per year and an annual reduction of greenhouse gas emissions of 24 megatonnes from what would otherwise have been the case. More than 30 performance indicators contained in this report demonstrate that NRCan's programs contributed to this improvement in energy use.

Nevertheless, our challenge continues, because a growing national economy, our growing population and growing exports have resulted in higher energy consumption levels overall.

NRCan has built a strong foundation in many areas that are critical to achieving improved energy performance. The department delivers a wide range of initiatives related to energy efficiency, renewable energy and alternative transportation fuels. Market transformation programs are designed to encourage and help Canadians improve their energy use through information, demonstration, training, incentives and regulation. Research and development programs are designed to help create and bring to the market equipment, buildings, and industrial processes that are more energy efficient and less carbon-based.

Key developments during the reporting period include the following:

- In 1998, NRCan established the Office of Energy Efficiency to coordinate most of its energy efficiency programs and to intensify efforts to reduce greenhouse gas emissions.
- NRCan sponsored the Green Building Challenge 1998, an international project to develop and test a system to assess the environmental performance of buildings around the world.
- The Government of Canada established Technology Early Action Measures (TEAM), a $56-million component of the Climate Change Action Fund. TEAM supports early-action technology projects to reduce greenhouse gas emissions that contribute to climate change, while sustaining economic and social development.
- In 1998, NRCan launched the Renewable Energy Deployment Initiative, a $12-million three-year program to stimulate market demand for reliable and cost-effective renewable energy systems for space and water heating and cooling.
- The Office of Energy Efficiency sponsored the very successful first Canada's Energy Efficiency Conference, Trade Show and Awards in May 1999.

Over the next year, we expect the trend of improved energy performance to continue and strengthen. The Government of Canada will continue to provide leadership and tools to help meet the energy demands of today, while building a higher quality of life for ourselves and our children.

Improving our nation's energy efficiency is one important component of fulfilling the mission statement I have advocated for NRCan: Canada must become and remain the world's "smartest" natural resources steward, developer, user and exporter – the most high-tech, the most environmentally friendly, the most socially responsible, the most productive and competitive – leading the world as a living model of sustainable development.

Ralph Goodale

Executive Summary

This sixth 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 1997–1998 and 1998–1999 fiscal years. These initiatives are a critical foundation on which Canada can build 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). Over 1997–1999, 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 initiative; more work needs to be done in this area. Future reports will further refine these indicators and develop additional ones.

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 7 791 petajoules in 1997. The industrial sector was responsible for 39 percent of this energy use, followed by the transportation sector (27 percent) and the residential and commercial sectors (18 percent and 13 percent respectively). More than $89 billion, or 12 percent of the country's gross domestic product, was spent on secondary energy in Canada during 1997.

Secondary energy use – including emissions produced indirectly by power generators to meet end-use demand for electricity – produces about 83 percent (429 megatonnes) of total CO_2 emissions in Canada (the primary GHG). Between 1990 and 1997, secondary energy use increased by 11.4 percent. However, related CO_2 emissions increased by only 8.6 percent, as secondary energy users and the electrical generation industry switched to less carbon-intensive fuels. NRCan estimates that there was an improvement in energy efficiency of more than 6 percent between 1990 and 1997; 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 $5 billion in expenditures on energy and an annual reduction in GHG emissions from secondary energy use of 24.4 megatonnes.

This report includes introductory chapters on the policy context of EAE programs, a description of the Act and Regulations, and trends since 1990 in energy use, energy efficiency and greenhouse gas 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 cooperation in EAE matters.

Quantifiable indicators have been used where possible. Between 1990 and 1997, significant progress has been achieved, as indicated in Table 1.

Table 1: Selected Programs and Progress Indicators

Program	Progress Indicators
The Act and Regulations	
Energy Efficiency Regulations	• Residential sector: energy efficiency gains of 21 to 38 percent for household appliances since 1990 • Commercial sector: lighting regulations estimated to save 10 petajoules of electricity by 2000 • Industrial sector: changes to electric motor regulations estimated to save 16.3 petajoules by 2010
Residential Sector	
R-2000 Home Program	• Since the Yukon Housing Corporation began delivering the R-2000 HOME Program in 1997, one quarter of all new houses in the territory have been built to the equivalent of R-2000 energy efficiency standard.
Energuide for Houses Program	• Performed energy efficiency evaluations on more than 5 000 houses, showing homeowners where they could save 20 to 50 percent of heating costs
Reno$ense	• Expanded sponsorship network from 266 to 3 500 retail outlets from spring 1997 to spring 1999.
Commercial and Institutional Sector	
Model National Energy Codes	• Codes adopted as the specification for new facilities for the 13 major custodial departments in the federal government
Commercial Building Incentive Program	• Approved grants for eight buildings that would use 26 to 65 percent less energy than designs based on the Model National Energy Code for Buildings
BETA Plan – Large Buildings	• Organization of the Green Building Challenge ’98, an international project to develop a test of the environmental performance of buildings around the world. Culminated in an international conference in Vancouver in 1998, at which more than 550 delegates from 20 countries reviewed some of the greenest commercial buildings in the world.
Energy Innovators Initiative	• Registration of 502 organizations in the program that have implemented 196 energy saving projects • Since the program began, Energy Innovators have invested $455 million in energy efficiency projects. They estimate that these projects will reduce energy costs by $105 million a year and lower CO_2 emissions by 154 000 tonnes a year
Federal Buildings Initiative	• Total investment commitments in FBI projects of $180 million, with estimated annual energy savings of $24 million
Federal Industrial Boiler Program	• Savings of more than 500 terajoules of energy in 1998–1999, the equivalent of the annual energy use of almost 200 000 refrigerators
Industrial Sector	
Industrial Energy Efficiency Initiative	• Recruitment of 249 industrial companies – representing 74 percent of industrial energy use – as Industrial Energy Innovators • During 1990 to 1997, 22 of the 39 industrial sectors improved their energy efficiency. Five sectors had efficiency gains of 27 to 50 percent. • During 1990 to 1997, the energy intensity of the 21 CIPEC task forces improved on average by 0.9 percent per year.
Industry Energy Research and Development	• Financial support of Stackpole Canada in developing a powder metallurgy technology to fabricate high-stress automotive components. The project yielded energy savings of 0.4 petajoules over conventional methods, and a reduction in CO_2 emissions of 19 kilotonnes in 1997–1998.
Advanced Combustion Technologies Program	• Organization with the IEA of the Activities Implemented Jointly Conference in Vancouver. More than 250 delegates from 40 countries attended the conference which included sessions on $C0_2$ management and storage, energy efficiency technology, and renewable and transportation technologies.
Transportation Sector	
Motor Vehicle Fuel Consumption Initiative	• Reduction of 2.9 percent in the fuel consumption of new light-duty vehicles between 1990 and 1997
FleetSmart	• FleetSmart Tool Kit distributed to 946 clients, representing more than 120 000 commercial vehicles
Alternative Transportation Fuels	• Increase of number of fueling stations selling ethanol-blended fuels from 266 to 947 between 1990 and 1999
Renewable and Community Energy	
Green Power Initiative	• Signed a 10-year agreement to purchase 10 000 megawatt-hours a year of electricity generated from new renewable energy sources for its facilities
Renewable Energy Deployment Initiative	• Approved 12 applications from Canadian businesses for renewable energy systems, representing investments of $1.5 million
Renewable Energy Technologies Program	• Support for the 1998 Renewable Energy in Cold Climate Conference, which attracted more than 550 participants and 30 exhibitors and featured a public forum on issues related to climate change.
Intergovernmental Cooperation	
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 the Canadian Standards Association’s Advisory Committee on Energy Efficiency.
Municipal	• The February 1999 federal budget committed $1.6 million over three years to Municipal Buildings Retrofit Program, to be administered by the Federation of Canadian Municipalities (FCM). NRCan and FCM converted budget commitment into formal contribution agreement between NRCan and FCM.
International	• NRCan chairs initiative to promote energy efficiency in equipment and buildings under Hemispheric Energy Initiative. Organized two international workshops on this topic.

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

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 federal government'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 sixth 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 two fiscal years, from April 1, 1997 to March 31, 1999.

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; and
- NRCan's measures of progress in achieving greater EAE.

Chapter 2 describes the Act, the Energy Efficiency Regulations and the program for developing and administering the regulations for energy performance and labelling.

Chapter 3 outlines the connection between energy use and greenhouse gas emissions and reports on changes in energy use, energy efficiency and greenhouse gas emissions from 1990 to 1997.

Chapters 4 to 7 address each of the energy use sectors, with descriptions of program initiatives, achievements and progress indicators.

Chapter 8 covers renewable and district energy initiatives.

Chapter 9 describes NRCan's intergovernmental (provincial–territorial, municipal and international) cooperation in EAE.

NRCan's EAE initiatives are managed by

- the Office of Energy Efficiency, 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.

Chapter 1
Policy Context

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 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 greenhouse gas 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 that a clearer understanding develops of the implications of global warming and 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 1997–98 and 1998–1999).

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. Through the EAE program, the department has enhanced its statutory authority, improved its data-gathering and analysis capabilities and forged stronger information and planning links with the provinces and other 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 greenhouse gas 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 subsequently tabled at the first meeting of the Conference of the Parties to the Framework Convention in Berlin, Germany, in April 1995. A key element of the NAPCC strategy is to promote energy efficiency in all sectors of the economy.

To 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). This federal–provincial initiative broadens awareness of the need to act and, it publicizes the plans and accomplishments of organizations that reduce their greenhouse gas emissions. 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 greenhouse gas emissions and to file these, as a well as progress reports and achievements, on its public registry, posted on the Internet.

The federal budget of February 1997 announced a $60-million, three-year program, commencing April 1, 1998. These additional funds have resulted in new initiatives to provide financial incentives for energy efficiency improvements in new commercial buildings; encourage commercial building retrofits; provide for energy performance labelling for houses; and stimulate demand for cost-effective renewable energy systems for space and water heating and cooling that are reliable enough to be sold commercially.

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 greenhouse gas 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 greenhouse gases. Although carbon dioxide (CO_2) accounts for about 76 percent of Canada's greenhouse gas 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. The Kyoto Protocol also allows credit for greenhouse gas sinks, such as forest plantations. To meet the Kyoto challenge on a least-cost basis, Canada will need to examine all possible means. The Protocol will enter into force when at least 55 parties to the Framework Convention, representing 55 percent of industrialized countries' greenhouse gas emissions, have ratified it. The Protocol will then be legally binding on those countries.

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 various implementation options open to Canada. The process engaged more than 450 experts from across Canada, who examined the climate change challenge, both vertically (by economic sector) and horizontally (by cross-cutting themes). As a result, recommendations will go to governments and help form the basis for a national climate change implementation strategy.

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 greenhouse gas 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 greenhouse gas 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 greenhouse gas 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 new 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 new annual Energy Efficiency Conference, an energy efficiency technology products and services tradeshow, and Canada's Energy Efficiency Awards ceremony.

NRCan's Office of Energy Research and Development (OERD) coordinates and funds non-nuclear, energy-related R&D for the Canadian government in partnership with eleven different 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. In October of 1998, OERD began a restructuring of its Program of Energy Research and Development (PERD) in order to make it more flexible and, hence, more responsive to emerging issues and priorities. As a response to climate change and, more specifically, Canada's Kyoto commitments, OERD, through PERD, has subsequently dedicated over 50 percent of its annual $53 million R&D budget to study options related to energy efficiency ($16.2 million) and alternative energy ($9.7 million). In addition, PERD has directed some $5.5 million of its funding towards studies aimed at understanding climate change and developing mitigation or adaptation options related to it.

In February 1999, the federal budget provided $1.6 million over three years for the development of a Municipal Building Retrofit Program, through which NRCan will help the Federation of Canadian Municipalities improve the efficiency of energy use in municipal operations.

This report covers progress in energy efficiency and alternative energy measures for the 1997–1999 federal government fiscal years. As such, it does not take into account the greenhouse gas emission reduction targets that Canada agreed to at Kyoto, or the preparations for achieving these targets, which will be the subject of future reports. 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 4, 5, 6 and 7 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 greenhouse gas 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, as well as make other changes in the ways we use energy.

Alternative energy includes renewable sources other than large hydroelectric 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 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 7 and 8 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., fueling 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 fueled 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 disseminates reliable information to consumers and assesses economic and environmental aspects of renewable sources of energy.

In November 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 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 greenhouse gases to those that produce power from renewable energy sources. Also, on April 1, 1998, NRCan started the Renewable Energy Deployment Initiative to stimulate demand for renewable energy systems for space and water heating and cooling.

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 federal-government 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.

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 federal government 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 federal government the authority to establish regulations for the collection of statistics and information on energy use and alternative energy.

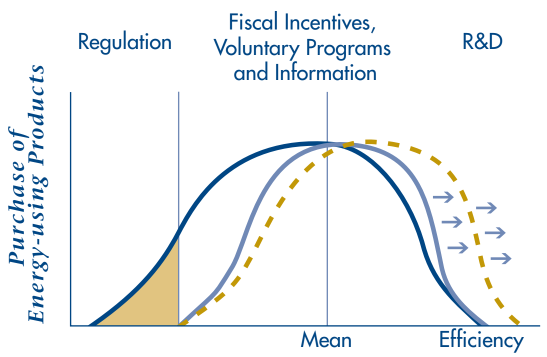
Research and Development

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.

Figure 1: Moving the Market



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. To describe program outputs is to outline what items are produced, how many are produced, when they are produced and how they are delivered to clients or target groups. Examples of program outputs are information and marketing materials, training, demonstration projects, building codes, voluntary agreements, technology development, financial incentives, regulations, and institutional arrangements with industry associations and provincial governments. Program outputs are important measures of effort that are intended to affect behaviour: program outputs are designed to lead to program outcomes – another measure of progress.

Program outcomes are the changes in the behaviour of groups targeted by a program. These groups may be either energy users or parties that influence the behaviour of energy users. For example, program outcomes occur when consumers purchase more energy-efficient appliances, and industries set higher targets for energy efficiency improvements than they would in the absence of the program. Ultimately, these program outcomes affect the amount and type of energy consumed, thus stimulating an observable market outcome – the third measure of progress.

Market outcomes reflect the results of programs – changes in energy efficiency and the use of alternative energy. 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 greenhouse gas emissions.

Measuring program and market outcomes can be difficult. In particular, quantification of program outcomes requires client and data surveys and detailed analyses of energy use. NRCan's National Energy Use Database (NEUD) initiative (see box this 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.

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

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 how effectively the Canadian market addresses these opportunities. It is an invaluable resource in supporting national efforts to mitigate the impacts of energy use on the environment.

To fulfill its objectives, the NEUD has a two-pronged approach — developing energy end-use data and establishing a strong base of expertise for analysing the data.

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:

- Expansion of Annual Industrial Consumers of Energy Survey (1992–97)
- Energy Consumption of Major Household Appliances Marketed in Canada – Trends from 1990 to 1997
- Survey of Household Energy Use (1993, 1997)
- Household Equipment Survey (1994, 1995)
- Survey of Houses Built in Canada (1994)
- Home Energy Retrofit Survey (1994, 1995)
- National Private Vehicle Use Survey (1994–1996)
- Farm Energy Use Survey (1997)

NRCan is developing a new survey on the characteristics of energy-using equipment and buildings in the commercial sector to support analytical requirements. In addition, the department will repeat some previous surveys.

NRCan has developed a network of data and analysis centres in universities across Canada. These centres compile, organize and analyse energy end-use data from the residential, agricultural, commercial and industrial sectors, and data on private vehicle use.

NRCan's Office of Energy Efficiency created a detailed end-use analysis framework that contributes to prospective analyses of energy use (such as *Canada's Energy Outlook*), as well as historical reviews of energy efficiency in Canada (such as *Energy Efficiency Trends in Canada*). Under the analytical framework, new data are brought together with old, providing guidance for new survey activities.

Chapter 2
The *Energy Efficiency Act* and Regulations

The Act

The *Energy Efficiency Act*, which came into force on January 1, 1993, gives the federal government 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; 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.

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 – Energy Performance Levels for Equipment

Purpose

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

Program Description – Establishing 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.

In February 1995, NRCan established energy performance levels for the following products:

- major residential appliances – electric clothes dryers; clothes washers; integrated stacking washer-dryers; dishwashers; refrigerators, freezers and refrigerator-freezers; and electric and gas ranges;
- space-conditioning equipment – room air conditioners; single-package and split-system air conditioners and heat pumps; ground- or water-source and internal water-loop heat pumps; and gas furnaces;
- water-heating equipment – oil-fired, gas-fired and electric; and
- other energy-using equipment – fluorescent lamp ballasts and electric motors.

In 1996, minimum energy performance levels for fluorescent lamps and incandescent reflector lamps were implemented. These Regulations cover the most common types of lamps used in commercial lighting.

In November 1997, the minimum energy performance levels for 1- to 200-HP electric induction motors were increased, requiring motors to meet performance levels that used to be considered "high efficiency."

In December 1998, NRCan established minimum performance levels for the following products:

- compact clothes dryers;
- gas-fired boilers;
- dehumidifiers;
- ice-makers;
- large air conditioners;
- large condensing units;
- large heat pumps;
- oil-fired boilers;
- oil-fired furnaces;
- packaged terminal air conditioners;
- packaged terminal heat pumps;
- three-phase single package central air conditioners;
- three-phase single package heat pumps;
- three-phase split-system central air conditioners; and
- three-phase split-system central heat pumps.

NRCan also increased minimum performance levels for single-phase, split-system central air conditioners and heat pumps at this time.

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. NRCan is developing, or considering, the following amendments to the Regulations:

- increasing the minimum performance levels for refrigerators, refrigerator-freezers and freezers;
- adding minimum performance levels for dry distribution transformers;
- adding bulged-reflector lamps and revising the requirements of the classification system for incandescent-reflector lamps;
- adding commercial and industrial products that are identified and ranked in an NRCan commissioned study by the *Centre de recherche industrielle du Québec* and not already regulated in other jurisdictions;
- adding products the provinces have regulated since December 31, 1998; and
- adding products regulated in the United States but not in any Canadian province.

Compliance – Monitoring and Enforcing Performance Levels

The main compliance activities of the program are monitoring the industry and enforcing the Regulations, and NRCan assigns these activities to third-party certification agencies accredited by the Standards Council of Canada.

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 federal government. No one can sell or lease the product until it has an exterior verification mark.
- Customs Release Documents – Dealers who import a prescribed product must submit customs clearance documents to the Canada Customs and Revenue Agency, which sends NRCan a copy of the completed document. The reports must include specific information:

- type of product (e.g., stove, clothes dryer);
- brand name;
- model number;
- dealer's name and address; and
- purpose for which the product is being imported (sale or lease, modification in Canada or re-export).

NRCan outlines its approach to compliance in "Compliance Policy for the *Energy Efficiency Act* and the *Energy Efficiency Regulations*," released in March 1995. The department is committed to achieving a high level of compliance with the Act and the Regulations and believes that the best way to ensure voluntary compliance is to ensure that all stakeholders support its administration of the Act and the Regulations. This philosophy is reflected in some of NRCan's operating principles for administering the Act:

- consulting and cooperating with stakeholders, especially other governments and affected industries;
- minimizing the administrative burden of compliance;
- harmonizing regulations with those of other jurisdictions; and
- informing the public.

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. In collaboration with the Canada Customs and Revenue Agency, NRCan has instituted monitoring at border points. NRCan verifies information on products in customs release documents with its own database to ensure 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' Laboratory and Intertek Testing Services.
- Inspections – NRCan conducts periodic marketplace audits. This varies from monitoring sales locations for the presence of labels to arranging for the performance testing of product samples in accredited laboratories.

Communications

NRCan has produced a comprehensive *Guide to Canada's Energy Efficiency Regulations*, as well as specific fact sheets on the following topics:

- reports under section 5 of the *Energy Efficiency Act*;
- procedures for importing an energy-using product into Canada;
- energy efficiency verification marks;
- exemptions from the *Energy Efficiency Regulations*;
- EnerGuide labels for energy-using products;
- electric motors; and
- lighting products.

It has posted these documents on the OEE Web site (http://oee.nrcan.gc.ca).

In addition, NRCan periodically publishes *The EnerGuide Reporter*, a newsletter about the development of standards, regulatory requirements, marketing initiatives and related activities.

The Regulations – EnerGuide Labels for Appliances

The purpose of the EnerGuide for Appliances Program is to encourage consumers to purchase energy-efficient equipment. This is done by disseminating information on the energy performance of a range of competing products. The first regulations under the *Energy Efficiency Act* included labelling requirements for eight major household appliances, as well as the introduction of the EnerGuide label to show the annual energy use of a product and its ranking on an energy efficiency scale for similar products available in Canada. The following are the initial eight products:

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

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 2). EnerGuide labels for room air conditioners describe energy performance as an energy-efficiency ratio (see Figure 3). 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. Comprehensive information campaigns foster consumer understanding of the EnerGuide label and the benefits of both owning an energy-efficient product and using it efficiently. In these campaigns, NRCan provides web-based information to consumers, retailers and manufacturers on the EnerGuide label; prepares and distributes publications and media releases; and participates in consumer exhibits. NRCan also develops training material to educate retail salespeople on how to use the EnerGuide label.

Achievements in 1997–1999

- NRCan improved the way it provides information to industry on the labelling requirements of the *Energy Efficiency Regulations*. It now posts labelling instructions on the EnerGuide Web site, along with the requirements for the information to be included in the labelling scales (or the comparative bar) on EnerGuide labels. NRCan also sends labelling instructions to each manufacturer or dealer with the yearly labelling scales.
- NRCan consulted with stakeholders on changes to the format of the EnerGuide label to include comparative information on energy costs.
- NRCan consulted with suppliers of gas-fired products (commercial boilers, service water heaters, domestic water heaters and fireplaces) to assess their support for a labelling regulation.

Figure 2: EnerGuide Label for Appliances

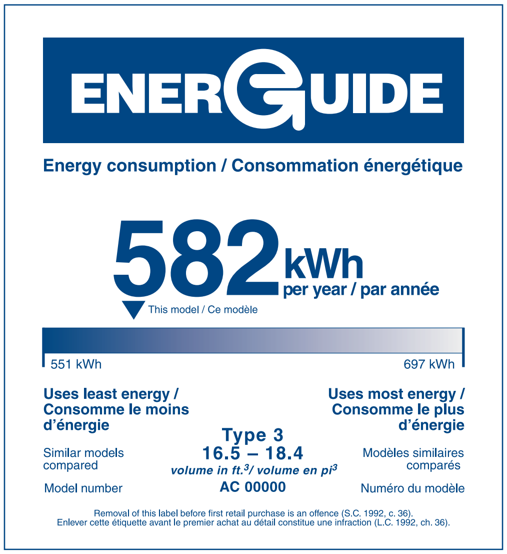
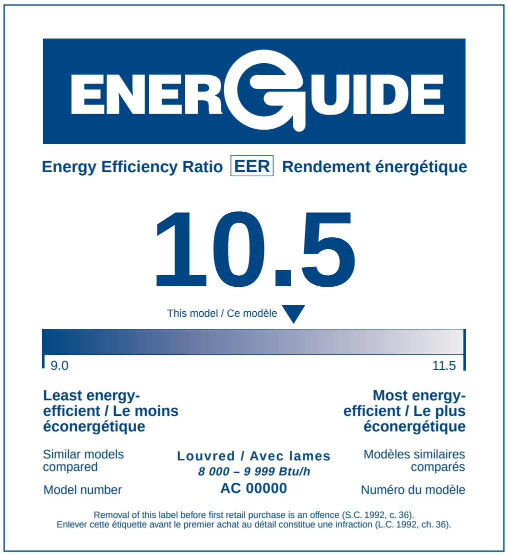


Figure 3: EnerGuide Label for Air Conditioners



Chapter 3
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 Canadians spend on energy indicates its importance to Canadians and the Canadian economy. Canadians spend more than $89 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 about 12 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 15.3 percent between 1990 and 1997, from 9 500 petajoules to 10 955 petajoules.

Secondary energy use (7 791 petajoules) accounted for 71 percent of primary energy use in 1997. It was responsible for about 83 percent (429 megatonnes) of total CO_2 emissions in Canada, if we include indirect emissions (i.e., those produced by electric utilities to meet end-use electrical demand). Carbon dioxide is a major greenhouse gas, representing 76 percent of Canada's greenhouse gas emissions. (All subsequent references to CO_2 include both emissions from the electricity used by secondary energy users and those attributable directly to secondary energy use.)

Secondary energy use increased by 11.4 percent from 1990 to 1997, but CO_2 emissions attributable to secondary energy use increased by only 8.6 percent, because secondary energy users and the electricity-generating industry both switched to less carbon-intensive fuels. By 1997, the oil share of secondary energy use had fallen by 1.1 percentage points from 1990 levels, from 36.3 percent to 35.2 percent, and the electricity share also declined slightly. The natural gas share increased to 26.8 percent from 25.4 percent 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 1997. The transportation sector is the second-largest energy user at 27 percent, followed by the residential sector at 18 percent, the commercial sector at 13 percent and the agricultural sector at 3 percent.

The 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*, while this report uses a definition better suited for the purpose of energy end use analysis. It should also be noted that for the 1990-1997 period, Natural Resources Canada initiated and funded a major review of QRESD, which resulted in several sector re-allocations and data improvements. Some modifications to the original Statistics Canada data were required and are documented in Appendix C of NRCan's *Energy Efficiency Trends in Canada 1990-1997.*

Energy Efficiency

NRCan annually publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use (and CO_2 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 much 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 commercial 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.

Table 2: Explanation of Changes in Secondary Energy Use, 1990 to 1997

Explanatory Factor	Increase (Decrease) in Energy Use	
	Percent	Petajoules
Activity	13.5	945
Structure	3.9	275
Weather	1.0	70
Energy efficiency	(6.2)	(435)
Other factors	(0.8)	(55)
Actual Change	11.4	800

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 11.4 percent between 1990 and 1997 (from 6992 to 7791 petajoules). Three factors tended to increase it (see Table 2):

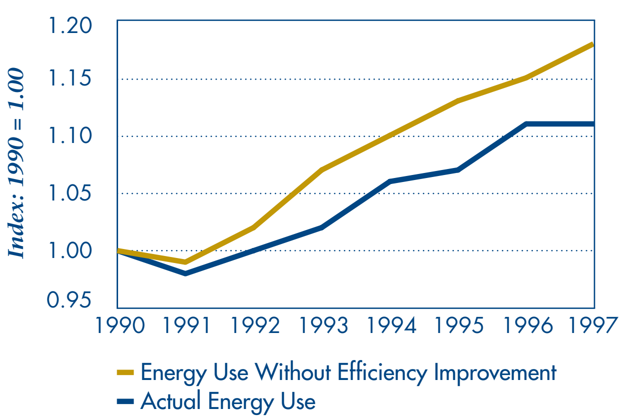
- activity (economic growth) raised secondary energy use by 13.5 percent (945 petajoules);
- the structure of activity raised secondary energy use by 3.9 percent (275 petajoules) – the industrial sector shifted to more energy-intensive activities and road transport grew more rapidly than other modes of transportation; and
- weather raised secondary energy use by 1.0 percent (70 petajoules) – the winter of 1997 was colder than 1990, resulting in a greater demand for heating in the residential and commercial sectors.

If only these three factors had been in effect, secondary energy use would have increased by 18.4 percent. However, improvements in energy efficiency worked to decrease energy use by 6.2 percent (435 petajoules). As a result, energy use increased by only 11.4 percent. This change in energy use during 1990 to 1997, with and without changes in energy efficiency, is shown in Figure 4. The difference in energy use due to energy efficiency – the energy saving – represents a reduction in energy costs of $5 billion a year and a reduction in CO_2 emissions of over 24 megatonnes per year.

Changes in energy efficiency are estimated for each of the four end-use sectors using the approach described above and presented in Chapters 4 to 7. The energy efficiency improvements were largest in the residential sector (10.7 percent), followed by the transportation (8.1 percent), industrial (4.7 percent) and commercial sectors (1.8 percent).

NRCan's programs contributed to a portion of the energy savings due to energy efficiency, as shown in Figure 4. It is impossible, 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 will result from NRCan program initiatives undertaken between 1990 and 1998 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 significantly affect the average efficiency of the Canadian stock of appliances and equipment. For example, new refrigerators sold in Canada are now 36 percent more energy-efficient than those sold in 1990, as a result primarily 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 36 percent improvement. For these reasons, the following chapters do not, in most cases, quantify the energy use or CO_2 impact of NRCan's programs from 1990 to 1998. 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 reduce emissions.

Figure 4: Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1997



Chapter 4
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 17.8 percent (1 385 petajoules) of secondary energy use and 16 percent (69 megatonnes) of CO_2 emissions.

The majority of Canadian dwellings are single detached houses, followed by apartments, single attached dwellings and mobile homes (see Figure 5). Because single detached houses predominate, most NRCan residential building programs focus on these dwellings.

Space and water heating make up 80 percent of residential energy, followed by the shares devoted to operating appliances, lighting and space cooling (see Figure 6).

Between 1990 and 1997, residential energy use increased by 6 percent or 78 petajoules (from 1 307 to 1 385 petajoules). Carbon dioxide emissions from the residential sector rose by 2.1 percent from 1990 to 1997. A 2.1 percent increase in CO_2 emissions compared with a 6 percent increase in energy use reflects a decrease in CO_2 intensity, as a result of fuel-switching in this sector and the electricity-generating industry switching to less carbon-intensive fuels.

Three main factors tended to increase residential energy use – activity, weather and structure:

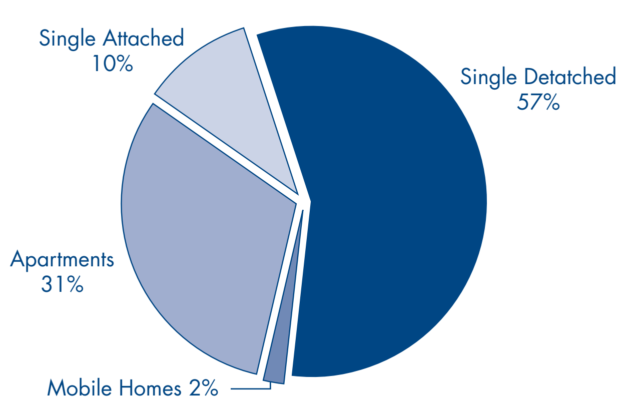
- *activity* – the change in the number of households (the principal measure of residential activity) increased energy use by 13.4 percent (175 petajoules);
- *weather* – colder weather in 1997 compared to 1990 led to an increase in space heating requirements. This increased energy use by 4.1 percent (53 petajoules); and
- *structure* – the structure of activity became more energy-intensive, primarily because of increased use of appliances and space cooling. This increased energy use by 0.7 percent (10 petajoules).

If only these three factors had been in effect, residential energy use would have increased by 18.3 percent (239 petajoules). However, improvements in energy efficiency worked to decrease energy use by 10.7 percent (140 petajoules). As a result, energy use increased by only 7.6 percent. This change in energy use during 1990 to 1997, as well as the energy savings due to energy efficiency, is shown in Figure 7.

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

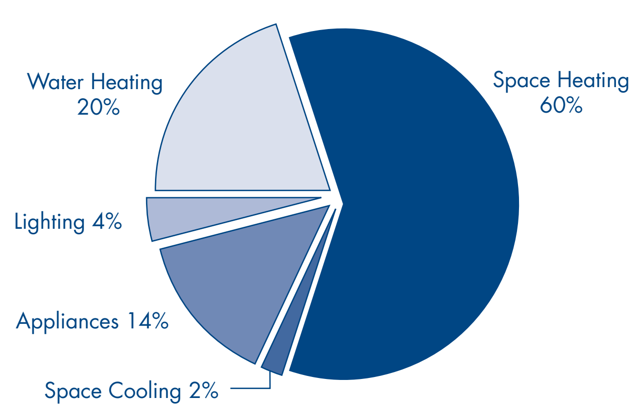
- new houses;
- existing houses; and
- residential equipment, including
  - energy performance regulations and
  - energy labelling.

Figure 5: Canadian Households by Type of Dwelling, 1997



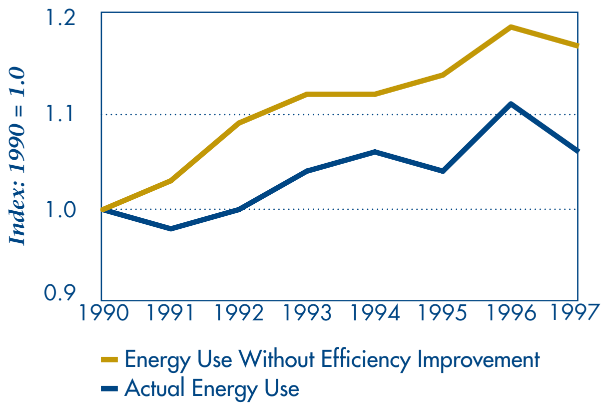
Total: 11 606 000 Households

Figure 6: Residential Energy Use, 1997



Total: 1 385 Petajoules

Figure 7: Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1997



New Houses

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

- R-2000 HOME Program;
- *Model National Energy Code for Houses*; and
- Buildings 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 and financial institutions – deliver it at the provincial level. As well, product manufacturers, equipment suppliers and other private 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 1997–1999

- NRCan trained 353 builders and other professionals in R-2000 construction techniques and technology, bringing the total to more than 10 000. There are currently 602 R-2000 builders across Canada that have been licensed by NRCan to build certified R-2000 homes.
- NRCan certified 682 R-2000 homes, bringing the total to more than 8 500 certified R-2000 homes across Canada.
- The international profile of the R-2000 HOME Program continued to grow. The New Brunswick Home Builders' Association certified seven R-2000 homes in Maine and Massachusetts. NRCan negotiated a licensing agreement with the Alaska Building Science Network to include R-2000 construction techniques in their builder workshops. The Canada Mortgage and Housing Corporation (CMHC) also began to use the R-2000 standard to export housing to other countries.
- In November 1997, NRCan organized and co-chaired the fifth annual Canada–Japan R-2000 Annual Meeting in Sapporo, Japan. The meeting attracted 70 industry and government participants from the two countries. Representatives of the Canadian and Japanese R-2000 programs agreed to collaborate in developing R-2000 homeowner surveys and indoor environmental monitoring protocols.
- Since the Yukon Housing Corporation began delivering the R-2000 HOME Program in 1997, one quarter of all new houses built in the territory have equalled the energy efficiency of the R-2000 standard. Since the spring of 1999, the Yukon Housing Corporation has offered a "Green Mortgage" with a preferred rate to these houses.
- The Canadian Home Builders' Association, with support from Canada Trust, promoted R-2000 with the R-2000 EnviroHome Project. EnviroHomes are R-2000 demonstration homes with additional environmentally responsible features. From 1997 to 1999, 22 R-2000 EnviroHomes were built across Canada.

- Health Canada, as part of a study on home health conducted by the R-2000 HOME Program, conducted a survey to compare the health of homeowners living in 50 R-2000 homes with that of homeowners living in 52 non-R-2000 homes. Preliminary results from the survey suggest that up to 30 percent of the R-2000 homeowners reported significant reductions in the incidence of sore throat, cough, fatigue and irritability after moving into an R-2000 home.

Model National Energy Code for Houses

The *Model National Energy Code for Houses* aims at increasing the energy efficiency of new Canadian houses by specifying minimum requirements for energy use on an economic basis (depending on location and energy source). NRCan developed the code in collaboration with energy utilities, provincial and territorial governments, and the National Research Council (NRC). The Canadian Commission on Building and Fire Codes published the code in 1997. NRCan provides software, training and implementation materials to support the adoption and implementation of this model code by the relevant housing authorities (i.e., provinces, territories and municipalities). The department also monitors and analyses the impact of such codes.

Achievements 1997–1999

- In collaboration with the provinces and energy utilities, NRCan developed state-of-the-art software to verify compliance with the requirements of the *Model National Energy Code for Houses*.

BETA Plan – Residential Buildings

The BETA Plan – Residential Buildings provides technology development, technology and transfer and quality assurance to promote energy-efficient and environmentally responsible technologies for new and existing housing. It gives priority to emerging technologies with potential for use in new construction or retrofit projects, such as residential space- and water-heating systems, ventilation and windows. The BETA Plan – Residential Buildings also provides technical support for other initiatives such as the R-2000 HOME Program and the *Model National Energy Code for Houses*. Work has begun on the development of audit software for identifying cost-effective retrofit opportunities and supporting the development of a Home Energy Rating System.

Achievements 1997–1999

- NRCan released HOT2™ XP[1] (a spin-off of its HOT2000 energy analysis software) to respond to industry demand for a simple way to analyse residential energy use. A major market focus of HOT2 XP™ is large-volume residential auditing, with potential for sale to utility companies, for example. It is also the basic tool of the EnerGuide for Houses Program.
- NRCan organized and led the Canadian mission to the fourth Canada–Japan Housing Research and Development Workshop in Sapporo, Japan, in November 1997. More than 30 Canadian delegates attended, and five Canadian companies exhibited their products and services.
- NRCan co-hosted a workshop in Mississauga, Ontario, on "Reinventing the Gas Fireplace for the New Canadian Home: Residential Integrated Fireplace Systems." With its co-sponsors, the Hearth Products Association of Canada and Gas Technology Canada, NRCan brought together a cross section of manufacturers, builders, associations, utilities and experts to highlight the potential for Canadians to achieve new levels of energy efficiency.
- NRCan and the Canadian Oil Heat Association co-hosted a workshop aimed at accelerating the development and commercialization of advanced oil heating systems for housing. Advanced oil systems are one of the top nine technologies to emerge from NRCan's Advanced Houses Program, and they offer Canada significant economic and environmental benefits, both domestically and in the export market.
- NRCan signed a joint venture agreement with K. Ito and Associates of Vancouver, British Columbia and Tsuchiya TwoBy Home of Japan to build a steel-frame Super E™ demonstration home in Sapporo, Japan, which will have more than 50 percent Canadian content. The Super E initiative introduces Canadian value-added, energy-efficient, healthy building products, services and techniques to Japanese home builders. NRCan will work with Tsuchiya TwoBy to coordinate Super E training, installation, quality assurance and marketing in the Sapporo area.

[1]HOT2 is a trademark of Natural Resources Canada.

- Along with the NRC, CMHC and PERD, NRCan sponsors the Canadian Centre for Housing Technology, a federal initiative whose objective is to accelerate the technical development and market acceptance of energy-efficient, sustainable and affordable construction methods and products. The Centre completed construction of its first two research houses, located at the Centre, and is now collecting performance-monitoring data on these houses.
- NRCan released version 8.0 of HOT2000, its low-rise residential energy analysis software, and has signed agreements with the Canadian Home Builders' Association and Conservation Capital Corporation to resell the program to firms in the industry.
- NRCan signed an agreement with Irving Oil Ltd. to allow it to act as a reseller and distributor of HOT2™ XP, the "express" version of HOT2000. HOT2™ XP helps Canadians identify the best ways to reduce energy consumption in their homes, such as insulation, energy-efficient windows and high-efficiency furnaces.

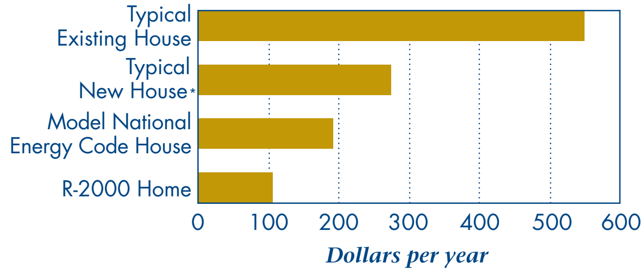
Progress Indicators

The three program initiatives described above help reduce energy consumption in new residential units. A new house that meets the model energy code costs about 30 percent less to heat than a conventional new house, while an R-2000 house costs about 60 percent less to heat (see Figure 8).

The proportion of R-2000 homes among new housing starts across Canada in the 1990s has remained fairly constant, at less than 1 percent. At the regional level, however, the proportion of R-2000 housing starts varies considerably, owing to variations in fuel availability and prices and the more aggressive promotion of R-2000 houses in some regions. For example, in New Brunswick, home builders used R-2000 construction for between 5 and 10 percent of new houses during 1992 to 1995, but this figure dropped in 1996 because New Brunswick Power stopped providing grants for R-2000 houses. In Nova Scotia, R-2000 houses represented 3 to 4 percent of total housing starts during 1995 to 1998 (see Figure 9).

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. That new houses are increasingly airtight is another indicator of improved overall energy efficiency. Air leakage is an important element in heat loss, and this 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, the average number of air changes per hour in all newly constructed houses has decreased from more than 5 to 3 (see Figure 10), and the number continues to drop.

Figure 8: Average Annual Heating Costs for Houses Constructed to Different Standards



*Typical New House: For a natural gas-heated house in British Columbia

Figure 9: R-2000 Share of National, Nova Scotia and New Brunswick Housing Completions, 1983 to 1998

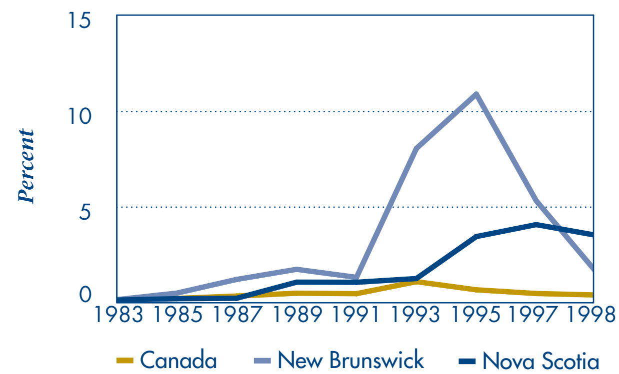
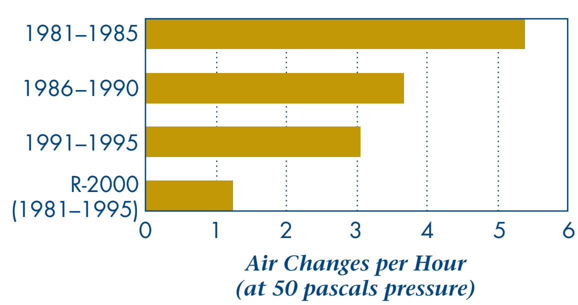


Figure 10: National Trends of Air Leakage in Houses by Construction Period



Existing Houses

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

- EnerGuide for Houses Program;
- Reno$ense; and
- BETA Plan – Residential Buildings.

EnerGuide for Houses Program

EnerGuide for Houses Program (a new program initiative as of April 1998) 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 Home Energy 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 in 1997–1999

- NRCan ran a pilot project in Ontario, Quebec and Yukon to test field delivery options, including a software tool to analyse the energy efficiency of houses, evaluation procedures, and administrative and technical guidelines. It obtained data files on 450 houses participating in the pilot project to assess the energy efficiency of these houses and measure the energy efficiency improvements resulting from the retrofits.
- It used focus groups in Alberta, New Brunswick and Ontario to determine the public perception of energy efficiency within the residential sector and interest in the EnerGuide for Houses concept.
- NRCan awarded licences for program delivery to seven agents.
- NRCan's delivery agents performed energy efficiency evaluations on more than 5 000 Canadian houses, meeting the program's targets for its first year. Data were gathered on the energy efficiency of the houses and the reductions resulting from the retrofits in energy use and greenhouse gas emissions. Homeowners learned how and where they could save 20 to 50 percent of heating costs, while improving comfort and indoor air quality.
- NRCan engaged key partners that share the department's interest in home renovations (e.g., financial institutions, retail hardware stores) and they helped to market the initiative through their own promotional materials.
- The department established an advisory committee, comprising representatives from private and public sector organizations involved in the delivery of the initiative, to advise on program improvements, based on lessons learned from across Canada. This led to improvements in software programs, homeowner reports and program delivery.
- NRCan added implemented a quality assurance component to the initiative to ensure consumer satisfaction with the service monitor quality of evaluations and delivery agent service and ensure the collection of correct data.

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 energy efficiency improvements through print and television campaigns, point-of-purchase displays and promotions, and utility mailings.

Achievements 1997–1999

- The retail sponsorship network expanded from a pilot project with one national chain of 266 stores to several chains representing 3500 outlets across Canada.
- Utilities were brought into the Reno$ense fold for the first time, offering the program a broad channel of distribution. Reno$ense "Enertips" messages were distributed to more than 2 million utility customers.

- Retail sponsors in the hardware and building supply industry distributed 750 000 copies of the *Reno$ense Checklist*, a colourful 24-page magazine full of energy saving tips and sponsor advertisements. Program partners designed and delivered in-store signs and point-of-purchase displays to support the project.
- Program partners developed and distributed the Reno$ense Buyers' Guide to Canadians through a network of 17 000 retailers and other program sponsors. The Guide promotes energy efficiency as a purchasing category at the retail level.
- The Weather Network tagged its messages on energy-efficient home renovations with the Reno$ense logo, thereby promoting the program and its message at very little cost to NRCan.
- A retail store sweepstakes offering prizes of energy-efficient products and services, including EnerGuide for Houses home energy evaluations, attracted 250 000 consumers.
- NRCan funding was leveraged by a factor of 10 to one.
- The energy efficiency message was distributed in retail flyers to 20 million Canadian households.

BETA Plan – Residential Buildings

The BETA Plan – Residential Buildings provides technology development, technology and transfer and quality assurance to promote energy-efficient and environmentally responsible technologies for new and existing houses. It gives priority to emerging technologies for use in new construction or retrofit projects and provides technical support for initiatives such as the R-2000 HOME Program and the *Model National Energy Code for Houses*. Work has begun on the development of audit software to identify cost-effective retrofit opportunities and support the development of an Home Energy Rating System.

Achievements 1997–1999

- NRCan signed a contract with the Northwest Territories Housing Corporation to assess the potential of oil-fired integrated space and water heating systems for northern applications. Based on the results, the Corporation will consider installing these units in six remote settlements, in a trial program, to replace the electric heat in dwellings with a less expensive and more appropriate energy system.
- NRCan hosted the Second Canadian Housing Technology Export Network Workshop in Winnipeg, Manitoba, a forum for industry and government to exchange information on strategies to increase Canada's exports of value-added housing products and services. Joint projects on ventilation and indoor air quality and durable building envelopes were established with Japanese research organizations at the workshop.

Residential Equipment – *Energy Efficiency Regulations*

The 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 1997–1999

- In December 1998, NRCan implemented new Regulations for compact clothes dryers, dehumidifiers, residential oil-fired furnaces, and oil- and gas-fired boilers. The energy efficiency standards were increased for single-phase split-system central air conditioners and heat pumps.

Progress Indicators

The Regulations apply to equipment that accounts for 73 percent of total residential energy consumption, almost all of the energy consumed in water heating, 72 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 11).

The Regulations have significantly affected the energy efficiency of appliances. Energy consumption by new appliances has decreased by about 21 percent for clothes washers and dryers, and between 29 and 38 percent for refrigerators, freezers and dishwashers. Energy consumption by refrigerators, which accounts for 24 percent of appliance energy use, improved by 35 percent between 1990 and 1997 (see Figure 12).

The Regulations, along with the EnerGuide Program, caused refrigerator sales to shift to more efficient models. Between 1990 and 1997, the sales-weighted average consumption of new refrigerators decreased by 37.6 percent (from 61.7 kilowatt hours [kWh] per cubic foot in 1990 to 38.6 kWh per cubic foot in 1997 (see Figure 13).

Since 1990, the Regulations and EnerGuide Program have contributed to energy efficiency gains of 35 percent for all refrigerators. Moreover, despite a 7-percent increase in the size of top-mounted refrigerator models over this period, their efficiency improved by 32 percent (see Figure 14).

The Regulations have 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). The minimum efficiency specified in the Regulations is 78 percent, while the maximum attainable with current technology is 96 percent. The aggregate Annual Fuel Utilization Efficiency (AFUE) for natural gas furnaces in 1996 was 85.5 percent.

Figure 11: Share of Residential Energy Consumption Subject to Energy Efficiency Regulations, 1997

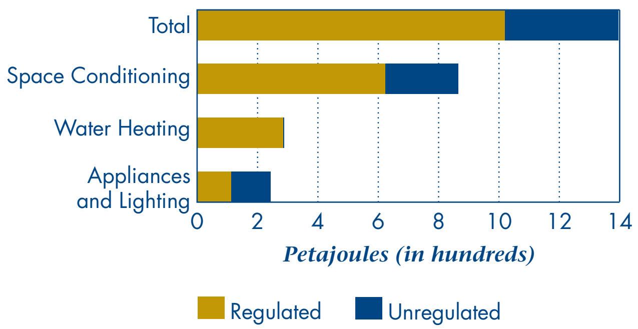


Figure 12: Average Energy Consumption of New Appliances, 1990 and 1997

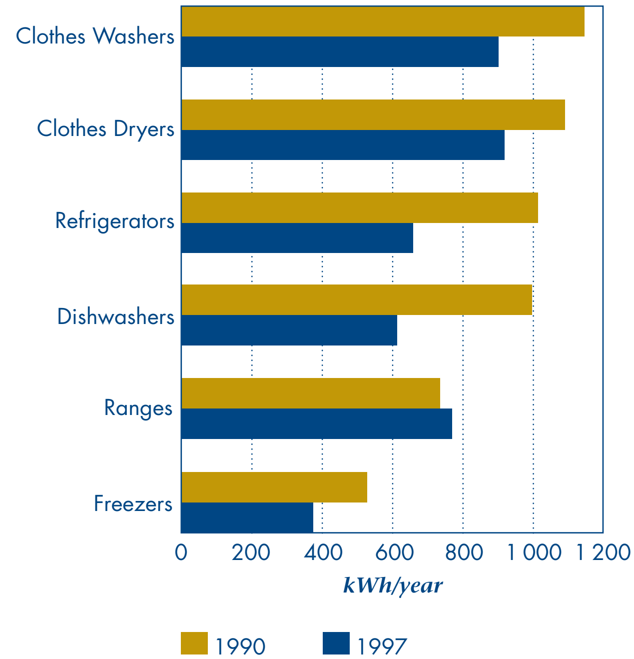


Figure 13: Distribution of Refrigerator Sales According to Energy Consumption, 1990 and 1997

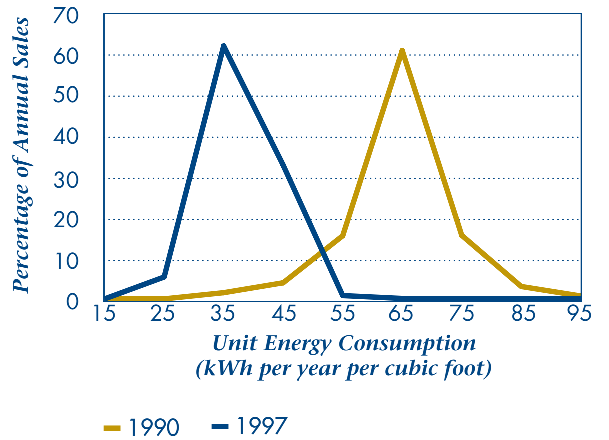


Figure 14: Size and Energy Consumption of New Type 3 Refrigerators, 1991 and 1998

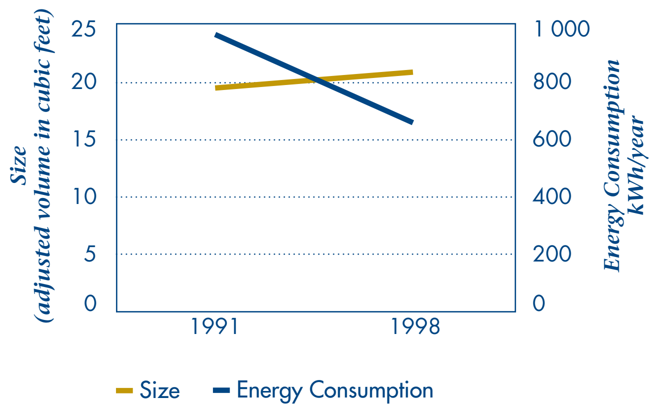
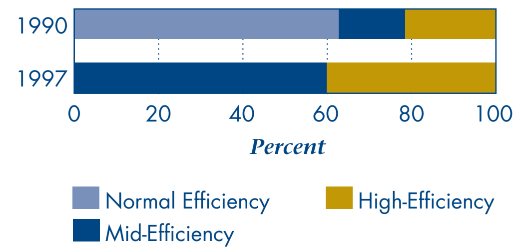


Figure 15: Natural Gas Furnace Sales by Efficiency Level, 1990 and 1997



Residential Equipment – Energy Labelling

NRCan promotes energy-efficient equipment through the following initiatives:

- EnerGuide for Appliances; and
- EnerGuide HVAC Energy Efficiency Rating System.

The BETA Plan provides technical support for these labelling initiatives.

EnerGuide for Appliances

The EnerGuide for Appliances initiative encourages consumers to buy energy-efficient household appliances and room air conditioners. It provides information on the annual energy consumption of a product and compares it with competing products of the same class and size. Regulations under the Act require these new products to display an EnerGuide label, providing an annual energy consumption rating or an energy efficiency ratio. Each year, NRCan updates the information that manufacturers and dealers must include on the product labels and publishes a directory of these products and their energy consumption ratings. 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.

Achievements 1997–1999

- In May 1998, the EnerGuide for Appliances initiative launched its first annual EnerGuide Month. This is a public relations event to increase awareness of the EnerGuide label and encourage consumers to purchase more energy-efficient appliances. Four major retailers of household appliances participated in EnerGuide Month and organized in-store promotions: Sears, Eaton's, Future Shop and the Brick. NRCan supplied training material for appliance salespeople and in-store promotional material for all participating stores. This event attracted a wave of publicity from print and radio media. EnerGuide was featured in six talk shows and more than 70 newspaper and magazine articles. In-store promotional material supplied to all retailers was very popular with consumers.
- NRCan upgraded the EnerGuide for Appliances Web site to increase its usefulness for manufacturers and the public. The site now includes:
  - an interactive listing of EnerGuide ratings for appliances and yearly operating cost estimates of appliance models, using average electricity costs per province; and
  - tips on buying more energy-efficient appliances and using them more efficiently.

Since the upgrade, there have been over 50,000 visits to the Web site.

- NRCan conducted consultations with suppliers of gas-fired products to assess support for labelling requirements which resulted in decisions to require labelling for gas fireplaces.
- NRCan amended the *Energy Efficiency Regulations* to
  - include compact clothes dryers and horizontal-axis clothes washers as prescribed products requiring an EnerGuide label;
  - clarify the definition of a household appliance; and
  - require the Canada wordmark on the EnerGuide label.

EnerGuide HVAC Energy Efficiency Rating System

The EnerGuide HVAC Energy Efficiency Rating System encourages consumers to buy energy-efficient home HVAC products by giving them information on the energy performance of these products. Manufacturers of HVAC equipment feature their EnerGuide rating in their product brochures. The EnerGuide label indicates the yearly energy consumption of a product and how this compares with ratings for its competitors, based on standardized testing. The Heating, Refrigerating and Air Conditioning Institute of Canada (HRAI) promotes this voluntary initiative under an agreement with NRCan. Under this agreement, 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.

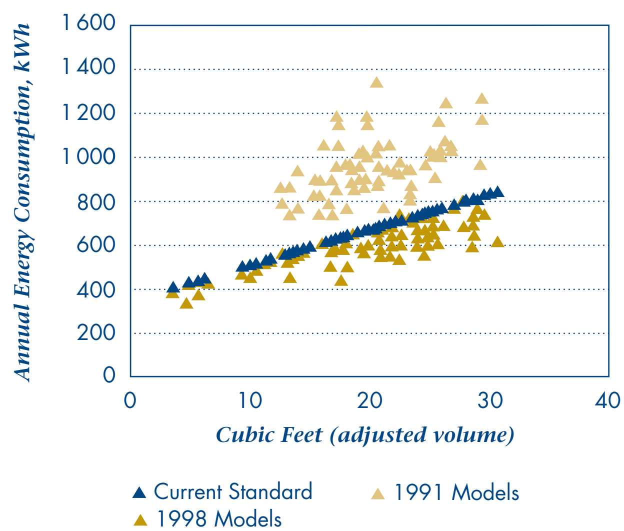
Achievements 1997–1999

- In September 1998, NRCan launched version 2 of the EnerGuide HVAC software, to enable dealers to calculate energy cost savings for consumers buying or retrofitting HVAC equipment. NRCan and HRAI are promoting this software as part of their activities to promote awareness among dealers and utilities. About 200 firms and utilities in Canada have purchased the software.

Progress Indicators

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 above 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 above the minimum standard. More than 25 percent of all standard dishwashers show EnerGuide ratings at 26 percent above 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 16: Energy Use Trends for Refrigerators, 1991 and 1998



Chapter 5
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 1997, the commercial and institutional sector accounted for 13.0 percent (1 015 petajoules) of secondary energy use and 12.5 percent (54 megatonnes) of CO_2 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 35 percent of that demand. NRCan programs address all of these major energy-using building types.

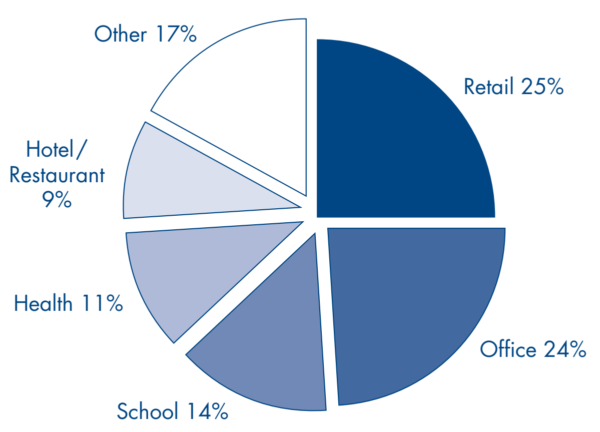
Energy is used for six purposes in commercial and institutional buildings. The largest of these is space heating, which accounts for more than half of all this sector's energy demand (see Figure 18). Each of the remaining five uses of energy in this sector accounts for between 5 and 15 percent of its energy demand.

Between 1990 and 1997, commercial and institutional energy use increased by 13.4 percent or 120 petajoules (from 895 to 1 015 petajoules). However, carbon dioxide emissions from the commercial sector rose by only 8.8 percent in the same period. The main factor causing emissions to increase less quickly than energy use was the reduction in the CO_2 intensity of electricity production. Slight changes in end-use fuel shares partly explained the remaining decline in CO_2 intensity.

Three main factors tended to increase commercial and institutional energy use – activity, weather, and structure:

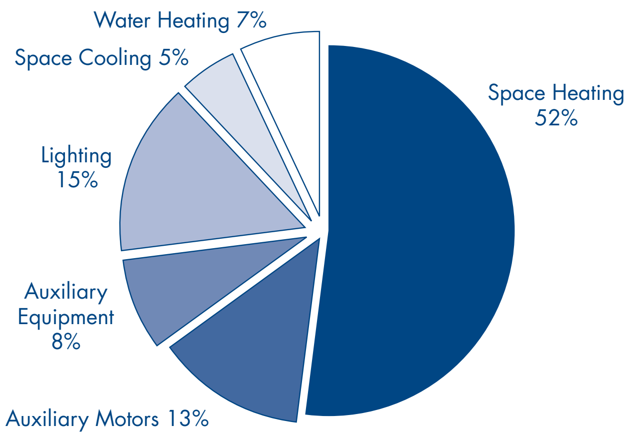
- *activity* – the change in commercial floor space (the principal measure of commercial activity) increased energy use by 13.3 percent (119 petajoules);
- *weather* – colder weather in 1997 compared to 1990 led to an increase in energy use by 1.9 percent (17 petajoules); and
- *structure* – the change in the distribution of floor space among different uses increased energy use marginally (2 petajoules).

Figure 17: Commercial and Institutional Energy Use by Building Type, 1997



Total: 1 015 Petajoules

Figure 18: Commercial and Institutional Energy Demand, by End Use, 1997



Total: 1 015 Petajoules

If only these three factors had been in effect, commercial and institutional energy use would have increased by 15.4 percent (138 petajoules). However, improvements in energy efficiency worked to decrease energy use by 1.8 percent (16 petajoules). As a result, energy use increased by 13.6 percent. This change in energy use during 1990 to 1997, 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:

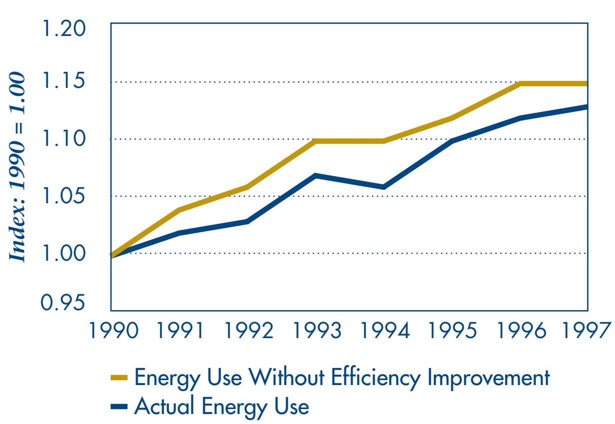
- new buildings;
- existing buildings; and
- equipment.

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.

Figure 19: Commercial Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1997



Model National Energy Code for Buildings

The MNECB aims to increase the energy efficiency of new Canadian buildings by specifying maximum requirements for energy use on an economic basis in different regions. It provides this region-specific energy standard by allowing for the climate and the cost of energy and construction in each region. NRCan developed the code in collaboration with energy utilities, provincial and territorial governments and the NRC. The Canadian Commission on Building and Fire Codes published the code in 1997. NRCan provides software, training and implementation materials to support the adoption and implementation of this model code by the relevant housing authorities (i.e., provinces, territories and municipalities). The department also monitors and analyses the impact of such codes.

Achievements 1997–1999

- As a result of NRCan's efforts, the 13 major custodial departments in the federal government have adopted the Model National Energy Code for Houses and the MNECB as their specification for new construction or leased facilities built to their specifications.
- In collaboration with the provinces and energy utilities, NRCan developed state-of-the-art software (EE4-Code) to verify compliance with the requirements of the MNECB. A derivative called EE4 CBIP is being used to verify compliance with CBIP criteria and can be downloaded from the OEE Web site.
- Because the MNECB provides a means to standardize measurements of energy efficiency across commercial and institutional buildings, NRCan was able to develop and launch the CBIP in April 1998.

Commercial Building Incentive Program

CBIP, launched in April 1998, provides financial incentives to builders and developers to incorporate energy efficient technologies and practices into the design and construction of new commercial, institutional and multiunit 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. CBIP makes an initial payment of 80 percent during the building design stage and the remaining 20 percent after receiving proof that the construction meets design specifications.

Achievements 1997–1999

- By March, 1999, CBIP had received 13 applications and approved 8 grants worth $200,000 for buildings with energy use 26 to 65 percent lower than the MNECB design.
- It held four training sessions for engineers and architects. Full program documentation, software and case studies are available on the OEE Web site.
- NRCan issued several technical support tools: six technical guidelines, EE4 CBIP (compliance software), a software-based help file and six case studies.

BETA Plan – Large Buildings

NRCan's BETA Plan – Large Buildings supports the development, commercialization and adoption of energy efficient, environmentally responsible technologies for large buildings. Its S&T activities are designed to inform builders of the benefits and costs of introducing environmentally friendly, energy-efficient technologies. One component of the BETA Plan – Large Buildings is the C-2000 Program. It demonstrates methods to improve the energy efficiency, indoor environment and environmental impact of commercial buildings, with the aim of accelerating the adoption of new technologies.

Achievements 1997–1999

- NRCan announced the Green Building Challenge '98, an international project to develop a test of the environmental performance of buildings around the world. The process culminated in an international conference in Vancouver in 1998, at which more than 550 delegates from 20 countries reviewed the greenest commercial buildings.
- A new building in the Crestwood Corporate Centre in Richmond, British Columbia, used advanced features of an ultra energy-efficient building from NRCan's C-2000 Program for Advanced Commercial Buildings. The building is expected to save 40 percent more in overall energy consumption than a new building built to current standards.
- NRCan developed BILTRAD software to allow builders to easily verify whether their designs meet the MNECB to encourage provincial authorities to adopt the MNECB. NRCan has released the software, which can be downloaded from NRCan's Web site.
- NRCan developed technical guidelines for CBIP. They define criteria for the eligibility of buildings such as small office buildings and hotels.
- NRCan hosted the International Daylighting Conference 1998 in Ottawa, at which about 150 lighting experts from 14 countries discussed such issues as light quality and desirability, automated controls and the need for national standards.
- NRCan developed the MNECB Comply software on behalf of the Canadian Consortium for Building Energy Compliance Software, a venue for federal and provincial governments and energy utilities to collaborate on commercial building energy simulation software. Architects and engineers can use Comply to demonstrate the compliance of their designs with the MNECB.

Progress Indicators

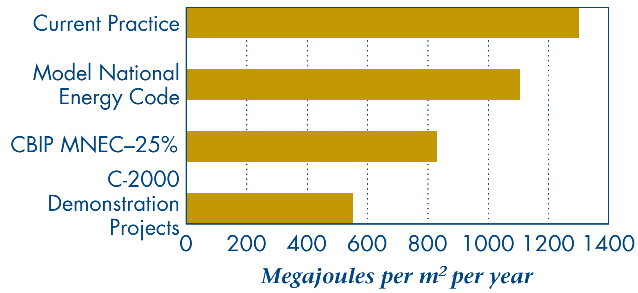
In March 1997, the MNECB received technical approval from the Canadian Commission on Building and Fire Codes. Among its key features, the MNECB has regionally sensitive cost-effective energy efficiency measures to account for the climate and the cost of energy and construction in each region.

Since provinces and territories have jurisdiction over construction regulations, the model code only comes into force if it is incorporated into provincial building codes. By March 1999, 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 could 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 at least 25 percent more efficient than stipulated in MNECB requirements.

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, 1997



Existing Buildings

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

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

Energy Innovators Initiative

The EII promotes energy efficiency upgrades and building retrofits in the commercial and institutional sector. The EII 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 emissions from its operations, registered with the VCR Inc.

The EII provides a wide range of products and services to help organizations plan, finance and implement comprehensive energy efficiency improvements, including:

- 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 a key strategy called “savings financing,” public and private sector organizations can use energy savings to pay for the projects they implement. Furthermore, under an energy performance contracting arrangement, they can mount an energy retrofit project without incurring up-front capital costs. They can obtain financing through the ESCo engaged in the energy performance contract. The ESCo guarantees the energy savings used to repay the project.

Energy Innovators Plus

Energy Innovators Plus began in April 1998 as an expanded version of the EII. The "Plus" includes a Pilot Retrofit Incentive Program, expanded partnerships and benchmarking.

The Pilot Retrofit Incentive Program offers financial incentives to Energy Innovators implementing comprehensive energy efficiency pilot retrofits. Initially, NRCan contributed up to 25 percent of project costs to a maximum of $350,000; in July 1999, the maximum was reduced to $250,000. Participants agree to replicate their pilot project in at least 25 percent of similar facilities that they own or occupy.

Energy Innovators Plus Partnerships expand the reach of the original EII through partnerships with key sectoral associations (which enhance NRCan's understanding and the involvement of target companies) such as the Retail Council 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 under development will allow organizations to measure their efficiency against similar organizations and identify where to obtain better performance.

Achievements 1997–1999

- By March 1999, Energy Innovators had invested a total of $455 million in energy efficiency projects since the program began. They estimate that these projects will reduce energy costs by $105 million a year and lower CO_2 emissions by 154 000 tonnes a year.
- Energy Innovators Plus Partnerships resulted in several important projects in 1998–1999 to increase awareness, recruit Energy Innovators and encourage the development of energy management plans and projects:
  - the Hotel Association of Canada carried out a national corporate promotion of energy efficiency;
  - the Retail Council of Canada advertised the success stories of small, medium-sized and large retail stores;
  - the Canadian School Boards Association doubled recruits from 35 school boards to 70 of them, representing 2 200 schools (seventy percent of enrolled school boards recognize the Energy Innovators Plus Partnership as a source of energy efficiency information);
  - the Canadian College of Health Service Executives increased the number of health care recruits from 44 to 73 and tripled the value of energy expenditures represented by health care facilities recruited into the program; and
  - an Energy Innovators Plus Partnership with the Association of Canadian Community Colleges resulted in new projects estimated to decrease energy costs by $10 million a year and reduce CO_2 emissions by 40 000 tonnes.

Federal Buildings Initiative

NRCan estimates that the federal government's annual energy bill is $800 million. Building use is by far the largest source of energy demand, accounting for more than 90 percent of federal energy use. Through the same kinds of services and products offered under the EII, the FBI facilitates comprehensive energy efficiency upgrades and building retrofits for federal government departments, agencies and Crown corporations.

Achievements, 1997–1999

- National Defence continued to make energy efficiency improvements in its facilities across the country. Approximately $90 million of FBI-type energy efficiency improvement projects have been completed in National Defence facilities, with estimated energy savings of over $10 million per year.
- Seven National Defence bases – CFB Suffield in Alberta; CFB Montréal in Québec; 14 Wing in Greenwood, Nova Scotia; CFB Petawawa in Ontario; CFB Borden in Ontario; 4 Wing in Cold Lake, Alberta; and 19 Wing in Comox, British Columbia – are implementing energy management measures under FBI contracts. The total investment commitment in these projects is more than $43 million, with associated savings of more than $5 million annually.
- CFB Cold Lake undertook an FBI energy management training initiative as part of the $4.6 million energy efficiency retrofit project at the base. A needs assessment determined the skills in and knowledge of energy efficiency of 53 personnel from 4 Wing Construction Engineering Squadron. Based on the needs assessment, the squadron developed a training profile and an outline of courses and training each participant needed to obtain various levels of certification.

Federal Industrial Boiler Program

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

The FIBP services are available to all federal departments and agencies, Crown corporations…, provincial ministries, municipal departments and the private sector. The federal government owns 52 central heating plants, housing more than 270 boilers that consume more than 8 000 terajoules of fuel annually. Services delivered under the FIBP help federal departments adopt heating technologies to 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 1997–1999

- NRCan provided technical support to the Department of National Defence (DND) for a retrofit of three boilers at CFB Cold Lake; it resulted in a 60 percent reduction in NO_x emissions, thereby meeting Environment Canada's emissions guidelines for boilers. An NRCan report also prompted DND to replace two boilers in a retrofit of the heating plant at CFB Bagotville. NRCan served as technical expert on that project, which will reduce annual operating and energy costs and bring plant emissions into compliance with national emissions guidelines.
- NRCan investigated the HVAC system at the Canadian High Commission in Islamabad, Pakistan, on behalf of the Department of Foreign Affairs and International Trade (DFAIT). NRCan recommended options to retrofit the system. DFAIT subsequently awarded NRCan a contract to undertake the retrofit engineering, prepare the specifications and supervise the work.
- NRCan received a contract from Agriculture and Agri-Food Canada (AAFC) for an equipment survey and energy audit at its Greenhouse and Processing Crops Research Centre in Harrow, Ontario. The report identified two options for reducing heating costs, one of which was selected for implementation.
- The Auditor General of Canada recognized NRCan for its efforts to help AAFC improve the environment and lower costs at the Vineland Research Station in Ontario. The project could save AAFC about $100,000 a year and reduce the facility's CO_2 emissions by 40 percent and NO_x emissions by 60 percent.
- NRCan won a contract to make recommendations to NRC on replacing a central heating plant boiler at its facility in Ottawa, Ontario, with a view to lowering costs and environmental emissions. To date, NRCan has completed a technical report on boiler selection and optimum boiler size.
- Correctional Service Canada (CSC) selected NRCan to develop a strategy to reduce NO_x emissions at five of its institutions. NRCan will compile data on all heating plants, assess their emissions and make capital and operating recommendations to reduce these emissions and improve energy efficiency. Under a contract from Rose Technology, the FIBP completed a similar assessment at five other CSC institutions during the fall of 1997.

Progress Indicators

As of March 1999, a total of 502 commercial, institutional and municipal participants had registered as Energy Innovators (see Figure 21). One hundred and fifty new Energy Innovators joined the program in 1997–1999. In 1996–1997, the Government of New Brunswick initiated a Provincial Buildings Initiative (PBI) to extend its energy-management program to colleges, hospitals and schools. New Brunswick adopted the FBI model for PBI retrofit projects. Manitoba has a program in place for government facilities, and British Columbia is designing a similar program to be launched early in 2000.

Through the program, Energy Innovators have implemented 196 energy saving projects. These organizations undertook 84 projects in the reporting period (see Figure 22). In 1998–1999, 14 of these qualified for financial incentives under the Energy Innovators Plus Pilot Retrofit Incentive Program.

Energy Innovators – Case Studies

- The South East Health District in Saskatchewan implemented initiatives to produce annual energy savings of $180,000. This represents energy-cost savings of nearly 20 percent and a project payback period of 6.7 years.
- The Toronto School Board is implementing a $180-million, four-phase energy savings program to displace 260 000 tonnes of CO_2. When all four phases of the project are complete, $20 million in energy costs will be saved annually.
- Canadian Pacific Hotels initiated a $10.1 million comprehensive energy retrofit project for several of its properties, saving $3.1 million in energy costs a year.
- In February 1999, the Southern Alberta Institute of Technology received a VCR Inc. Leadership Award in recognition of its energy efficiency initiatives, which reduced its greenhouse gas emissions by 38 percent.

Figure 21: Recruitment of Commercial Energy Innovators, 1992–1993 to 1998–1999

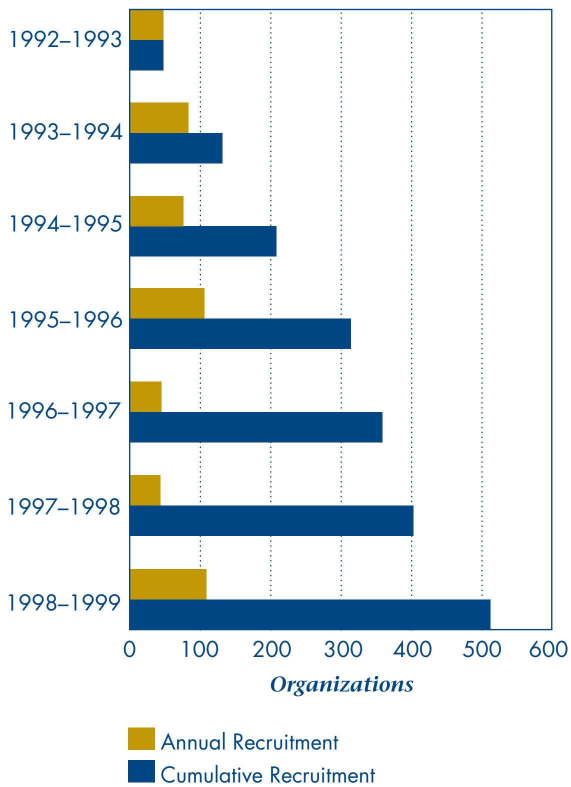
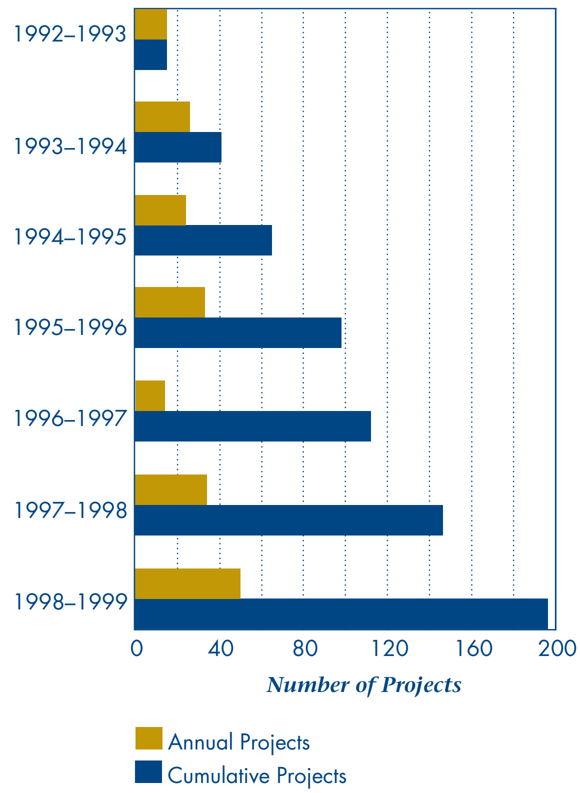


Figure 22: Projects Under the Energy Innovators and Innovators Plus Programs, 1992–1993 to 1998–1999



Since it was introduced in April 1998, the Energy Innovators Plus Pilot Retrofit Program has had a significant impact on the level of energy retrofit activity in Canada (see Table 3). The program contributed $2.9 million of federal funds to stimulate a twenty-fold investment ($60 million) by Energy Innovators. This is expected to save almost $5.4 million per year in energy costs and reduce carbon dioxide emissions by 39.4 kilotonnes per year.

ESCo activity has increased considerably in this decade (see Figure 23). The value of ESCo contracts rose from $41 million in 1991 to about $214 million in 1997–1998, an increase of more than 400 percent. The value of contracts signed in 1996 – 1997 dropped to $152 million from $278 million largely because the value of signed contracts in 1995 – 1996 was inflated by one sizable contract.

The federal government owns or leases about 23 million square metres of floor space, with 90 percent of it concentrated in five departments. Energy efficiency retrofit projects involving an estimated 5 500 buildings have been initiated under and registered with the FBI. In 1997–1999, government departments increased the investment commitments under the FBI by $55 million, bringing these commitments since the program began to $180 million (these commitments comprise private sector investment plus interest during repayment). These investments are expected to yield energy savings of $24 million. By March 1999, almost all of these energy efficiency retrofit projects had been completed. Table 4 summarizes the investment commitments and associated energy savings of FBI projects, including the activity undertaken by the five leading departments (see also Figure 24). Although data on actual savings are not yet available, ESCos guarantee the savings from the FBI retrofits they perform.

FIBP projects implemented in 1998–1999 saved 77 terajoules a year (see Figure 25). Since 1991–1992, the energy savings from this program have risen to 504 terajoules a year and the cumulative energy savings since the program began are about 1.5 petajoules.

Table 3: Energy Innovators Plus Pilot Retrofit Program, 1998 to 1999

Federal incentives	$2.9 million
Private sector investment	$59.9 million
Annual Energy Savings	$5.4 million
Reduction in CO_2 emissions	39.4 kilotonnes per year

Figure 23: Value of ESCo Contracts, 1991–1992 to 1997–1998

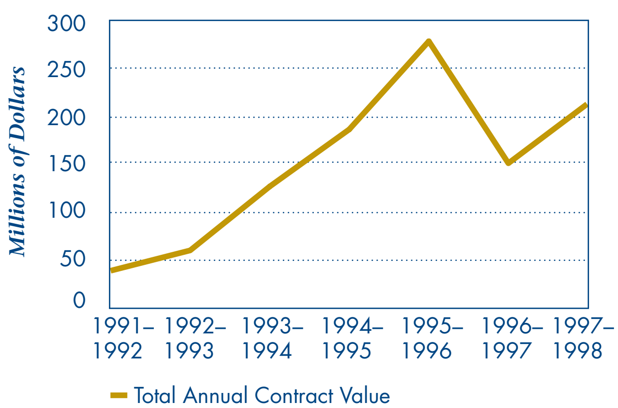


Table 4: Investment Commitments and Energy Savings of FBI Projects

Investment commitments (cumulative to date)	180
Estimated annual energy savings	24

FBI investment commitments by leading departments (millions of dollars)

	Investment Commitment *(cumulative to date)*	Estimated Annual Energy Savings	Payback Period *(Years)*
National Defence	89.7	10.2	8.8
Public Works and Government Services Canada	41.0	6.3	6.5
Industry Canada	13.1	2.3	5.7
Environment Canada	8.7	1.1	7.9
Natural Resources Canada	9.2	1.0	9.2
	161.7	20.9	7.7

Figure 24: FBI Investment Commitments and Estimated Annual Energy Savings for Five Leading Departments

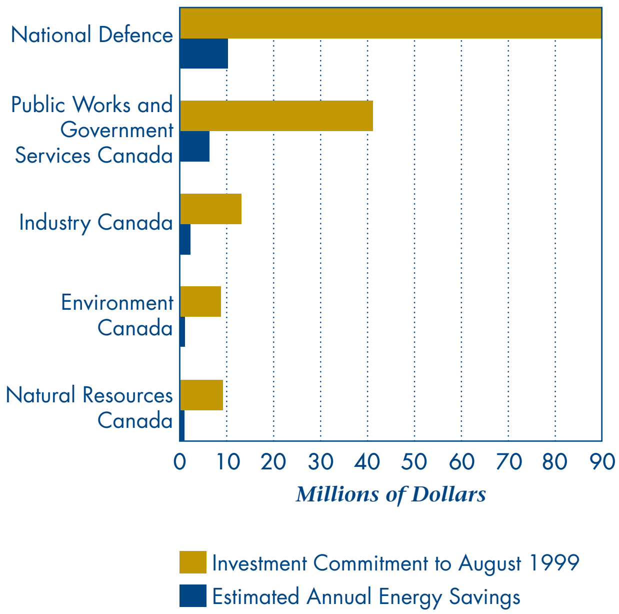
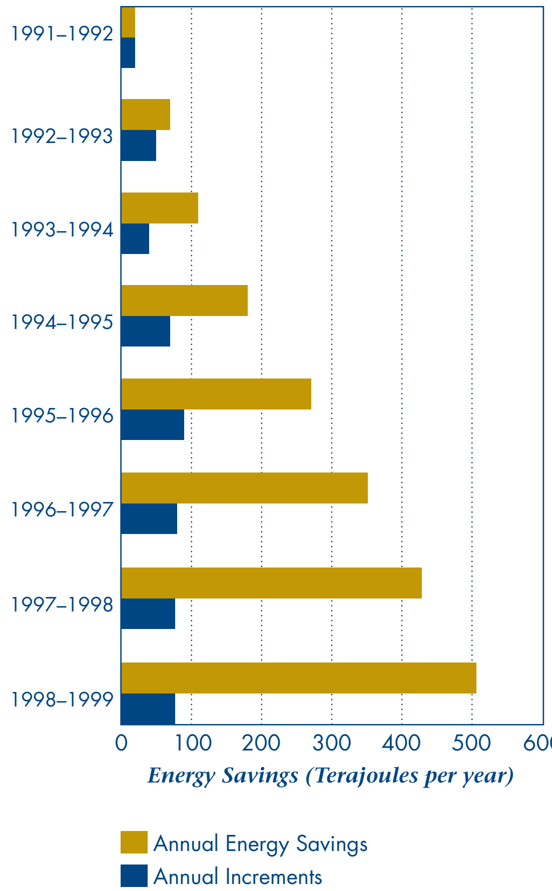


Figure 25: Energy Savings from FIBP, 1991–1992 to 1998–1999



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
- the Heat Management R&D for Buildings Program.

The Regulations

Under 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, including testing procedures to determine the energy performance of the equipment. NRCan fosters the development of these standards by funding and participating in nationally accredited standards – writing committees administered by CSA International.

Achievements in 1997–1999

- NRCan implemented higher minimum energy performance levels for 1- to 200-HP electric induction motors on November 27, 1997.
- In December 1998, it implemented regulations for large air conditioners, heat pumps and condensing units, packaged-terminal air conditioners and heat pumps, three-phase split-system central air conditioners and heat pumps, three-phase single-package central air conditioners and heat pumps, gas- and oil-fired boilers, oil-fired furnaces, and ice-makers.

Heat Management R&D for Buildings

Heat Management R&D for Buildings has two goals:

- to develop and disseminate knowledge and technology to reduce greenhouse gases and other emissions in Canada through energy efficiency improvements in buildings; and
- to promote job and wealth creation by helping the Canadian buildings energy efficiency industry capture growing domestic and international markets.

The program achieves these goals by developing advanced technologies and knowledge with and for industry, on a cost-shared basis. Work focuses on HVAC systems, equipment and controls in existing and new buildings.

An equipment component (HVAC for Buildings) focuses on the development and evaluation of advanced low energy heating, cooling and humidity control technologies. A controls component (Advanced Intelligent Controls and Residential Controls) focuses on the development of software tools to detect and diagnose faults in HVAC systems, to emulate buildings, and to test smart control technologies for space conditioning systems in residential buildings.

Achievements 1997–1999

- NRCan conducted a process integration analysis at the Cabano pulp and paper mill, which demonstrated the potential to reduce water consumption by 80 percent, reduce effluent volume by 50 percent, improve pulp-washing quality, reduce expenditures on the treatment of process water and the operating cost of the wastewater treatment system and reduce CO_2 emissions by 25 000 tonnes a year. Cascade, which owns the Cabano mill, is considering using this analysis technology at several of its other plants.
- As a result of NRCan's technical expertise, Venmar Ventilation, a heat- and humidity-recovery ventilator manufacturer, is producing two new lines of residential heat and humidity exchangers for the North American market, at a new plant built for that purpose. The project won the 1998 energy efficiency R&D award from *Association québecoise pour la maîtrise de l'énergie*.
- Chillers are refrigeration machines at the heart of large commercial building cooling systems, and they are the single largest electricity-consuming equipment in these buildings. NRCan, Public Works and Government Services Canada and a chiller manufacturer joined forces to test a chiller at the National Film Board facilities in Montréal. The project aims to develop methods for building operators to maintain optimum chiller performance.

Progress Indicators

The first *Energy Efficiency Regulations*, which took effect in February 1995, covered two commercial energy-using products, electric motors (discussed in Chapter 6, "Industrial Energy Use") 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 8-foot, high-output lamp and by 15 percent for the 4-foot, medium bi-pin lamp, two of the most popular fluorescent lamps (see Figure 26).

Recent sales data suggest that these two regulated high-efficiency lamps account for more than three-quarters of all lamp sales. The 4-foot, medium bi-pin fluorescent lamp accounts for almost two-thirds of the market (see Figure 27).

NRCan estimates that these regulations will result in net energy savings of 10 petajoules and a net reduction in CO_2 emissions of 5.3 megatonnes in 2000 (see Table 5). This reduction in emissions is equivalent to the annual CO_2 emissions of more than one million cars.

Table 5: Savings Arising from Federal Energy Efficiency Regulations Related to Lighting

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 CO_2 emissions in 2000	5.3 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.

Figure 26: Influence of Lighting Regulations on the Energy Use of Two Fluorescent Lamp Types, 1996

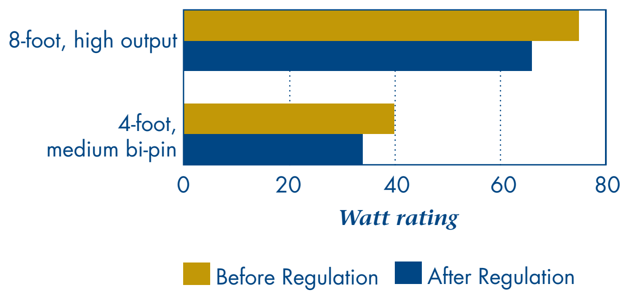
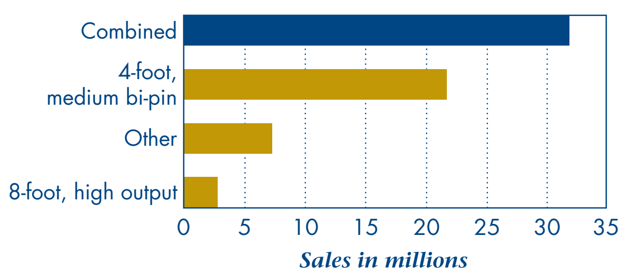


Figure 27: Annual Sales and Market Share of Common Fluorescent Lamps, 1996



Chapter 6
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 (3 068 petajoules) of secondary energy use and 34 percent (147 megatonnes) of CO_2 emissions.

Manufacturing is the largest energy user, accounting for about 87 percent of industrial energy use in 1997. Within the manufacturing sector, energy is consumed primarily in Petroleum Refining, Iron and Steel, Upstream Mining, Aluminum, Organic Chemicals, Pulp, Newsprint and Other Paper Industries. Together, these sectors account for 65 percent of total industrial energy demand in 1997 (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).

Figure 28: Energy Use by Industrial Subsector, 1997

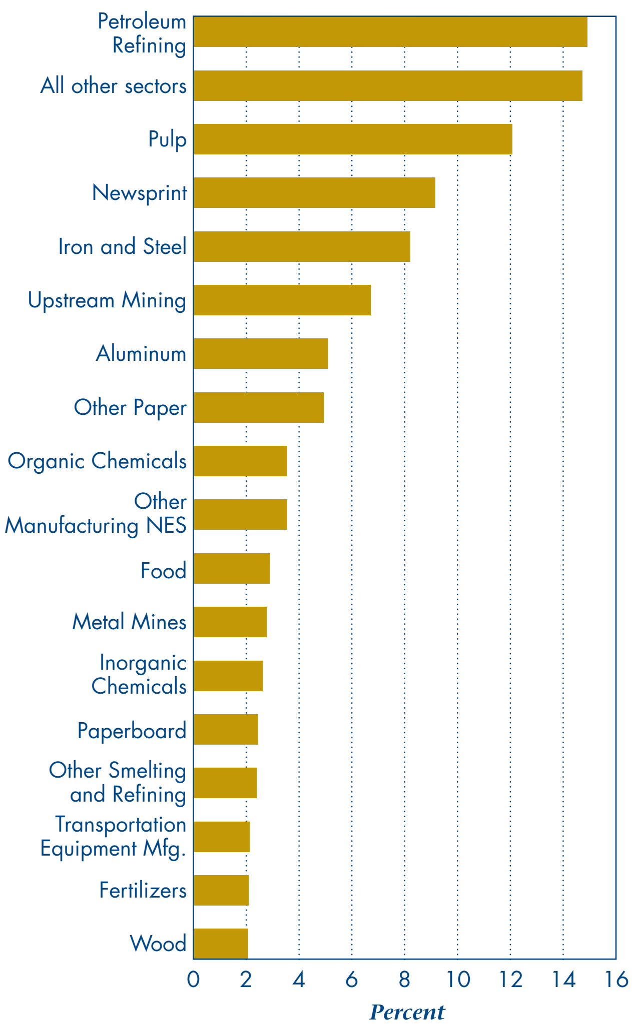
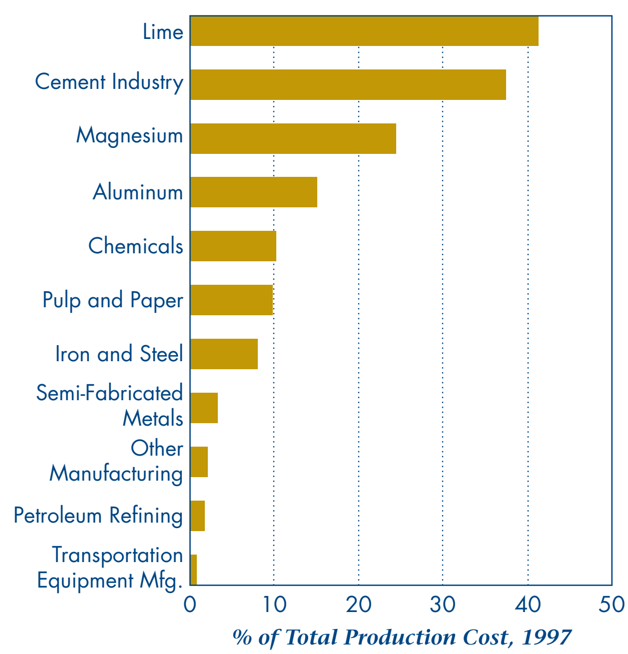


Figure 29: Cost of Energy Used by Industry as a Percentage of Total Production Cost, 1997



After decreasing slightly from 1990 to 1991, as a result of the recession, industrial energy use increased by about 12 percent (327 petajoules) by 1997 (from 2741 to 3068 petajoules) (see Figure 30). Two main factors increased industrial energy use – activity and structure:

- *activity* – increases in physical industrial output and GDP contributed to an increase in energy use of 12.6 percent (346 petajoules);
- *structure* – the change in the mix of activity towards more energy intensive industries (such as pulp and paper, iron and steel, aluminum and mining) resulted in a 5.7 percent increase in energy use (155 petajoules).

If only these two factors had been in effect, industrial energy use would have increased by 18.3 percent (501 petajoules). However, improvements in energy efficiency worked to decrease energy use by 4.7 percent (129 petajoules). As a result, energy use increased by only 13.6 percent. This change in energy use during 1990 to 1997 as well as the energy savings due to energy efficiency are shown in Figure 30.

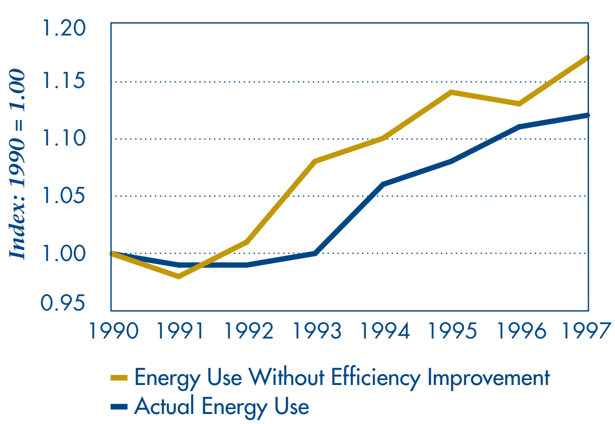
While energy use between 1990 and 1997 increased by 12 percent, industrial CO_2 emissions increased by only 6.7 percent. Emissions grew more slowly than energy use, in part because several industries, – especially pulp and paper, rubber, machinery, printing, publishing and allied industries and leather and allied products – were switching from heavy fuel oil, coal and coke oven gas to other less CO_2-intensive fuels and electricity.

Industrial Processes and Technologies

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

- Industrial Energy Efficiency Initiative (IEEI);
- Industry Energy Research and Development (IERD);
- Heat Management R&D for Industry Program;
- Advanced Combustion Technologies Program (ACTP);
- Energy Technologies for High-Temperature Processes;
- Processing and Environmental Catalysis Program (PECP); and
- Minerals and Metals Technologies Initiative.

Figure 30: Industrial Energy Use and Energy Savings due to Energy Efficiency, 1990 to 1997



NRCan also provides technical advice to Revenue Canada 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 Initiative

The IEEI provides a framework for a voluntary government–industry 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. CIPEC has an Executive Board, and its membership includes senior executives who serve on the Council of Champions of the VCR Inc. The board provides "top-down" leadership for associations, task forces and companies. CIPEC also:

- holds sector task force meetings to exchange energy efficiency information, encourage technology transfer and promote networking;
- establishes leadership teams to expand CIPEC participation;
- produces communication material to increase public and industry awareness of the activities and achievements of CIPEC member industries; and
- undertakes energy efficiency tracking, reporting and benchmarking.

Once CIPEC task forces establish targets and action plans, the Industrial Energy Innovators Initiative (IEII) helps to transform these commitments into company action. To become an Industrial Energy Innovator, a company's president and/or CEO submits a letter to the Chair of the CIPEC Executive Board (with a copy to the Minister of NRCan committing) the company to

- developing and implementing a target and action plan for energy efficiency improvement;
- appointing a corporate energy efficiency champion; and
- tracking their improvements in energy efficiency and reporting on them annually against their action plan.

Once the company makes this commitment, NRCan provides tools and services for participants to utilize innovative options for implementing and financing projects. Examples include employee awareness kits, best practices guides, technical information and workshops on energy management.

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

Achievements 1997–1999

- NRCan developed and delivered Energy Management Planning and Energy Monitoring and Tracking Workshops for Industry. During 1997–1999, 210 companies from the industrial sector took advantage of this service.
- NRCan developed and piloted an energy-benchmarking service in three industrial sectors: pulp and paper, cement and dairy.
- NRCan developed and published energy efficiency handbooks for the rubber, pulp and paper, brewery, aluminum, lime and dairy sectors.
- NRCan launched the *Heads Up CIPEC* newsletter which provides Canadian industry with industrial energy management information 24 times per year. From an initial press run of 55 copies, circulation now exceeds 1 700.

Industry Energy Research and Development

The IERD encourages and supports the development and application of leading-edge energy-efficient and environmentally responsible processes, products, systems and equipment in all Canadian industrial sectors, including metals and minerals, pulp and paper, buildings, chemicals, clothing and textiles, transportation, electrical production, and food. IERD shares technology development costs with industry and other stakeholders. Contributions are repayable to NRCan based on the commercial success of the development project. Program clients range from small and medium-sized R&D companies striving to carve out market niches to Canadian divisions of larger companies competing for product mandates.

Achievements 1997–1999

- NRCan financially supported Stackpole Canada in developing a technology to use powder metallurgy to fabricate high-stress automotive components. The project has yielded energy savings of 0.4 petajoules over conventional methods, 132 new jobs and a reduction in CO_2 emissions of 19 kilotonnes in 1997–1998.
- With NRCan's assistance, Pyrogenesis Inc. of Montréal, Quebec, successfully completed a field trial of a pilot-scale project to recycle aluminum dross, a by-product formed on the surface of molten aluminum. Until now, the aluminum industry has been able to only partially recycle this by-product. This new process allows up to 70 percent recovery. The technology also promises a reduction in CO_2 emissions and landfill waste – about 1 tonne of CO_2 and salt cakes (salt is used to treat the dross) for every tonne of dross.
- NRCan, with Gas Technology Canada, the Ontario Ministry of Environment and Energy, and British Gas, supported the development of a clean burner. The Canadian Gas Research Institute has filed an application to patent the burner, which would meet the requirements for low NO_x emissions in applications with high levels of air preheat or high furnace temperatures, such as in glass furnaces or steel reheat furnaces.
- With support from NRCan, Zimmark Inc., of Ontario, developed a technology to recover and recycle lube oil on site. Canada, China, Hong Kong, Malaysia, Mexico and the United States now use this technology. To date, Zimmark has recycled more than 12 million litres of oil, 9 million of which were recycled in Canada, yielding cumulative energy savings of more than 600 terajoules (equivalent to 100 000 barrels of oil) and a corresponding reduction in CO_2 emissions of more than 13 kilotonnes.
- In 1995–1996, NRCan provided financial assistance to Goodfellow Technologies Inc., of Toronto, Ontario, to develop and commercialize its expert furnace-system optimization process (EFSOP). EFSOP is a tool to continuously assess the volume and composition of furnace combustion products

and to design and operate safe exhaust ventilation systems. Results show energy savings of 640 terajoules and a reduction in CO_2 emissions of 18 kilotonnes over the past three years.

- NRCan provided financial assistance to Galvacor Inc. of Québec City to apply an innovative method to galvanize 1 000 tonnes of steel wire, using the Delot horizontal galvanizing line. Compared with conventional galvanizing processes, this new process is 50 percent more energy-efficient, has less environmental impact and is more productive.
- In 1996, NRCan supported material handling systems expert R.J. Cyr Co. Inc., of Windsor, Ontario, in its development of an improved natural gas scrap preheater for small and medium-sized foundries that lowers energy costs and atmospheric emissions. As a result, R.J. Cyr Co. sold a $500,000 system to an American electric fittings and automotive parts manufacturer.

Heat Management R&D for Industry Program

The Heat Management R&D for Industry Program works with and for industry, on a cost-shared basis, to develop technologies for the most energy-efficient use of industrial-process heat energy, compatible with sound economic and environmental practices. The delivery mechanism for the program is collaborative in-house R&D involving manufacturers, service providers and end users. Work is focused on energy recovery from industrial waste heat streams; the economical recovery of waste heat from industrial processes; energy efficiency improvements in industrial processes, such as drying; the optimization of energy use; and the minimization of environmental impacts from industrial processes.

Achievements 1997–1999

- NRCan, Barr-Rosin Inc. (a major Canadian dryer manufacturer) and Gas Technology Canada developed a pulsed fluid-bed dryer for recycled plastics that is more energy-efficient than conventional dryers. NRCan is working with Barr-Rosin to develop a pulsed fluid-bed dryer for high-temperature drying. If this research is successful, it could broaden the range of application for the technology.
- NRCan scientist Dr. Tadeusz Kudra co-authored a recently published book entitled Thermal Processing of Bio-Materials. Bio-materials are of strategic importance in the agrifood, medicine, environmental protection and chemical industries. The book discusses the use of thermal processing to treat these materials without affecting their quality or properties.
- NRCan signed an agreement with the United States Environmental Protection Agency (EPA) to promote the use by industry of catalytic flow-reversal reactor technology, which recovers energy and eliminates methane (a powerful greenhouse gas) from the ventilation air of underground coal mines. Currently, methane is released into the atmosphere, where it has a greenhouse gas potential 21 times that of CO_2.
- Dr. Marzouk Benali of NRCan, with Dr. Christophe Guy and Eve Ostiguy of École Polytechnique de Montréal, received a U.S. patent as co-inventors of a process to treat industrial liquid effluent containing organic substances, using free radicals. They already hold a U.S. patent on the equipment for this process, which was piloted at NRCan's facilities and successfully demonstrated the destruction of organic substances commonly found in industrial liquid effluents.
- NRCan and the National Technical University of Ukraine signed a letter of intent to conduct a research program on process integration for water treatment systems. The program seeks to use computer-aided system design to extend the possibilities for reuse of water and reduction in effluent and emissions in the industrial sector.

Advanced Combustion Technologies Program

The ACTP helps industry develop cleaner, more energy-efficient combustion processes, with lower emissions of acid rain precursors, greenhouse gases, particulates and identified priority substances (trace elements and organic compounds). The ACTP'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 and computer modelling capabilities.

The ACTP 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 1997–1999

- NRCan helped initiate and organize the Activities Implemented Jointly Conference, held in Vancouver and organized by the International

Energy Agency's Greenhouse Gas R&D Programme. The conference attracted more than 250 delegates from 40 countries and included sessions on CO_2 management and storage, energy efficiency technology and renewable and transportation technologies.

- NRCan developed and successfully tested a new method to reactivate spent fluidized bed combustors (FBC) sorbent for reuse. In the FBC process, limestone is injected as a sulphur-capture sorbent. NRCan's process converts the active portion of the sorbent to its original limestone state.
- NRCan developed and installed an expert system at the municipal waste incinerator in Burnaby, British Columbia. Trial results showed significant benefits in reduced lime consumption, better control of sulphur dioxides and reduced volume and treatment of landfill wastes. Projected savings, when applied over the entire plant, are estimated at $300,000 a year.
- NRCan, in partnership with Dell-Point Combustion, developed an advanced pellet stove, which uses a patented pyrolysis gasifier technology. The stove's efficiency rating exceeds 80 percent, whereas that of competing suppliers averages only 60 percent. It can burn lower-cost, higher-ash fuels, and its particulate emissions are lower than those of any other pellet stove on the market today.
- NRCan and Syncrude Canada began a joint research project – Coker 2000 – to increase Syncrude's bitumen upgrading capacity and improve plant performance through higher production rates and lower production costs.
- In 1999, the CANMET Energy Technology Centre's Advanced Combustion Technology – Vertical Combustor Group, the Characterization Laboratory, and the Energy for High Temperature Processes technology groups all received ISO 9002 certification for their quality management systems.
- NRCan began to develop a cleaner-burning artificial fire log, with Westcan Manufacturing Limited of Calgary, Alberta, which manufacturers a range of wood-waste-based products, including fire logs. Research has shown that these logs can be manufactured to produce significantly lower emissions than traditional firewood.

Energy Technologies for High-Temperature Processes

The Energy Technologies for High-Temperature Processes program is designed primarily to enhance the energy efficiency, productivity, competitiveness and waste management 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 1997–1999

- With Praxair Ltd., NRCan completed a study on a technology to use hot oxygen in a blast furnace combustion system to improve energy efficiency. This study used NRCan's coal-injection pilot plant and Praxair's thermal oxygen nozzle and led Praxair to patent its thermal nozzle.
- NRCan completed joint research on industrial coking simulation with the Canadian Carbonization Research Association, an organization of all major Canadian coal and steel producers. The researchers found that certain coal properties and carbonization operating parameters relate to the quality of coke produced for blast furnace use. As a result of this research, Dofasco Inc. has applied new energy-saving methods in its operations.
- NRCan undertook a study, supported by the Canadian Carbonization Research Association, on a novel co-injection technology (using natural gas and coal) to improve the efficiency of the blast furnace process. Refinement of this technology could significantly reduce CO_2 production in Canadian blast furnaces.
- NRCan conducted a study for Falconbridge Ltd. to assess a variety of coals for their suitability for a more energy efficient process of nickel and copper production that has the advantage of being an entirely coal-based process, requiring no external gasifier or coal pretreatment. NRCan recommended two coals for pilot trials, which proved very successful.
- NRCan helped Hornos de Mexico implement coal-injection technology in its blast furnaces using NRCan's blast furnace computer models. NRCan also evaluated the suitability of two Mexican coals for blast furnace injection.
- NRCan and Technology Scientific of Calgary, Alberta, conducted a study on the use of a Gulf Canada anthracite in the Corex process, an alternative, more energy efficient iron-making process. Data from this study reveal the competitive advantages of Gulf Canada's product

Processing and Environmental Catalysis Program

The PECP seeks to solve industrial process problems and research areas with high potential to produce environmental and economic benefits. A strong analytical capability supports the PECP's facilities, which include pilot-scale plants for hydrotreating and scale-up of other chemical conversion processes. The PECP works with consortiums to develop catalytic systems for removing NO_x from engine emissions and converting natural gas to liquid fuels, fuel components, petrochemicals and synthesis gas. Another PECP objective is to develop a process to derive high-quality transportation fuels from low-value, biomass-derived oils. Clients include refineries, petroleum producers, natural gas producers and utilities, petrochemical research organizations, companies developing specialized technologies, used-oil re-refineries, pulp and paper producers and engine and catalytic-converter manufacturers.

Achievements 1997–1999

- The New Energy and Industrial Technology Development Organization of Japan contracted with NRCan to assess the feasibility of pyroelectric conversion technology. This was based on earlier work by NRCan on the conversion of low-grade waste heat to high-voltage electricity using pyroelectric copolymer films, a technology that could increase the energy efficiency of industrial processes.
- NRCan worked with Par Excellence Development (PED), of Sudbury, Ontario, to develop the ROBYS process for purifying and stabilizing thermally cracked used oil. PED subsequently signed an agreement with Enviro Mining Inc. of Edmonton, Alberta, for a sub-licence to build a ROBYS plant in Germany. Enviro-Mining awarded a contract to NRCan to evaluate the integration of the ROBYS process into a conventional thermal-cracking process, developed by Great Northern Processing Inc., of Indiana, USA.
- NRCan conducted an R&D project that provided recommendations on requirements for synthesis gas production, methanol synthesis, and methanol–water purification for an oxygenated transportation-fuel demonstration plant. Integrated Energy Development Corporation, of Kincardine, Ontario, then designed the pilot plant to demonstrate an innovative process for deriving oxygenated transportation fuel (methanol) from electrolytic hydrogen and oxygen, natural gas and CO_2.

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 using 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; provincial governments; energy utilities; and industrial, trade and standards associations.

Achievements 1997–1999

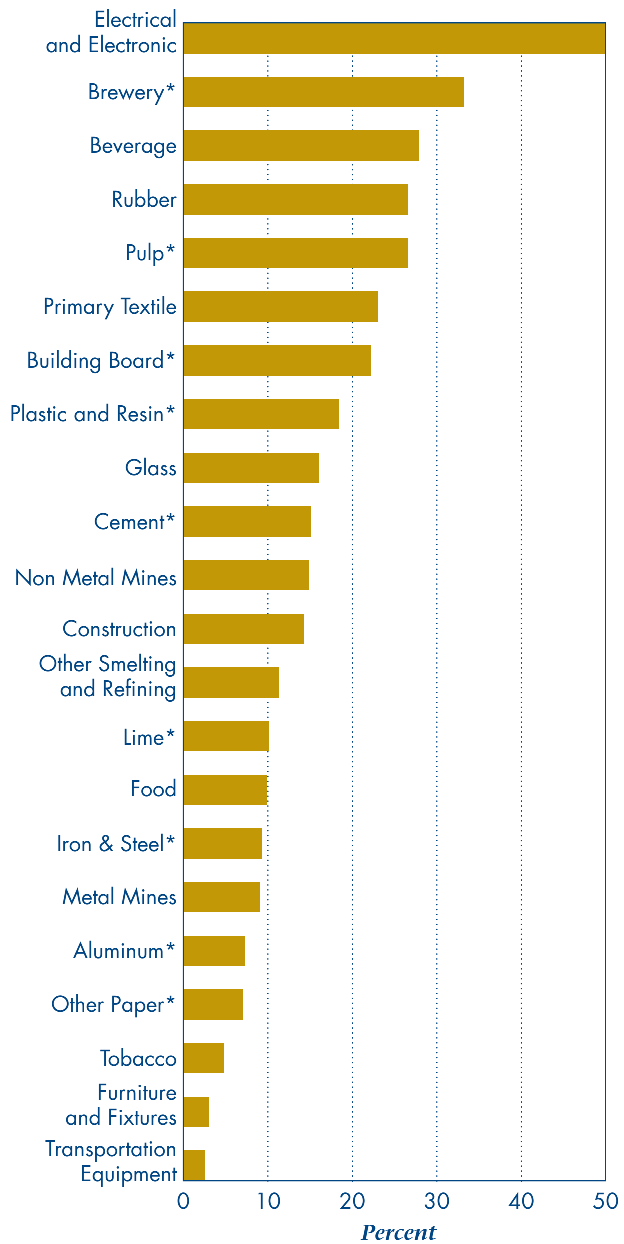
- NRCan further developed the CANDRILL, a water-powered rock drill for Canadian conditions, by developing and adapting South African drill technology to reduce weight, recirculate 70 percent of the water used, and improve reliability, handling and ease of operation. When compared to compressed-air equivalents, tests to date indicate the CANDRILL could offer double the penetration rates, reduced vibration and dust, eliminate oil emissions, and improve energy efficiency. By converting to hydraulic power, mining operations could reduce their total energy consumption by more than 30 percent. Final trials of the CANDRILL are scheduled for the spring of 2000 and commercialization for January 2001.
- NRCan promoted to the mining industry energy efficiency through ventilation automation and optimization. Ventilation is typically responsible for 40 percent of an underground mine's total energy use. By reducing overall ventilation requirements and providing the most energy-efficient ventilation specific to the cyclical demand of operations, this technology can achieve significant energy savings. In 1997–1999, two mines adopted NRCan's recommendations for ventilation optimization, and a third mine initiated a major ventilation-automation trial. This third mine was able to optimize the use of its existing air volumes to allow ventilation of a new orebody, thereby significantly extending the life of the mine.
- In 1997–1998, the final year of the Mobile Foundry Laboratory (MFL) program, 14 foundries were audited in Ontario and Quebec. A formal evaluation of this three-year program indicated that identification of energy-related problems was a major benefit for about 70 percent of the 45 foundries visited across Canada. About half of these foundries have cut energy costs by implementing MFL recommendations.

- NRCan has developed the technologies to substitute a proportion of the cement in concrete with materials such as fly ash, a byproduct of coal-burning in power plants, which normally goes to landfill. Manufacturing cement for concrete is energy-intensive and releases one tonne of CO_2 per tonne of cement. In 1997–1998, CANMET started a major initiative to establish an International Centre for Sustainable Development of Cement and Concrete. The Minister announced the creation of this centre, to be known as ICON, in 1998–1999. With a goal of 10 percent material substitution globally, this initiative could lead to a reduction of CO_2 emissions of 100 million tonnes annually.
- During 1998–1999, NRCan launched the Canadian Lightweight Materials Research Initiative (CLiMRI). This initiative brings together industries in primary metal production, parts manufacturing and vehicle assembly, along with federal research laboratories and Canadian universities. Together, companies and research organizations are tackling the technology challenge of reducing the weight of vehicle components. This goal will be achieved through increased use of high-strength steels, aluminum and magnesium alloys. Vehicle efficiency is directly related to vehicle weight – every 10 percent reduction in weight results in a 5–7 percent improvement in fuel efficiency.

Progress Indicators

During 1990 to 1997, 22 of the 39 industrial sectors improved their energy efficiency. The most notable efficiency gains were made by the electrical and electronic, breweries, beverage, rubber and pulp sectors, which realized efficiency gains of 27 to 50 percent (see Figure 31).

Figure 31: Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 1997



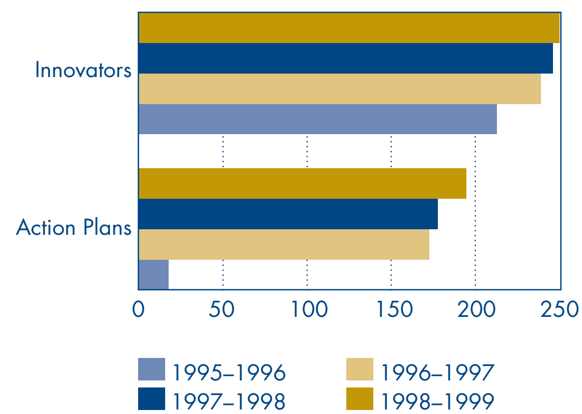
*Physical Units of production was used as the measure of activity for those subsectors. For the remaining subsectors, gross domestic product (GDP) was used.

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 enables 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.

Most task forces committed to energy efficiency improvements of 1 percent a year from 1995 to 2000. Exceptions are breweries (3 percent), textiles (2 percent), cement (0.7 percent) and aluminum (0.3 percent). During 1990–1997, the energy intensity of the 21 CIPEC task forces improved on average by 0.9 percent per year.

By March 1999, the IEEI had recruited 249 industrial companies as Industrial Energy Innovators, representing about 74 percent of industrial energy use (see Figure 32). Over the past year, the IEEI has focused on encouraging participating companies to prepare and implement action plans to realize energy savings. By March 1999, more than 194 participants had prepared action plans describing their energy efficiency projects.

Figure 32: Industrial Energy Innovators and Action Plans, 1995–1996 to 1998–1999



Equipment

The Regulations

NRCan uses regulations to encourage the use of energy-efficient equipment in the industrial sector.

NRCan regulates energy efficiency for some industrial equipment under the *Energy Efficiency Act*. However, the Energy Efficiency Regulations apply to fewer items in the industrial sector than in the residential or commercial sectors.

Achievements 1997–1999

- NRCan introduced higher minimum energy performance levels for 1- to 200-HP electric-induction motors November 27, 1997.

Progress Indicators

The amendments to the *Energy Efficiency Regulations* raised the efficiency standard for industrial motors by about 5 percent (see figure 33). 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 34). The estimated reduction in CO_2 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.

Figure 33: Energy Efficiency Standards Before and After Motor Regulations

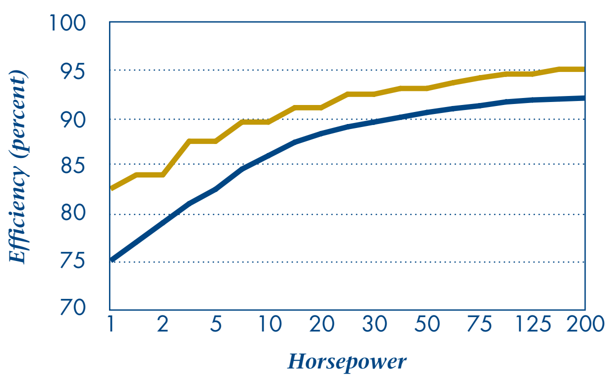
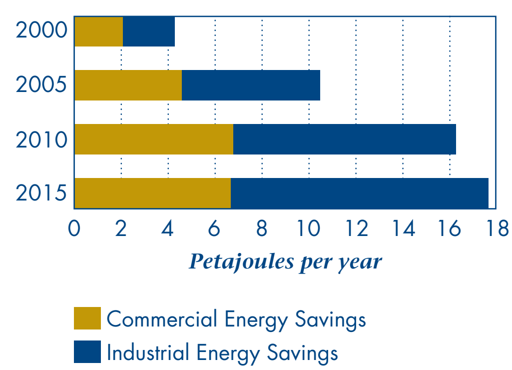


Figure 34: Energy Savings from Motor Regulations, 2000 to 2020



Chapter 7
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 – 82 percent of passenger energy use and 77 percent of freight energy use (see Figure 35). All NRCan transportation energy-use programs focus on the energy used in road transportation.

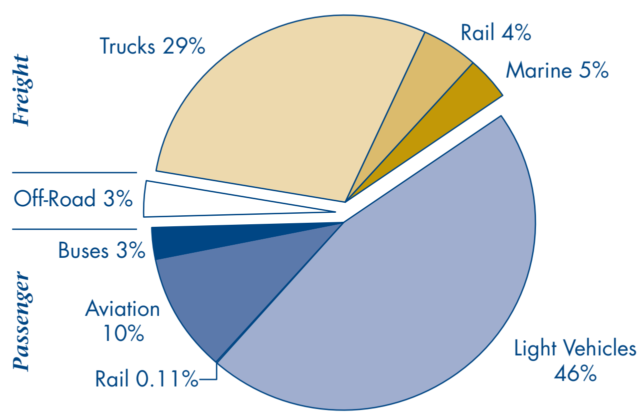
Transportation energy use increased by about 13 percent (243 petajoules) from 1990 to 1997 (see Figure 36). Passenger transportation energy use increased by almost 7 percent (79 petajoules) while freight transportation energy use increased by almost 24 percent (151 petajoules). Two main factors were responsible for this increase – activity and structure:

- *activity* – due to increase 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 over 16 percent (305 petajoules). The freight and passenger segments have contributed equally to this increase; and
- *structure* – shifts between modes of transport was significant in the freight segment, resulting in an increase of almost 6 percent in transportation energy use (108 petajoules).

If only these two factors had been in effect, transportation energy use would have increased by 22 percent (413 petajoules). However, improvements in energy efficiency worked to decrease energy use by 8 percent (150 petajoules). As a result, energy use increased by 14 percent. This change in energy use during 1990 to 1997, as well as the energy savings due to energy efficiency, is shown in Figure 36.

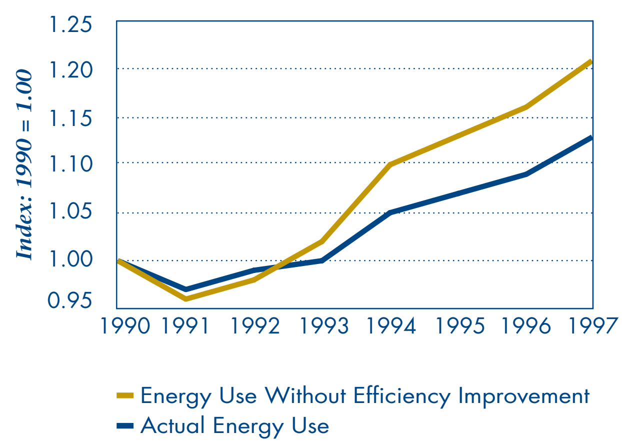
The transportation sector accounts for almost 27 percent (2 093 petajoules) of secondary energy use and almost 34 percent (145 megatonnes) of CO_2 emissions (see note in Appendix 2 regarding sources of data used in this report). From 1990 to 1997, transportation energy use increased by 13.1 percent, and CO_2 emissions increased by 13.3 percent. The change in CO_2 intensity of transportation energy use was negligible.

Figure 35: Transportation Energy Use by Mode, 1997



Total: 2 093 Petajoules

Figure 36: Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1997



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 Motor Vehicle Fuel Consumption Initiative;
- EnerGuide for Vehicles; and
- Auto$mart.

Motor Vehicle Fuel Consumption Initiative

The Motor Vehicle Fuel Consumption Initiative is a voluntary initiative with vehicle manufacturers to improve new- and in-use vehicle fuel efficiency. The initiative encourages motor-vehicle 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 new opportunities to improve both new vehicle and on-road vehicle fuel efficiency.

The Motor Vehicle Fuel Efficiency Initiative is based on the earlier Motor Vehicle Fuel Consumption Program, initiated in the late 1970s, which encourages motor vehicle manufacturers to meet voluntary annual CAFC targets for new automobiles sold in Canada. The *Motor Vehicle Fuel Consumption Standards Act* was passed by Parliament in 1981, but not proclaimed as the Canadian vehicle manufacturers offered to meet the requirements on a voluntary basis. Compliance with the CAFC targets has been very good.

Under this initiative, Transport Canada (TC) administers and monitors compliance with the CAFC standards. TC also collects annual data on the fuel consumption and sales of new vehicles from vehicle manufacturers. These data are used by TC and NRCan to

- monitor manufacturer compliance with the CAFC targets;
- support the publication of the annual *Fuel Consumption Guide*, which lists fuel-consumption ratings for new vehicles; and
- support the EnerGuide for Vehicles program (see below) and the annual Most Fuel-efficient Vehicle Awards.
- assess trends in new vehicle fuel efficiency and specific technologies.

This initiative is managed by NRCan in cooperation with the motor vehicle industry and TC. NRCan and TC are responsible for the administration and delivery of the program.

Achievements 1997–1999

- NRCan and the U.S. Department of Energy initiated a study in 1998–1999 to assess the efficiency potential of direct-injection gasoline engines.
- NRCan and vehicle manufacturers initiated a study on the impacts of traffic congestion on vehicle fuel consumption.

EnerGuide for Vehicles

The EnerGuide for Vehicles program initiative, launched April 1998, informs consumers about the fuel efficiency of new light-duty vehicles to help them buy the most fuel-efficient vehicle that meets their needs. Under a voluntary agreement, vehicle manufacturers affix an EnerGuide fuel consumption label to passenger cars, vans and light-duty trucks. The standardized label on the side window of each new vehicle 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 and on the Internet, provides the same information for all motor vehicles. The annual EnerGuide Awards for the Most Fuel-efficient Vehicle 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 1-800 publication line.

Achievements 1997–1999

- NRCan launched this initiative in 1998, introducing a new standard EnerGuide Label for Vehicles to be attached to all new cars, vans and light trucks for sale in Canada. Twenty vehicle manufacturers signed a Letter of Agreement to voluntarily affix the new label on all their vehicles, beginning in January 1998. The Canadian Auto Dealers Association participated in the launch, and pledged strong support by car dealers. Over 36 000 new car dealerships became distribution centres in 1998.

- The department redesigned the *Fuel Consumption Guide* to include the fuel cost of operating a vehicle, as well as the estimated annual fuel consumption and fuel cost of operating a vehicle. It distributed 450 000 copies of the 1998 and 470 000 copies of the 1999 *Fuel Consumption Guide*.
- NRCan launched an EnerGuide Awards program to recognize the manufacturers of the most fuel-efficient vehicles in nine broad categories.

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. The initiative 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 1997–1999

- In April 1998, NRCan helped the private sector launch a private vehicle maintenance program. Motorists purchase or receive free, as a promotion, an Autolink membership that provides them with a personalized vehicle maintenance guide, a log book and savings on products and services to support and encourage regular vehicle maintenance. Since the launch, over 5 000 motorists and 650 service centers have joined Autolink.
- Since 1997, Auto$mart launched four web-based partnerships to share fuel consumption data with private Web sites and software products.
- In 1998–99, the Auto$mart and EnerGuide for Vehicles Web site received more than 78 000 hits a month, with 3 000 user sessions.
- NRCan received an average of 365 calls a month on the information 1-800 line in 1997–1998 and, with the launch of the EnerGuide for Vehicles program, this figure increased by 51 percent in 1998–1999.
- Auto$mart and EnerGuide for Vehicles produce six major publications. The programs distributed 760 000 of these publications in 1997–1998 and more than 650 000 in 1998–1999.
- In 1998–1999, over 34 000 new drivers attended the Auto$mart Novice Driver Training program, for a total of about 160 000 since this program began in April 1997.

Progress Indicators

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, mostly 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 6).

From 1990 to 1997, the energy intensity of the light-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 2.9 percent from 1990 to 1997, and the average on-road fuel consumption of the total stock of light-duty vehicles in Canada increased by 4.4 percent. These improvements occurred in the face of a trend toward heavier, more powerful vehicles in the 1990s. For example, the share of new light trucks in the new car and light-truck market increased from 30 percent in 1990 to 44 percent in 1997 (see figure 37).

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 (divide by) weight (and, thus, size), and to standardize for power. These alternative indicators of fuel consumption have shown more rapid improvement than L/100 km. Whereas the fuel consumption (L/100 km) of new cars decreased by 1.8 percent from 1990 to 1998, the fuel consumption measured in terms of L/100 km/kg over the same period decreased by 7.4 percent; and measured in terms of L/100 km/HP it decreased by 19.9 percent (see Figure 38). The negative impact of greater vehicle weight and power was more than offset by improved fuel efficiency.

Table 6: Vehicle Vintage and Characteristics*

Year/Vintage	1970s and Earlier Vintage	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 37: New Passenger Car and Light Truck Market Shares, 1990 to 1997

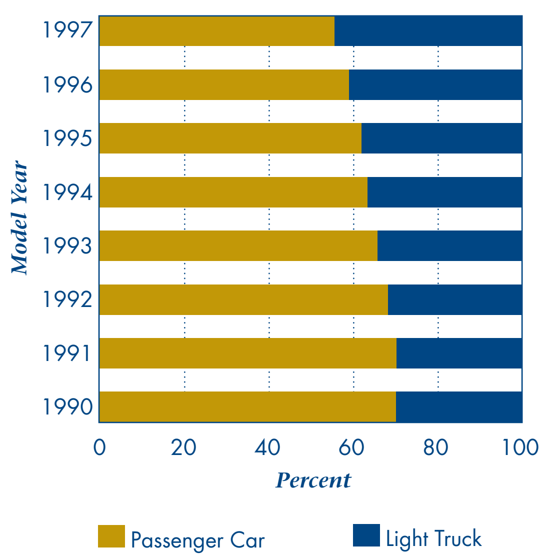
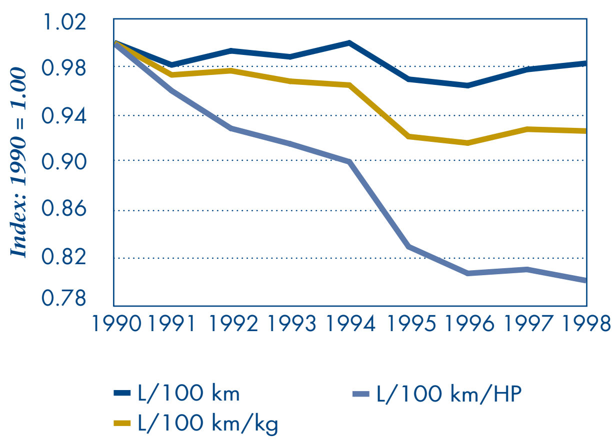


Figure 38: New Car Fuel Economy, Normalized for Weight and Power, 1990 to 1998



Commercial Fleets

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

- FleetWise, for the federal government; 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 greenhouse gas 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's Motor Vehicle Policy.

The initiative provides fleet managers with an assessment of fleets at low to no cost, campaigns to encourage vehicle operators to select alternative fuels, and technical advice on the use of alternative fuels and the acquisition of alternative fuel vehicles. Four departments participate in planning and reporting on the initiative: Treasury Board Secretariat, NRCan, Environment Canada and PWGSC. NRCan is responsible for implementing the initiative.

Achievements 1997–1999

- Under Fleetwise, NRCan commissioned eight assessments of fleet operations to advise fleet managers on general fleet improvements and provide a baseline from which to measure future improvements.
- NRCan also commissioned four in-depth studies of regional fleets, with vehicle-by vehicle assessments.
- The department initiated two demonstration projects to identify the operational challenges of using alternative fuels.
- FleetWise undertook a joint campaign with the Canadian Renewable Fuels Association to promote the use of ethanol-blended gasoline, an alternative fuel in terms of Treasury Board policy.
- FleetWise provided software analysis tool on the NRCan web site, to offer vehicle purchasers assessments of the suitability of alternative fuels.

FleetSmart

FleetSmart aims to improve the fuel efficiency of and the use of alternative fuels 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 1997–1999

- NRCan distributed the FleetSmart Tool Kit to 946 clients, representing more than 120 000 commercial vehicles.
- NRCan developed an eight-hour training curriculum called SmartDriver for Heavy Vehicles and distributed it to 341 fleet trainers, representing 51 000 drivers.
- FleetSmart developed and launched a SmartDriver Master Trainer network to link trainers across the country.
- Fleetsmart conducted a survey of school board vehicle operations through the Canadian School Board Association; 279 school boards participated.
- It conducted five FleetSmart workshops, in partnership with provincial trucking associations.

Progress Indicators

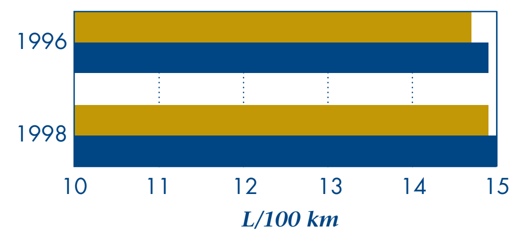
Since the FleetWise initiative was launched in October 1995, the federal vehicle fleet (that is, on-road civilian vehicles) decreased by 8.3 percent, and the average annual distance driven per vehicle decreased by 7.9 percent. As a result. total fuel consumption of the fleet decreased by 14.7 percent.

On the other hand, the energy intensity of the federal fleet (as measured by vehicle fuel consumption per kilometer) increased by 1.4 percent from 1996 to 1998, contrary to the national trend (see Figure 39). Several factors, including the relative age of the fleet, might be responsible for this.

Table 7: Federal Fleet Characteristics, 1995–1996 and 1997–1998

Federal Fleet	1995–1996	1997–1998	Increase (Decrease)	
Number of vehicles	24 854	22 796	(2 058)	(8.3%)
Average km/vehicle per year	24 684	22 732	(1 952)	(7.9%)
Total fuel consumption (gasoline equivalent, 000s of litres)	88 725	75 684	(13 041)	(14.7%)
Average vehicle age (years)	3.8	4.7	0.9	23.7%

Figure 39: Energy Intensity of the Federal Vehicle Fleet, 1996 and 1998



Transportation Research and Development

NRCan promotes energy efficiency and the use of alternative transportation fuels (ATFs) and ATF vehicles through the Transportation Energy Technologies (TRANSET) Program.

Transportation Energy Technologies

TRANSET works in partnership with industry to develop and deploy leading-edge transportation technologies to 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 ATFs 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 systems efficiency (advanced materials and processes, driving-cycle analysis, auxiliaries and regenerative braking systems); and
- fuelling infrastructure (fueling station hardware, hydrogen systems and battery-charging systems).

TRANSET works in cooperation 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 1997–1999

- NRCan has financially supported fuel cell development at Ballard Power Systems Inc., of Burnaby, British Columbia, since 1983. After years of work, efforts are finally paying off. In 1997, Ballard and Daimler-Benz AG signed an agreement on the commercialization of an environmentally friendly car and formed a new engine development company, DBB Fuel Cell Engine GBH. Also in 1997, Daimler-Benz unveiled its fuel-cell-powered prototype passenger car, the first in the world. Ballard supplied these fuel cells, and NRCan supported their development.
- NRCan supported safety tests on cylinders for natural gas and hydrogen, manufactured by Dynetek Industries of Calgary, Alberta. Dynetek makes the world's lightest composite cylinders for compressed natural gas and compressed hydrogen gas storage on board vehicles. Germany's regulatory body advised Dynetek that its composite cylinders passed all safety and standards tests, and a German organization placed an order for Dynetek's hydrogen tanks.
- NRCan participated in a project to build an advanced water electrolyzer module in Shawinigan, Quebec. Les Industries d'Electrolyseurs du Québec designed and constructed the 100-kW unit. The new design will reduce capital costs by at least a factor of two, relative to the best current design.
- NRCan supported Tektrend International of Montréal, Quebec, in its development of a model to evaluate the safety hazards of large hydrogen spills. Tektrend subsequently won a contract from Air Liquide Canada to assess the safety hazards of a potentially large liquid hydrogen spill at Air Liquide's liquid hydrogen plant in Hamilton, Ontario.
- NRCan supported Toyota Canada's 1998 launch of its hybrid electric Prius car, which will go on sale in Canada in 2000. The Prius uses a smaller gasoline engine and, unlike an electric vehicle, requires no external power source for battery charging. Instead, it uses an optimized gasoline engine and regenerative braking as the source of energy for its battery pack. When configured for Japanese driving conditions, the Prius produces 90 percent fewer hydrocarbon emissions and 50 percent fewer greenhouse gas emissions than a similar gasoline vehicle.
- NRCan-funded NGV Corp.'s development of the world's first cargo carrying, two-wheeled, natural-gas-powered motorcycle. The NGV CargoCycle is a low-cost cross between a motorcycle and a motorscooter, with engine and fuel tanks integrated in a composite chassis. Target markets for this vehicle include urban centres in Southeast Asia and the developing world.
- NRCan, along with the U.S. Department of Energy, sponsored the 14th annual Windsor Workshop, in Toronto. More than 150 delegates from Belgium, Canada, Finland, Germany, Hong Kong, Hungary, the United Kingdom and the United States discussed emerging transportation technologies.
- NRCan helped organize and judge the 1998 Future Car Challenge, held in Auburn Hills, Michigan. Thirteen university teams from Canada and the United States took up the challenge to convert vehicles to attain a fuel-efficiency level of 80 miles per gallon (mpg). Vehicles designed by Wisconsin University and Lawrence Tech from the United States both achieved 75 mpg, compared with 37 mpg of an equivalent gasoline control vehicle. Concordia University was the sole Canadian entry and, with its hybrid electric vehicle, it placed sixth overall.
- NRCan helped to organize and implement the 1998 Ethanol Vehicle Challenge, which involved more than 200 students and faculty advisors from 14 colleges and universities in Canada and the United States. The challenge was to convert a gasoline-powered Chevrolet Malibu to run on E85 (85 percent denatured ethanol and 15 percent gasoline). Wayne State University of Detroit, Michigan, won the challenge, and the University of Waterloo placed second.
- NRCan supported BC Research Inc. (BCRI) in developing its adaptive hybrid vehicle control system. BCRI won the 1998 Energy Research and Development Award from the Canadian Institute for Energy, for this energy-efficient technology, and it has formed a spin-off company, Azure Dynamics, to market components and subsystems for hybrid vehicles.
- NRCan was a co-sponsor of the 9th Canadian Hydrogen Conference, held in Vancouver, British Columbia. The conference featured the official opening of Canada's first fuel-cell bus hydrogen refuelling station and the announcement that Stuart Energy Systems had won funding from the Technology Early Action Measures component of the Climate Change Action Fund and Technology Partnerships Canada. This funding was to enable Stuart to continue to advance and commercialize its hydrogen fleet refueller.

Alternative Transportation Fuels

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

Alternative and Future Transportation Fuels Initiative

This initiative encourages the development, production and use of alternative and future vehicle and fuels 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 sponsors workshops periodically with the industry and other governments to review market, technical and policy issues.

Achievements 1997–1999

- A project was cost-shared with the US Department of Energy to develop a full fuel-cycle greenhouse gas emissions model for conventional and future transportation vehicles and fuels. The model was used to study the impacts of different transportation policies on international greenhouse gas emissions as well as domestic options for reducing Greenhouse gas emissions.
- The Interdepartmental Steering Committee on Ethanol, which is chaired by NRCan, prepared a report to Ministers in July 1998, on the achievements of the (then-completed) 5-year, $12 million Federal Initiative to Encourage the Production and Use of Ethanol.
- NRCan co-sponsored and co-chaired a national workshop in the Spring of 1998 on the potential for greenhouse gas reductions in transport.
- NRCan provided assistance to the Electric Vehicle Association of Canada to construct a public Web site containing comprehensive information on electric vehicles.

Natural Gas for Vehicles Incentives Program

The Natural Gas for Vehicles Incentives Program applies to regions of Canada serviced 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 1997–1999

- The Minister of Natural Resources struck a Task Force on the MDIP fund, which was led by NRCan. The Task Force reported to the Minister in April 1998, with recommendations on allocating the remaining MDIP funds. (There were no other achievements during the period, given the date at which the program was renewed – February 1999)

Progress Indicators

The annual level of conversions of motor vehicles from gasoline to propane declined from 24 000 in 1991 to about 2 500 in 1997 (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, limited availability and high incremental cost of factory-built 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 5 000 in 1991 to 1 750 in 1998. This is attributable to a decline in the price differential between gasoline and natural gas and technical difficulties in converting vehicles 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 the national demand.

The number of fuelling stations selling ethanol blended gasoline increased from 266 in 1990 to approximately 970 by March 1999 (see Figure 41). The increase in stations resulted from the introduction of ethanol blends into the Ontario and Quebec markets. Ethanol-blended gasoline can be found in all provinces 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 1997. Natural gas use increased by about half between 1990 and 1997, while use of alcohol fuels doubled (see Figure 42).

Figure 40: Conversion of Vehicles to Natural Gas and Propane, 1990 to 1998

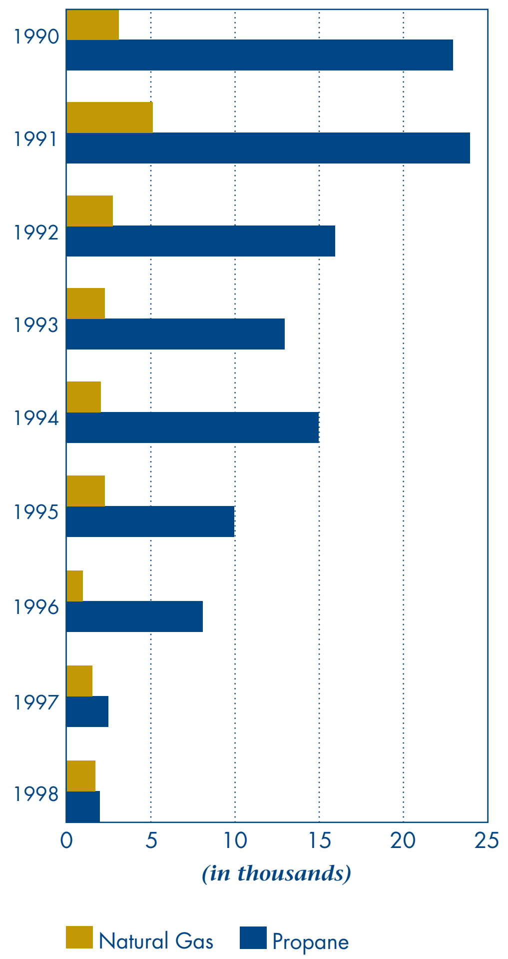


Figure 41: Number of Fueling Stations Selling Ethanol-blended Fuels, 1990 to 1999

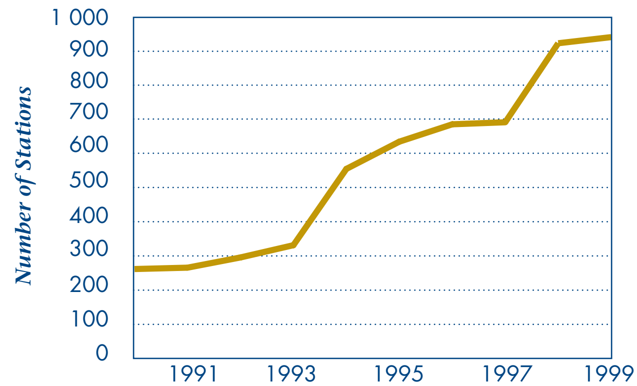
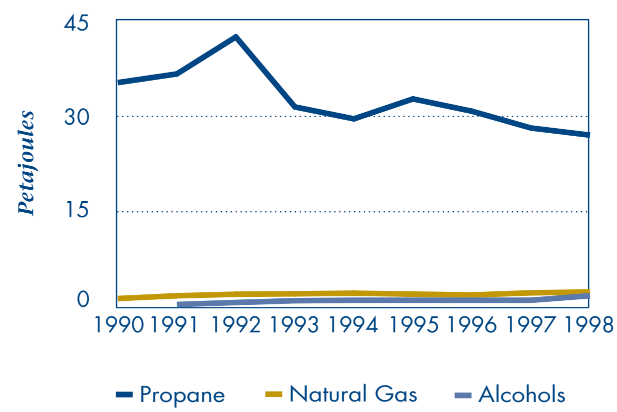


Figure 42: Use of Alternative Transportation Fuels, 1990 to 1998



Chapter 8
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 feed-stocks – this is covered under Agriculture and Agri-Food Canada (AAFC) programs.

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

Table 8: 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

Renewable Energy Use

In 1998, renewable energy sources accounted for about 18 percent of Canada's primary energy use, 1 922 out of 10 955 petajoules (see Table 9). Most of the renewable energy used in Canada comes from either hydro-electricity or wood biomass sources.

Table 9: Estimates of Primary Energy Production from Renewable Sources – 1998 (input in petajoules)

Hydro	1 255.00
Tidal	0.10
Biomass:	
industrial (P&P) electricity from wood waste and spent pulping liquor	100.00
IPP electricity from wood waste	37.50
electricity from landfill sites	7.20
electricity from MSW (Municipal Solid Waste)	0.50
municipal waste incinerators	12.50
biogas from sewage plants	n/a
industrial (P&P) heat from wood waste	393.00
residential space heating	95.00
commercial/institutional heating	n/a
thermal energy from landfill sites	2.40
thermal energy from MSW	12.00
ethanol from biomass*	4.10
energy crops plantations	- -
agriculture wastes	n/a
Earth energy systems	1.50
Geothermal	0.00
Wind electric (including Le Nordais**)	1.20
Wind mechanical	n/a
Solar thermal (water and air)	0.20
Solar photovoltaic	0.01
Total renewable energy	1 922.21

* includes output of a plant opened in 1998
** completion of Le Nordais in 1999
- - 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 1 500 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 1 000 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 a metre or two below the surface is 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 under long-term contract. Several other wind energy facilities across Canada, mostly single-turbine facilities, contribute a further 5 megawatts of capacity.

In 1998, construction began on Le Nordais, a 100-megawatt wind farm on the Gaspé Peninsula in Quebec. It is scheduled for completion by the end of 1999, at which time it comprised 134 turbines, generating 750 kilowatts each. The electricity is sold to Hydro-Québec under a long-term contract. With the completion of Le Nordais, Canada's wind-generated supply of electricity would total 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.

An active solar thermal system developed in the early 1990s became a Canadian success story. 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. NRCan installed the first absorber of this kind for a federal government building in 1996 at its CANMET Energy Technology Centre in Bells Corners, Ontario.

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 1998 was about 4.5 megawatts, with an estimated annual production of 3.6 gigawatt hours of electricity. The bulk of this capacity is "off grid" (not connected to an electrical transmission system) where photovoltaics are price 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 7 000 navigational buoys, beacons and lighthouses.

Canada has fewer than 40 grid-connected photovoltaic systems, and they have a combined capacity of 267 kilowatts. Many of these were installed as technology demonstration projects, such as the 85-kilowatt system at the Hugh McMillan Rehabilitation Centre, in Toronto and the 20-kilowatt system at NRCan's Energy Diversification Research Laboratory, in Varennes, Quebec.

Renewable Energy Programs

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

- Renewable Energy Information and Awareness Program;
- Renewable Energy Market Assessment Program;
- Green Power Initiative;
- Renewable Energy Deployment Initiative (REDI);
- Renewable Energy Technologies 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 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 1997–1999

- In April 1997, NRCan sponsored the Renewable Energy: A Commercial Trade Show and Markets Conference. The event attracted more than 400 participants from the renewable energy industry, federal, provincial, and municipal governments, universities, and non-governmental organizations.
- During 1997–1999, the department signed contribution agreements with Énergie solaire Québec, the Canadian Wind Energy Association, the Canadian Earth Energy Society, Ontario Hydro, and the Metropolitan Toronto and Region Conservation Authority to develop and implement renewable energy projects. One of these, granting $92,000 over three years to the

Solar Energy Society of Canada Inc., provides for development of the second edition of the Canadian Renewable Energy Guide, production of two new folders (on micro hydro and earth energy systems), a public exhibit program, a national renewable energy education campaign and a Solar Youth Day.

- In the fall of 1998, NRCan and the Hearth Products Association of Canada promoted the safe use of high-efficiency, low-emission wood-burning appliances, developing and distributing three public education folders, a video on how to burn wood wisely and newspaper articles on wood heating. The department also undertook an advertising campaign for *A Guide to Residential Wood Heating*, one of NRCan's most popular publications (with more than one million copies distributed to date). The advertisement appeared in a number of newspapers, with a total circulation of more than 6 million. The department received more than 2 500 requests for copies of the guide and other information on wood heating. NRCan distributed more than 170 000 folders and publications on wood heating during the campaign.
- NRCan sponsored one-day workshops in Halifax, Moncton and Vancouver to educate practitioners, such as engineers, on ground source heat pump technology and the use of two types of software with this technology. More than 40 engineers and other practitioners attended.
- During 1997–1999, NRCan distributed about 300 000 renewable energy publications to Canadians.

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 1997–1999

- During 1997–1999, NRCan undertook studies to assist the ground source heat pump and the biomass combustion industries to identify and overcome barriers to market penetration of their technologies in Canada. By March 1999, the ground-source heat pump study was almost complete.
- NRCan also undertook the following studies:
  - *Biomass Energy in Canada with Emphasis on Electricity*, prepared by ThermoShare, April 1998. This study took a comprehensive look at where and how biomass energy – particularly electricity – is produced in Canada. The Biomass report concluded that the market is growing for several types of energy from biomass besides industrial wood waste. For example, municipal solid waste is being used to generate electricity and thermal energy.
  - *Opportunities for Wood Energy for the Residential Sector – A Background Document*, prepared by Cantera Mining Limited, January 1999. Residential wood combustion supplies about 5 percent of Canada's renewable energy, as thermal energy. About 1.5 million homes are heated to some extent using wood energy. The Opportunities report looked at the challenges for continued wood use, particularly in areas where natural gas prices are low. This report has been distributed to federal and provincial policy-makers interested in the area of high-efficiency, low-emission wood-burning appliances and wood burning legislation.

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. Because Alberta seems to have the most potential for supplying successful, competitive renewable energy, NRCan launched its green power pilot project there.

Achievements 1997–1999

- In January 1998, NRCan signed a 10-year agreement with Enmax, Calgary's electricity-generating system, to purchase 10 000 megawatt–hours a year of electricity generated from new renewable energy sources for its facilities. Under the agreement, Enmax is responsible for choosing the suppliers of green power and ensuring they meet contract specifications. One requirement is that the green power suppliers meet and maintain EcoLogo certification under Environment Canada's Environmental Choice Program. Environment Canada also signed an agreement with Enmax to supply 2 000 megawatt–hours a year of green power to meet the needs of facilities owned or operated by Environment Canada in Alberta. Together, the NRCan and Environment

Canada agreements will displace more than 10 000 tonnes of CO_2 a year, mostly from coal-fired electricity stations, as the two departments will not use a corresponding amount of Alberta's existing capacity.

- NRCan undertook several studies on green power, including
  - *Defining and Certifying Green Power*, prepared by TerraChoice Environmental Services Inc., February 1998. This report provides an overview of the issues and options in developing criteria for green power certification. It was the first step to developing a more precise definition of green power to enable Canadians to measure, report and possibly certify environmental impacts. At the end of 1998, TerraChoice Environmental Services Inc. initiated work supported by NRCan and Environment Canada to update the Environmental Choice Program guidelines to certify electricity products or green power.
  - *Estimated Environmental Benefits of Green Power Purchases for Federal Facilities*, prepared by Acres International Limited, September 1998. In 1997, NRCan contracted Acres to analyse and, where possible, quantify the benefits of purchasing electricity generated using renewable sources of energy (green power) over conventional, fossil-fuelled sources. These benefits include reduction in atmospheric emissions, potential hedge against future electricity price increases and stimulation of the demand for renewable energy. The focus of the analysis, which used data from existing literature, was on Alberta and Saskatchewan, which NRCan saw as likely locations for the federal government to first purchase green power. NRCan began to review its experience with purchasing green power and, with the results of this report, to assess green power policy options, which will be presented to the Minister of Natural Resources for consideration.

Renewable Energy Deployment Initiative

The objective of the REDI is to stimulate the demand from businesses and federal government departments for commercially reliable and cost-effective renewable energy systems for space and water heating and cooling (e.g., solar water heating systems, solar air heating systems, ground-source heat pumps and high-efficiency, low-emission biomass combustion systems). It is also available to assist in the development of small-scale pilot projects in other markets. Its activities include

- providing financial incentives. Businesses are eligible for an incentive equal to 25 percent of the purchase and installation cost of a qualifying system, up to a maximum contribution of $50,000. NRCan provides a similar incentive to federal departments that purchase and install qualifying renewable energy systems in their facilities;
- assisting with market development strategies, in cooperation with renewable energy industry associations and other partners – for example, carrying out information and marketing campaigns.

Achievements 1997–1999

- To raise awareness of the REDI, the department undertook an advertising and media campaign in selected business, engineering, architectural and farming magazines, directories and newspapers. During 1998–1999, NRCan inserted ads 63 times in 27 different publications, with a total circulation of about two million and a reach of around five million. As a result, the department received close to 600 requests for REDI for Business information packages.
- In December 1998, under REDI for Other Markets, the department 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. By March 1999, the department was assessing seven proposals on this project.
- The department signed a contribution agreement with the Canadian Solar Industries Association, providing more than $200,000 for 10 initiatives to stimulate the development and deployment of solar energy systems under the REDI. The activities include developing information bulletins and publications; creating a new Web site; technical workshops; the production of a new trade show exhibit; and the development of a solar photovoltaic training correspondence program.
- Under REDI for Other Markets, NRCan initiated discussions with the Federation of Canadian Municipalities (FCM) to explore ways for the FCM to help the department promote renewable energy heating and cooling technologies in the municipal market. As a result, the FCM and NRCan undertook a survey to identify municipal building stocks that could benefit from these technologies and municipalities with interest in implementing them. By March 1999, the survey was nearing completion.

- NRCan and Finance Canada commissioned a Conference Board of Canada study entitled *Tax Treatment of Electricity from Renewable Energy Sources and Energy Efficiency Technologies: An International Comparison* in March 1998. The report sets out information on the relevant tax measures in several countries and provides a quantitative comparison of the competitiveness of fiscal systems across jurisdictions. The most important conclusions of the study are that
  - Canada is in the "middle of the pack" in terms of its tax treatment of renewable sources of electricity and energy efficiency;
  - in all countries, electricity from renewable sources enjoys a more generous tax treatment than general machinery and equipment investments; and
  - in all countries, energy efficiency investments in the operation of commercial buildings systems are generally disadvantaged in comparison with other investments. Further, Canada's tax treatment of such investments – that is, depreciation at the same rate as the building in which they are installed – is the common practice in most other jurisdictions.

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, photovoltaics and wind energy.

NRCan champions and supports technology development and field trials, in partnership with the renewable energy industry. This initiative's activities are directed to improving the reliability and lowering the cost of these technologies, disseminating information on their feasibility and economic features to potential users, and helping industry commercialize these products in domestic and foreign markets.

Technology development takes several forms, including projects conducted on a cost- or task-shared basis with industry and other partners. Laboratory services supporting photovoltaics are available at NRCan's facilities in Varennes, Quebec, and NRCan's biomass laboratory services are in Ottawa, Ontario. These laboratories have state-of-the-art testing facilities to help clients conduct R&D or technology evaluations. In addition to private sector companies, NRCan's partners include universities, energy utilities, trade associations, other federal and provincial departments, and research institutes.

Achievements 1997–1999

- NRCan, the U.S. Department of Energy and the Centre québécois de la valorisation de la biomasse et des biotechnologies organized the Biomass Conference of the Americas, in Montréal, Quebec. Conference themes included the cost-effective development and expansion of the biomass resource base and the environmental impact, sustainability and development of biomass-driven industries as unique business opportunities.
- NRCan has supported Iogen Corporation of Ottawa, Ontario, in the development of its biomass-to-ethanol technology since the mid-1980s. The 1997 partnership announced by Iogen and Petro-Canada to build a demonstration plant, conduct R&D and create a licensing option for Petro-Canada to build full-scale ethanol refineries was a notable milestone in the production of fuel ethanol from cellulosic biomass.
- NRCan gave financial support to Wenvor-Vergnet Canada of Guelph, Ontario, to develop a Canadian version of a 25-kilowatt wind turbine designed by Vergnet of France. The first Canadian-built model went to the Atlantic wind-test site in Prince Edward Island.
- NRCan signed an Memorandum of Understanding (MOU) on cooperation for small hydro development in China with the Ministry of Water Resources of the People's Republic of China in 1997. As a result, NRCan signed a joint venture agreement to manufacture and market in China an automatic control system for small hydro plants (less than 25 megawatts). As well, the Hangzhou Regional Centre purchased seven automation units from Canadian Hydro Control Systems Ltd. (CHCS) to showcase across the country. CHCS also signed a contract with the Hangzhou International Centre for Small Hydro Power to supply small-hydro automatic control systems.
- NRCan provided financial support for the 1998 Renewable Energy in Cold Climate Conference, which attracted more than 500 participants and 30 exhibitors and featured a public forum on issues related to climate change. Other partners in the conference included the Solar Energy Society of Canada Inc., Canadian Wind Energy Association, Canadian Solar Industries Association, the Quebec Ministry of Natural Resources and Environment Canada.
- NRCan officially released RETScreen™ '98. The RETScreen™ project assessment tool, a software program for evaluating renewable energy tech-

nology projects worldwide, was developed by NRCan and a team of more than 40 industry and government experts, as part of the Renewable Energy for Remote Communities Program.

- NRCan submitted to the World Bank a list of Canadian photovoltaic companies and consultants potentially interested in investing in collaborative projects. As a result, 40 Canadian companies received a request for proposals from the World Bank for the Photovoltaic Market Transformation Initiative, which aims to accelerate the commercialization, market penetration and financial viability of photovoltaic technology in the developing world.
- With a contract from NRCan, Huron Windpower Inc. designed and manufactured a new blade for a 25-kilowatt wind turbine being built by Wenvor-Vergnet Canada Inc. Huron established manufacturing facilities in 1995, with support from NRCan, and has manufactured and exported $15.5 million worth of wind turbine blades to Germany. Huron produces blades for wind turbines that generate from 25 to 750 kilowatts and employs 145 people.
- With financial support from NRCan, Suncurrent Industries Inc. of Calgary, Alberta, installed a pumping system in Yellahs Valley, Jamaica. The Delta 16 wind water pump was built by Dutch Industries of Regina Saskatchewan. After considering the system's field trial performance, Jamaica's Rural Agricultural Development Authority committed itself to supporting the installation of five additional water-pumping wind turbines.
- NRCan's Canadian Small Hydro Database was selected for inclusion in the "GeoGratis" project of NRCan's Earth Sciences Sector, a collection of data from many sources to be available to the public, through the Internet, at no charge.
- Two small hydro joint-venture agreements initiated by NRCan were signed during Prime Minister Jean Chrétien's January 1999 Team Canada official visit to Poland. In partnership, a Canadian firm, Ecosystems International Ltd., and a Polish firm, Pumped Storage Powerplants Co., will construct 12 low-head hydro plants on the Odra River in Poland. They will result in an installed capacity of 20 megawatts. In another joint venture, Canada's Merol Power Corp. and Poland's Elektrim Energetyka S.A. will develop a 900-kilowatt low head hydro plant using Canadian Hydro Components Ltd.'s "pit" turbines. NRCan supported development of this technology.
- NRCan co-sponsored the annual International Fuel Ethanol Workshop, in South Bend, Indiana. One of the workshop's main objectives was to explore ways to integrate new cellulosic-ethanol production technologies into the existing corn-ethanol industry.
- NRCan cosponsored the Bioenergy '98 conference and associated trade show, in Madison, Wisconsin, which featured sessions on business development and commercialization of bioenergy technologies, in addition to technical sessions.
- NRCan helped Ensyn Technologies scale up its rapid thermal processing (RTP) technology from bench scale to commercial systems and develop fuel and chemical applications for bio-oil. Ensyn subsequently signed an agreement with Gulf Canada Resources Limited for a bitumen and heavy-oil upgrading test program using this RTP technology.
- NRCan and its partners, the Department of Fisheries and Oceans and Environment Canada, announced that Canada's first solar-heated salmon hatchery project had saved $11,600 worth of propane fuel during 1998. At this rate, the solar heating system will pay for itself in less than six years. The solar industry now uses the project as a showcase to help market similar systems to the B.C. aquaculture industry.

Energy from the Forest Program

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. This initiative undertakes research 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.

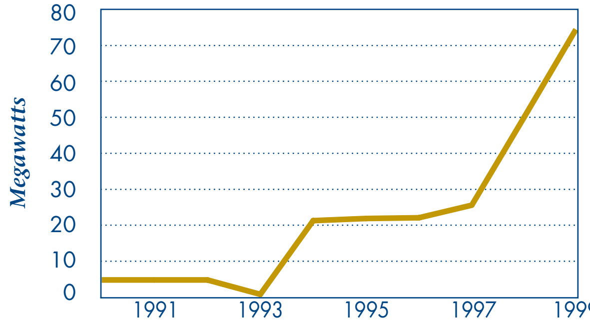
Achievements 1997–1999

- NRCan developed a forest management planning framework outlining two supply options: a system of conventional, commercial forest machines, such as skidders, forwarders and log trucks; and a system built around heavy-duty four-wheel-drive farm tractors and related tractor-powered forestry implements, such as winches, grapple loaders, bulk trailers and chippers.
- Under the International Energy Agency (IEA) Bioenergy agreement, the CFS continued to collaborate in a number of international projects in forest biomass production, including leadership of a new Task directed to developing conventional systems to supply bioenergy. Under the auspices of the IEA Bioenergy Task XII Activity 1.1, Forest Management, NRCan organized and hosted an international workshop and field study tour in Northern Ontario, with the theme of "Bioenergy and Boreal Forest Management."
- NRCan sponsored a workshop in March 1999 to consider alternative heating options for remote Aboriginal communities. The workshop profiled a decision-support manual that was developed to enable communities to evaluate the potential for biomass and to provide guidance in designing and implementing a biomass energy project, taking into consideration sustainable forest practices, equipment and human resources requirements, and terrain and wood supply.
- NRCan developed a forest management framework to provide Aboriginal communities with the necessary information and planning format to develop a sustainable and integrated resource management plan. Communities can use the framework as part of small-scale forestry operations to supply wood chips for burning in biomass-heating facilities. The framework recognizes and plans for the unique circumstances and characteristics of remote Aboriginal communities and allows individual communities to modify the format of the framework to suit their needs.
- NRCan held a national workshop on the (20-year-old) ENFOR program in March 1999 to determine what its successes have been and where it has missed opportunities. This was a critical exercise in developing significant opportunities for Canada to increase its use of renewable energies and its carbon-sequestration potential to meet its objectives under the Kyoto Protocol.

Progress Indicators

Wind power is a viable option for supplying renewable energy, particularly in remote, off-grid communities. Since 1990 installed capacity of wind power energy sources has increased 17-fold, to its current level of 75 megawatts (see Figure 43). The tripling in capacity from 1997 to March 1999 was due to the Le Nordais project in the Gaspésie region of Quebec.

Figure 43: Canadian Wind-power Capacity, 1990 to 1999



During the first year of the REDI, NRCan received 15 applications from Canadian businesses for renewable energy systems. NRCan approved 12 of these (representing investments of $1.5 million) and 8 of them were installed by March 1999. Although half of these were solar water heating systems, solar air and biomass systems accounted for most of the projects' investment. Table 10 summarizes the 8 completed projects.

To promote the federal government component of the program, NRCan informed all departments of the REDI and invited them to apply for it. NRCan received three applications and two installations were completed during 1998–1999 (see Table 11).

Table 10: Completed REDI for Business Projects 1998-1999

Business Name	Building Type	Province	Type of System	NRCan Contribution	Cost of Investment
Tapis Coronet Inc.	Carpet warehouse	Quebec	Solarwall™	$43 400	$189 567
Ferme M&M Chagnon	Farm building	Quebec	Thermo-dynamics solar water heating	$1 363	$5 450
Serge Venne Inc.	Farm building	Quebec	Thermo-dynamics solar water heating	$5 250	$21 000
Môtel St-Côme	Motel	Quebec	Thermo-dynamics solar water heating	$5 000	$20 000
Shaw Wood Industries	Furniture manufacturing	Nova Scotia	Biomass	$50 000	$922 500
Consoltex Inc.	Textile manufacturing	Quebec	Solarwall™	$18 220	$72 878
Enbridge Consumers Gas	Vehicle maintenance garage	Ontario	Solarwall™	$14 369	$57 478
Glen Bernard Camp Inc.	Summer Camp	Ontario	Solarcan solar water heating	$1 625	$6 500
Total				$143 217	$1.3 million

Table 11: Completed REDI for Federal Facilities Projects, 1998 to 1999

Department	Building Type	Province	Type of System	NRCan Contribution	Cost of Investment
Natural Resources Canada	Laboratories	Quebec	Solarwall™	$22 075	$88 300
Canadian Coast Guard	Maintenance building	Ontario	Solarwall™	$8 367	$33 810
Total				$30 442	$122 110

Community Energy Systems

Community Energy Technologies Program

The CETP 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. This 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 CETP 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. The program also promotes and fosters the adoption of integrated energy systems. The CETP's laboratory, which houses the world's first ice-slurry-based district cooling system, develops and tests district energy technologies.

Achievements 1997–1999

- With the FCM, NRCan sponsored a technical study tour to Finland to see examples of community energy systems, which are extensively used in that country. The tour helped lead to project feasibility studies in North Vancouver, Sudbury and Hamilton.

- NRCan initiated a prefeasibility study that led to the development of a Sudbury, Ontario, district energy project involving cogeneration and district heating and cooling. Toromont Energy and the City of Sudbury jointly own the project, and Sudbury Hydro will manage it.
- With Pragmatic Engineering of Kenora, Ontario, NRCan cost-shared a study that demonstrated that integrating the construction of sewer, water and district heating utilities can save more than 40 percent in construction costs. Those design concepts developed in NRCan's CANMET Energy Technology Centre. After considering these findings, NRCan has been exploring joint projects in a number of Aboriginal communities in northern Ontario.
- An NRCan feasibility analysis led, in 1998, to the expansion of the Windsor Utilities Commission's district heating and cooling system. The study determined the optimal size and location of the power plant, boiler and chiller plant to supply the new load. This will allow 11 new customers (consuming about 35 megawatts) to connect to the system.
- NRCan received a contract to recommend a heating plant configuration and the modifications needed to expand the Oujé Bougoumou district biomass heating system.
- An NRCan feasibility study, cofunded by the Region of Hamilton Wentworth and City of Hamilton, identified 80 buildings suitable for connection to a district energy system. These buildings could generate 114 megawatts for heating and 18 megawatts for cooling in the city core. As a result, a request for proposals was issued for supplying heat to the new district energy system.
- NRCan signed an agreement with Ontario Hydro Technologies to improve its ability to evaluate building system designs and components for their readiness to connect to district heating systems.
- NRCan is coproducing a *Municipal Guide to District Energy*, with the Chittenden County Regional Planning Commission in Vermont. The guide will target smaller cities, towns and communities interested in alternative energy and be applicable in both Canada and the United States.

Chapter 9
Intergovernmental Cooperation

Introduction

This chapter describes NRCan's intergovernmental cooperation activities in EAE during the reporting period at three levels: provincial–territorial, municipal and international.

Because federal, provincial, territorial and municipal governments deliver EAE programs, coordination is essential to avoid duplication and ensure efficient program delivery.

NRCan also cooperates with several international organizations and foreign countries and Canada benefits from its cooperation in two ways:

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

Provincial–Territorial Cooperation

Cooperation between NRCan and provincial and territorial governments took place during the reporting period at both the general and the program initiative levels.

General Cooperation

Cooperation took place through three main mechanisms:

Letters of Cooperation

- NRCan and the departments responsible for EAE programs in three provinces (Manitoba, Newfoundland, and Nova Scotia) cooperate under Letters of Cooperation (LOCs) on EAE. The LOCs cover all forms of program initiatives and establish a management committee of representatives from NRCan and the relevant provincial department to administer the agreement. The management committee reviews policy and program developments, progress on joint program initiatives and possible areas for further cooperation in EAE program delivery.
- NRCan held management committee meetings with Newfoundland and Nova Scotia in May 1997 and with Manitoba in April 1998.
- NRCan and the Agence de l'efficacité énergétique du Québec concluded a similar LOC in the first quarter of 1999, although it was not signed before the end of the reporting period.

Meetings with Other Natural Resources Ministries

- NRCan met with the Quebec Ministry of Natural Resources in April 1997 to review EAE policy and program developments and discuss potential areas of cooperation.

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 1998–1999, NACEE members included representatives from three provinces – New Brunswick, Quebec and Saskatchewan – who had the opportunity to comment on the OEE's business plan and programs.

Cooperation at the Program Level

Model National Energy Codes for Buildings

- NRCan and the provincial departments responsible for building energy efficiency in British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario and Quebec, as well as other parties, are members of the Canadian Consortium for Building Energy Compliance Software. The consortium provides a venue for governments and industry to collaborate on developing and supporting commercial building energy simulation software. The software is designed to simplify the compliance and administration of the MNECB, make building simulation more accessible, improve the general understanding of building energy performance, and allow building owners to make more informed decisions on energy use and building costs. Development work began on a new version of the software to verify compliance with the requirements of NRCan's CBIP.

Commercial Building Incentive Program

- The provinces – in particular, provincial health and education sectors – are the most active participants in the program.

R-2000 HOME Program

- NRCan and the provincial governments in Manitoba, New Brunswick, Newfoundland, Nova Scotia and Saskatchewan supported the R-2000 HOME Program through financial or in-kind contributions. Provincial home builders associations delivered the program, except in Manitoba, where Manitoba Energy and Mines delivered it under a licensing agreement with NRCan, and in Ontario, where the program is delivered by EnerQuality, a non-profit corporation comprised of the Canadian Energy Efficiency Alliance and the Ontario Home Builders Association.
- In March 1999, NRCan licensed to the Yukon Housing Corporation the rights to deliver the program in this territory.

EnerGuide for Houses Program

- Several provinces and Yukon participated in the Advisory Committee of the EnerGuide for Houses Program, which provides recommendations on making the program stronger by applying lessons learned from across Canada.
- In March 1999, NRCan signed licensing agreements with the Yukon Housing Corporation and the Agence de l'efficacité énergétique du Québec, committing these two organizations to delivering the program in their respective regions.

Enerhouse Conferences

- NRCan, the Nova Scotia Department of Natural Resources, CMHC, Nova Scotia Power, the Nova Scotia Home Builders' Association and the Atlantic New Home Warranty Corporation collaborated in the preparation of Enerhouse '97 and Enerhouse '98, annual housing conferences that focus on energy efficiency.

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 the Canadian Standards Association's Advisory Committee on Energy Efficiency. NRCan hosted several standards – development workshops.

Alternative Transportation Fuels

- The governments of Canada and Alberta established the Market Development Incentives Program (MDIP) in 1981, from contributions made by the natural gas industry to develop new markets for Alberta natural gas. The MDIP fund was extended three times to give the industry an opportunity to use it to meet program targets. NRCan and Alberta Energy cooperated through a task force formed in September 1997 to advise the federal Natural Resources Minister on options for spending the remaining $7 million of the fund. In December 1998, the Minister approved the task force's recommendations. This led to the establishment of a new two-year Natural Gas for Vehicles Program, initiated in February 1999.

Transportation and Greenhouse Gas Emissions

- NRCan and six provincial governments collaborated through the Transportation Working Group of the National Air Issues Coordinating Committee.

Community Energy Systems

- NRCan and the Government of the Northwest Territories cooperated on a project at Fort MacPherson for the extension of a district heating system in the community, which recovered heat from the diesel generators to heat several of the local buildings. NRCan provided guidance and funding through the Technology Early Action Measures component of the Climate Change Action Fund, to allow the project to capitalize on all available resources.
- NRCan and the Government of the Northwest Territories cooperated with several local entrepreneurs on the installation of a district energy system at Arviat to make use of rejected heat from the local diesel generating station. NRCan provided advice and technical support.

Directory of EAE Programs in Canada

- NRCan, provincial and territorial departments, provincial energy utilities, and larger Canadian municipalities collaborated on NRCan's production of the 1997 and 1998 editions of the *Directory of Energy Efficiency and Alternative Energy Programs in Canada*.

Municipal Cooperation

NRCan cooperated with the FCM and several municipalities on specific projects.

Federation of Canadian Municipalities

- NRCan signed an agreement with the FCM in November 1997 that ran until March 31, 1999. Under this agreement, the FCM
  - produced an energy efficiency tool kit for municipal managers, comprising an energy efficiency handbook and case study book;
  - designed, tested, and developed a bulk-purchase program for small and medium-sized municipalities;
  - wrote a series of success stories on sound energy management practices in the municipal sector in the FCM's *Forum Magazine*; and
  - assisted NRCan in marketing its "Dollars to $ense" energy management workshops.
- The February 1999 federal budget committed $1.6 million over three years to a Municipal Buildings Retrofit Program, to be administered by the FCM. The aim is to promote sustainability through reductions in energy and water consumption. The program will provide a range of services to municipalities, including project identification, development, financing and management services. During February and March 1999, NRCan and the FCM worked together to convert the budget commitment into a formal contribution agreement between NRCan and the FCM.
- To increase the number of applications under REDI, NRCan signed an agreement with the FCM in March 1999. The FCM will undertake a market research survey to identify municipal buildings that could use technologies promoted by REDI and identify new building construction and major renovation projects.

Municipalities

- Through the CETP, NRCan cooperated with several municipalities to identify, analyse, advise on and provide services to assist in the development and application of community energy systems. These are reported on in Chapter 8, in the section on "Community Energy Systems."

International Cooperation

Research and Development

In addition to the activities outlined below in various international contexts, 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.

International Energy Agency

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

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 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 Cooperation

Since the first meeting of the Energy Ministers of Asia–Pacific Economic Cooperation (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. The steering group first met in March 1997 in Vancouver, British Columbia.

The steering group is managing an assessment of options for a multilateral testing laboratory program, so that suppliers can have their products performance-tested only once, at a regionally recognized laboratory. In addition, a project was undertaken to determine regional differences in test standards and establish a regional notification system on the use of standards. Finally, the steering group is exploring ways of having the standards needs of APEC economies more effectively communicated in international standards-making processes. By March 1999, the steering group concluded that they would likely complete their task in 1999–2000 in time to make recommendations at the next APEC Energy Ministers meeting.

NRCan also participates in the APEC Energy Working Group's Expert Group on Energy Efficiency and Conservation.

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 is the "Promotion of energy efficiency in the hemisphere," which in turn comprises four initiatives:

- creation of a Web site on energy efficiency;
- development of a hemispheric "clean cities" initiative;
- facilitation of financing of energy efficiency and renewable energy; and
- promotion of energy efficiency in equipment and buildings in the hemisphere.

NRCan is leading the fourth initiative. During the reporting period, NRCan organized two major events:

- It held a Workshop on Energy Efficiency in Equipment and Buildings in Toronto, in June 1997. Five countries (Brazil, Canada, Costa Rica, Mexico and the United States) and four international organizations (Institute of International Education, Inter-American Development Bank, United Nations Development Program and the World Bank) attended the workshop. Participants shared information on the barriers to greater energy efficiency of buildings and equipment in the Americas and possible solutions to these barriers. They also discussed potential for cooperation among interested countries in this area. The workshop identified seven areas in particular:
  - information sharing on energy efficiency programs;
  - building energy codes;
  - energy efficiency of government buildings;
  - product testing and labelling;
  - the motor challenge program (a U.S. program on motor energy efficiency);
  - mass buys (i.e., common procurement of energy efficiency goods, services or technologies by a group of countries); and
  - continuity of the HEI.
- Canada held a Workshop on Hemispheric Cooperation on Energy Efficiency Testing and Labelling of Products in Washington in September, 1997. The purpose of the workshop was to share information on experience in the hemisphere pertaining to energy efficiency testing and labelling of products; and to discuss and agree on possible areas of cooperation between countries in this area. NRCan and the Institute of International Education organized the workshop, and the U.S. Agency for International Development and United Nations Development Program co-sponsored it. Eleven countries and six international organizations sent delegates to the workshop. Participants identified two areas of possible work:
  - collection and sharing of information on energy efficiency labelling and testing of products, either at the hemispheric or the regional level (one proposal was to develop a central depository of information, possibly a Web site, on labelling and standards within the hemisphere); and
  - development of information on specific topics.

Two proposals emerged from the Washington workshop:

- a study of differences in the hemisphere in test standards and laboratory-testing capabilities; and
- a joint project (possibly supported by international organizations) involving countries about to launch labelling programs for the first time.

A number of countries also expressed a desire that the HEI place a higher policy priority on energy efficiency labelling and standards in the hemisphere.

Proceedings of the two workshops are available from NRCan's OEE.

United States

Equipment Energy Efficiency Regulations and Labelling

- NRCan collaborated with the U.S. Department of Energy and the U.S. Federal Trade Commission on energy efficiency regulations and labelling of equipment. Discussions took place on modifications to the regulation and harmonization of products, performance levels, testing methods, and reporting between the two countries.

Motor Vehicle Fuel Efficiency and Fuels

- In March 1996, NRCan and the U.S. Department of Energy signed an 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 U.S. Department of Energy have agreed to formalize contact, as both nations consider options in responding to their respective climate change commitments. The two parties met annually in 1997–1999. They initiated an in-depth study to calculate the cost of new fuel economy technologies. They also undertook a joint study of the impacts on Canadian and U.S. emissions of policies that affect motor vehicles and fuels, using a detailed accounting model of greenhouse gas emissions.

Alternative Transportation Fuels

- NRCan, the U.S. Department of Energy and the motor vehicle industry jointly sponsored the propane and future car student challenges. Teams of university students from Canada and the United States built propane-fuelled or hybrid electric vehicles, either working from entirely new designs or by converting production models, and entered them in the technical competition. These challenges generate valuable technical data and provide experience to new engineers.

Renewable and Community Energy Systems

- NRCan is coproducing a Municipal Guide to District Energy, with the Chittenden County Regional Planning Commission in Vermont. The guide will target smaller cities, towns and communities interested in alternative energy and be applicable in both Canada and the United States.

Mexico

MOU on Energy Efficiency and Alternative Energy

- NRCan signed an MOU with the Mexican Energy Secretariat on EAE 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 (Comision Nacional para el Ahorro de Energia or CONAE); and
  - enhancing trade, investment and technical and other exchanges related to energy-efficient products, energy management services, and alternative energy goods and services.
- The second management committee meeting under the MOU on EAE was held in Ottawa in April 1997. The committee discussed recent EAE policy and program developments in both countries and further explored potential joint projects identified in the first meeting. The third meeting was in Cozumel, Mexico, in November 1997. During the meeting, the committee prepared a report on cooperative activities under the MOU on EAE, as well as drawing up an action plan for 1998 cooperative projects. The action-plan items included
  - a seminar in Canada on opportunities to invest in and supply cogeneration and self-supply facilities in Mexico's electricity sector;
  - a seminar with Canadian ESCos for CONAE officers;
  - development of mechanisms to identify opportunities for Canadian renewable energy developers to invest in renewable energy in Mexico;
  - a seminar in Mexico for Canadian small hydro producers;
  - the possible organization of a natural gas seminar in Mexico; and
  - NRCan technical advice to CONAE on some of its programs.
- Communications and collaboration between NRCan and CONAE have improved as a result of the MOU. The two organizations exchange publications and participate in many of each other's EAE seminars and workshops. Although the MOU has not yet resulted in any joint commercial projects, informal and formal discussions continue on getting such projects underway. NRCan will continue sending industry association representatives to relevant Mexican seminars and workshops to explore opportunities in Mexican markets.

China

- NRCan and China's Ministry of Water Resources signed an MOU in May 1997. Since then they have jointly undertaken extensive work under this MOU, including a demonstration project on small hydro control systems, the creation of a joint venture between Powerbase (Ontario) and the Hangzou International Centre, and training of Chinese technicians in the installation and maintenance of control systems.

Appendix 1
NRCan's Efficiency and Alternative Energy Initiatives and Expenditures ($ million)

	1997/98	1998/99
General Programs	6.0	7.9
Public Information		
Community Energy Technologies Program		
National Energy Use Database		
Energy Efficiency - Equipment	2.7	2.7
Energy Efficiency Regulations		
EnerGuide for Appliances		
EnerGuide HVAC Energy Efficiency Rating System		
Energy Efficiency - Buildings	11.8	18.4
R-2000 HOME Program		
Model National Energy Code for Houses and Buildings		
Buildings Energy Technology Advancement Plans		
EnerGuide for Houses Program		
Reno$ense		
Commercial Building Incentive Program		
Energy Innovators Initiative and Innovators Plus		
Federal Buildings Initiative		
Federal Industrial Boiler Program		
Heat Management R & D for Buildings Program		
Energy Efficiency - Industry	20.6	21.0
Industrial Energy Efficiency Initiative		
Industry Energy Research and Development		
Heat Management R & D for Industry Program		
Advanced Combustion Technologies Program		
Energy Technologies for High-Temperature Processes		
Processing and Environmental Catalysis Program		
Minerals and Metals Technologies Initiative		
Energy Efficiency - Transportation	2.5	3.3
Motor Vehicle Fuel Consumption Initiative		
EnerGuide for Vehicles		
Auto$mart		
FleetWise		
FleetSmart		
Alternative Energy - Alternative Transportation Fuels	8.2	9.7
Transportation Energy Technologies Program		
Alternative and Future Transportation Fuels Development Initiative		
Natural Gas for Vehicles Incentives Program (1998-99)		
Alternative Energy - Renewable Energy Sources	9.0	12.6
Renewable Energy Information and Awareness Program		
Renewable Energy Market Assessment Program		
Green Power Initiative		
Renewable Energy Deployment Initiative		
Renewable Energy Technologies Program		
Energy from the Forest Program		
Total	**60.8**	**75.6**

Appendix 2
Data Presented in the Report

The 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*, while this report uses a definition better suited for the purpose of energy end use analysis. It should also be noted that for the 1990-1997 period, Natural Resources Canada initiated and funded a major review of QRESD, which resulted in several sector re-allocations and data improvements. Some modifications to the original Statistics Canada data were required and are documented in Appendix C of NRCan's *Energy Efficiency Trends in Canada's 1990-1997*.

Figure 4: Secondary Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1997 (Index: 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997
Actual Energy Use	1.00	0.98	1.00	1.02	1.06	1.07	1.11	1.11
Energy Use Without Efficiency Improvement	1.00	0.99	1.02	1.07	1.10	1.13	1.15	1.18

Figure 5: Canadian Households by Type of Dwelling, 1997 (Percent) (Total Households 11 606 000)

Single-Detached	56.76
Mobile Homes	1.90
Apartments	31.08
Single-Attached	10.27

Figure 6: Residential Energy Use, 1997 (Percent)

Space Heating	60
Space Cooling	2
Appliances	14
Lighting	4
Water Heating	20

Figure 7: Residential Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1997 (Index: 1990 = 1.0)

	1990	1991	1992	1993	1994	1995	1996	1997
Actual Energy Use	1.00	0.98	1.00	1.04	1.06	1.04	1.11	1.06
Energy Use Without Efficiency Improvement	1.00	1.03	1.09	1.12	1.12	1.14	1.19	1.17

Figure 8: Average Annual Heating Costs for Houses Constructed to Different Standards (Dollars per year)

Typical Existing House	550
Typical New House	275
Model National Energy Code House	192
R-2000 Home	106

Figure 9: R-2000 Share of National, Nova Scotia and New Brunswick Housing Completions, 1983 to 1998 (Percent)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Canada	0.025	0.001	0.086	0.114	0.209	0.196	0.357	0.279	0.333	0.673	0.959	0.504	0.534	0.331	0.341	0.265
New Brunswick	0.021	0.000	0.362	0.470	1.076	1.767	1.603	0.596	1.184	6.254	7.907	9.148	10.739	2.976	5.181	1.471
Nova Scotia	0.000	0.000	0.072	0.026	0.093	0.438	0.933	1.727	0.928	0.642	1.121	1.201	3.311	3.572	3.934	3.379

Figure 10: National Trends of Air Leakage in Houses by Construction Period (Air Changes per Hour)

1981–1985	5.38
1986–1990	3.67
1991–1995	3.05
R-2000 (1981–1995)	1.24

Average ACH @ 50 Pa by Region and Period with R-2000 houses.
Air Changes per House per Hour (at 50 pascals pressure)

Figure 11: Share of Residential Energy Consumption Subject to Energy Efficiency Regulations, 1997 (in Petajoules)

	Regulated	Unregulated
Total	1 013	372
Space Conditioning	620	240
Water Heating	282	2
Appliances and Lighting	112	130

Figure 12: Average Energy Consumption of New Appliances, 1990 to 1997 (kWh/year)

	1990	1997
Clothes Washers	1 150	905
Clothes Dryers	1 095	922
Refrigerators	1 018	661
Dishwashers	1 000	616
Ranges	738	772
Freezers	530	377

Figure 13: Distribution of Refrigerator Sales According to Energy Consumption, 1990 and 1997 (Percentage of Annual Sales)

	kWh per cubic foot								
	15	25	35	45	55	65	75	85	95
1990	0.0	0.0	1.5	3.9	15.3	60.2	15.4	3.0	0.7
1997	0.0	5.3	61.3	32.4	0.8	0.1	0.0	0.0	0.0

Figure 14: Size and Energy Consumption of New Type 3 Refrigerators, 1991 and 1998

	Size *(Adjusted volume in cubic feet)*	kWh/year
1991	19.55	967.84
1998	20.93	661.48

Figure 15: Natural Gas Furnace Sales by Efficiency Level, 1990 and 1997 (Percent)

	1990	1997
Normal Efficiency	62.67	0.00
Mid-Efficiency	15.83	59.90
High-Efficiency	21.50	40.10

Figure 16: Energy Use Trends for Refrigerators, 1991 and 1998

Source: Natural Resources Canada EnerGuide Database.

Figure 17: Commercial and Institutional Energy Use by Building Type, 1997 (Percent)

Retail	25
Office	24
Other	17
Health	11
School	14
Hotel/Restaurant	9

Figure 18: Commercial and Institutional Energy Demand, by End Use, 1997 (Percent)

Space Heating	52
Auxiliary Motors	13
Lighting	15
Auxiliary Equipment	8
Water Heating	7
Space Cooling	5

Figure 19: Commercial Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1997 (Index 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997
Actual Energy Use	1.00	1.02	1.03	1.07	1.06	1.10	1.12	1.13
Energy Use Without Efficiency Improvement	1.00	1.04	1.06	1.10	1.10	1.12	1.15	1.15

Figure 20: Energy Use in Commercial Buildings, 1997 (Megajoules per M^2 per year)

Current Practice	1 300
Model National Energy Code	1 105
CBIP MNEC–25%	829
C-2000 Demonstration Projects	553

Figure 21: Recruitment of Commercial Energy Innovators, 1992–1993 to 1998–1999 (Organizations)

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

Figure 22: Projects Under the Energy Innovators and Innovators Plus Programs, 1992–1993 to 1998–1999

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

Figure 23: Value of ESCo Contracts, 1991–1992 to 1997–1998 (Millions of Dollars)

	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998
Total Annual Contract Value	41	62	128	187	278	152	214

Figure 24: FBI Investment Commitments and Estimated Annual Energy Savings for Five Leading Departments (Millions of Dollars)

	Investment Commitment to August 1999	Estimated Annual Energy Savings
National Defence	89.7	10.2
Public Works and Government Services Canada	41.0	6.3
Industry Canada	13.1	2.3
Environment Canada	8.7	1.1
Natural Resources Canada	9.2	1.0

Figure 25: Energy Savings from FIBP, 1991–1992 to 1998–1999 (Terajoules per year)

	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999
Annual Energy Savings	20	70	110	180	270	350	427	504
Annual Increments	20	50	40	70	90	80	77	77

Figure 26: Influence of Lighting Regulations on the Energy Use of Two Fluorescent Lamp Types, 1996 (Watt Rating)

	Before Regulation	After Regulation
8-foot, high output	75	66
4-foot, medium bi-pin	40	34

Figure 27: Annual Sales and Market Share of Common Fluorescent Lamps, 1996

Combined	31 923 000
4-foot, medium bi-pin	21 781 000
Other	7 342 000
8-foot, high output	2 800 000

Figure 28: Energy Use by Industrial Subsector, 1997 (Percent)

Petroleum Refining	14.95
All other sectors	14.75
Pulp	12.09
Newsprint	9.17
Iron and Steel	8.22
Upstream Mining	6.72
Aluminum	5.12
Other Paper	4.95
Organic Chemicals	3.56
Other Manufacturing NES	3.55
Food	2.91
Metal Mines	2.78
Inorganic Chemicals	2.62
Paperboard	2.45
Other Smelting and Refining	2.39
Transportation Equipment	2.14
Fertilizers	2.10
Wood	2.08

Figure 29: Cost of Energy Used by Industry as a 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 1997 (Index: 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997
Actual Energy Use	1.00	0.99	0.99	1.00	1.06	1.08	1.11	1.12
Energy Use Without Efficiency Improvement	1.00	0.98	1.01	1.08	1.10	1.14	1.13	1.17

Figure 31: Reduction in Energy Use per Unit of Output for Selected Industries, 1990 to 1997 (Percent)

Electrical and Electronic	50.0
Brewery*	33.3
Beverage	27.9
Rubber	26.7
Pulp*	26.7
Primary Textile	23.1
Building Board*	22.2
Plastic and Resin*	18.5
Glass	16.1
Cement*	15.1
Non Metal Mines	14.9
Construction	14.3
Other Smelting and Refining	11.3
Lime*	10.1
Food	9.9
Iron and Steel*	9.3
Metal Mines	9.1
Aluminum*	7.3
Other Paper*	7.1
Tobacco	4.8
Furniture and Fixtures	3.0
Transportation Equipment	2.6

**Physical Units of production was used as the measure of activity for those subsectors. For the remaining subsectors, gross domestic product (GDP) was used.*

Figure 32: Industrial Energy Innovators and Action Plans, 1995–1996 to 1998–1999

	1995–1996	1996–1997	1997–1998	1998–1999
Innovators	212	238	245	249
Action Plans	18	172	177	194

Figure 33: Energy Efficiency Standards Before and After Motor Regulations (Percent)

	Size of Motor (in horsepower)									
	1	2	5	10	20	30	50	75	125	200
Efficiency* Before Regulation	75.0	79.0	82.5	86.0	88.3	89.5	90.5	91.2	91.8	92.0
Efficiency* After Regulation	82.5	84.0	87.5	89.5	91.0	92.4	93.0	94.1	94.5	95.0

**Efficiency @1 800 RPM*

Figure 34: 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 35: Energy Use by Transportation Mode, 1997 (Percent)

Passenger:		Freight:	
Light Vehicles	46.15	Trucks	29.15
Aviation	10.26	Marine	4.78
Buses	2.73	Rail	3.72
Rail	0.11		

Off-Road	3.11

Figure 36: Transportation Energy Use and Energy Savings Due to Energy Efficiency, 1990 to 1997 (Index: 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997
Actual Energy Use	1.00	0.97	0.99	1.00	1.05	1.07	1.09	1.13
Energy Use Without Efficiency Improvement	1.00	0.96	0.98	1.02	1.10	1.13	1.16	1.21

Figure 37: New Passenger Car and Light Truck Market Shares, 1990 to 1997 (Percent)

	Model Year							
	1990	1991	1992	1993	1994	1995	1996	1997
Passenger Car	70.1	70.3	68.3	65.8	63.4	62.0	59.0	55.6
Light Truck	29.9	29.7	31.7	34.2	36.6	38.0	41.0	44.4

Figure 38: New Car Fuel Economy, Normalized for Weight and Power, 1990 to 1998 (Index: 1990 = 1.00)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
L/100 km/hp	1.00	0.96	0.93	0.91	0.90	0.83	0.81	0.81	0.80
L/100 km/kg	1.00	0.97	0.98	0.97	0.96	0.92	0.92	0.93	0.93
L/100/km	1.00	0.98	0.99	0.99	1.00	0.97	0.96	0.98	0.98

Figure 39: Energy Intensity of the Federal Vehicle Fleet, 1996 and 1998 (L/100 km)

	1996	1998
Vehicle Average City Fuel Consumption, L/100 km	14.6	14.8
In-use Average City Fuel Consumption, L/100km	14.8	15.0

Figure 40: Conversion of Vehicles to Natural Gas and Propane, 1990 to 1998

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Natural Gas	3 122	5 147	2 781	2 294	2 076	2 304	1 009	1 571	1 750
Propane	23 000	24 000	16 000	13 000	15 000	10 000	6 500	2 500	2 000

Figure 41: Number of Fueling Stations Selling Ethanol-blended Fuels, 1990 to 1999

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

Figure 42: Use of Alternative Transportation Fuels, 1990 to 1998 (Petajoules)

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

Figure 43: Canadian Wind-power Capacity, 1990 to 1999 (Megawatts)

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