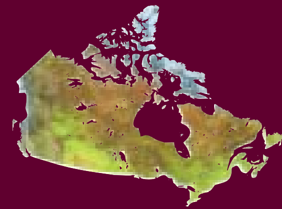

Energy Efficiency Trends in Canada,

1990 to 2003

June 2005

Natural Resources Canada / Ressources naturelles Canada

Canada

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

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Preface

This is the tenth edition of *Energy Efficiency Trends in Canada*, which delivers on Canada's commitment to track trends in energy efficiency, energy use and related greenhouse gas (GHG) emissions. Improving energy efficiency reduces GHG emissions that contribute to climate change. For a statistical overview of Canada's sectoral energy markets, readers are referred to this report's companion document, ***Energy Use Data Handbook, 1990 and 1997 to 2003***.

Energy Efficiency Trends in Canada, 1990 to 2003 covers the six sectors analysed by Natural Resources Canada's Office of Energy Efficiency (OEE), i.e. the residential, commercial/institutional, industrial, transportation, agriculture and electricity generation sectors. The period 1990 to 2003 was chosen because 1990 is the reference year for the Kyoto Protocol, and 2003 is the most recent year for which actual data are available.

A comprehensive database, including most of the historical energy use and GHG emissions data used by the OEE for its analysis, is available from the following Web site: *oee.nrcan.gc.ca/tables05*.

This year, we have added a new product – a CD containing electronic versions of this report, the *Energy Use Data Handbook*, energy and GHG emissions analysis tables, as well as detailed data tables for Canada from the comprehensive database. It is available upon request.

If you require more information on this product or the services that the OEE offers, contact us by e-mail at *euc.cec@nrcan.gc.ca*.

This report was prepared by Naima Behidj, Johanne Bernier, Samuel Blais, Sébastien Genest, William King, Carolyn Ramsum, Katherine Sassi and Nathalie Trudeau, who are staff of the Demand Policy and Analysis Division of the OEE, which is part of Natural Resources Canada. The project leader was Carolyn Ramsum, with Tim McIntosh providing overall direction.

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Chapter 1
Introduction

From 1990 to 2003, Canada's energy efficiency improved by an estimated 13 percent, or 883.3 petajoules, saving Canadians almost $13.4 billion in 2003 alone and reducing annual greenhouse gas emissions by 52.3 megatonnes.

About Energy Use, Energy Efficiency and Greenhouse Gas Emissions

Determining the impact of energy efficiency improvements on energy consumption levels for a vehicle, piece of equipment or appliance is straightforward; it can easily be tested and measured. However, determining how these individual improvements integrate and affect energy consumption and resulting greenhouse gas (GHG) emissions is more complex.

This report addresses the complicated question of what impact energy efficiency is having in Canada. It provides an analysis of the impact of energy efficiency on secondary energy use – the energy that Canadians use to heat and cool their homes and workplaces and to operate their appliances, vehicles and factories – and on the generation of electricity.

The analysis presented in this report uses a factorization method that separates the changes in the amount of energy used by the residential, commercial/institutional, industrial, transportation and electricity generation sectors of the economy into five factors. These factors are

1. **Activity:** Activity is defined differently in each sector. For instance, in the residential sector, it is defined as households and the floor space of residences; in the industrial sector, it is defined as industrial output such as tonnes of steel; and in the electricity generation sector, it is defined as gigawatt-hours produced.
2. **Weather:** Fluctuations in weather lead to changes in heating and cooling requirements. This effect is taken into account in the residential and commercial/institutional sectors, where heating and cooling account for a significant share of energy use.
3. **Structure:** Structure refers to change in the makeup of each sector. For example, in the industrial sector, a relative increase in output from one industry over another is considered a structural change; in the electricity generation sector, a relative increase in one fuel over another is considered a structural change.

4. **Service Level:** The increased penetration of auxiliary equipment in commercial/institutional buildings during the 1990s increased energy consumption for this end-use. Since we have only limited data on stocks, sales and unit energy consumption levels related to this equipment, an index has been estimated to capture the impact of these changes over time. This effect is measured only in the commercial/institutional sector.

5. **Energy Efficiency:** Energy efficiency refers to how effectively energy is being used, for example, for how long an appliance can be operated with a given amount of energy. For the electricity generation sector, it represents the conversion losses.

In this analysis, one complexity that arises is how to treat the secondary use of electricity that, unlike other fuels used at the end-use level, does not produce any GHG emissions. Thus it is common (but not universal) practice to allocate GHG emissions associated with electricity production to the sector that uses that electricity. This is achieved by multiplying the amount of electricity used by a national average emissions factor that reflects the average mix of fuels used to generate electricity in Canada. The sectors in this report are analysed with and without this allocation.

Total Canadian GHG emissions are estimated to have been 731.5 megatonnes[1] (Mt) in 2003; of this, 69 percent, or 501.8 Mt, resulted from secondary energy use (including electricity-related GHG emissions). GHG emissions resulting from secondary energy use are influenced by two principal factors: the amount of energy used and the GHG intensity of the energy used (the quantity of GHGs emitted per unit of energy). The sector-by-sector analysis in this report elaborates on these two principal factors and the impact that they, and energy efficiency, have on GHG emissions trends.

Chapter 2 provides an analysis of total secondary end-use energy efficiency, energy use and related GHG emissions trends. Chapters 3 to 8 describe the results of the sector-by-sector analysis of energy efficiency and GHG emissions. The appendix provides a glossary of terms.

[1]This is a preliminary estimate. Environment Canada is responsible for Canada's official GHG inventory.

Differences From Previous Reports

This report is the tenth annual review of trends in energy use, energy efficiency and GHG emissions in Canada, using 1990 as the baseline year. It updates last year's *Energy Efficiency Trends in Canada, 1990 to 2002* and delivers on Canada's commitment to track trends in energy efficiency, energy use and related GHG emissions. *Energy Efficiency Trends in Canada, 1990 to 2003* differs from previous reports in three key ways.

The first difference is in the commercial/institutional sector where floor space estimates were revised. At the request of the Office of Energy Efficiency (OEE), Informetrica Limited redeveloped its commercial/institutional floor space estimates so they would be consistent with the North American Industry Classification System (NAICS). These changes are necessary to ensure that floor space data are compatible with energy and expenditure investment data, which are now collected using NAICS definitions. Due to this change in definitions, in this report, floor space data are reported for ten activity types instead of the nine building types used previously. As well, floor space from industrial facilities, which was previously attributed to commercial building types, has been excluded from the new floor space total.

The second difference, also in the commercial/institutional sector, involves a change to the definition of service level in the factorization analysis. We were able to obtain actual penetration rates for air conditioned floor space from the *Commercial and Institutional Building Energy Use Survey* for 2000; as a result, we have removed the impact of space cooling from the service level effect. The index devised to estimate changes in service level now accounts for only the penetration of auxiliary equipment.

The third difference is in the passenger sub-sector of transportation where, this year, a new historical series for car and light truck occupancy rates was developed. Since occupancy rates are critical for calculating passenger-kilometres (the activity variable for passenger transportation), this change has affected the factorization results presented for this sub-sector. Compared with previous reports, the activity effect is noticeably larger and, as a result, energy efficiency improvements have also increased.

In this document, due to rounding, the numbers in the figures may not add up to the reported totals.

Chapter 2
Total End-Use Sector

Definition: The total end-use sector refers to an aggregation of the following five end-use sectors: residential, commercial/institutional, industrial, transportation and agriculture.

One petajoule is the amount of energy consumed by a small town of about 3700 people in a year for all uses, from housing and transportation to local services and industry.

Between 1990 and 2003, secondary energy use – the energy that Canadians use to heat and cool their homes and workplaces and to operate their appliances, vehicles and factories – increased 22 percent, from 6950.8 to 8457.3 petajoules (PJ). As a result, secondary energy-related GHGs (including GHGs related to electricity) increased 23 percent, from 407.9 to 501.8 Mt.

As Figure 2.1 indicates, if there had not been significant ongoing improvements in energy efficiency in all end-use sectors, secondary energy use would have been 13 percent higher in 2003 than it actually was. These energy savings of 883.3 PJ are roughly equivalent to 84 percent of the energy used by all cars and light trucks in passenger transportation.

Figure 2.1 Secondary Energy Use, With and Without Energy Efficiency Improvements, 1990–2003 (index 1990 = 1.0)

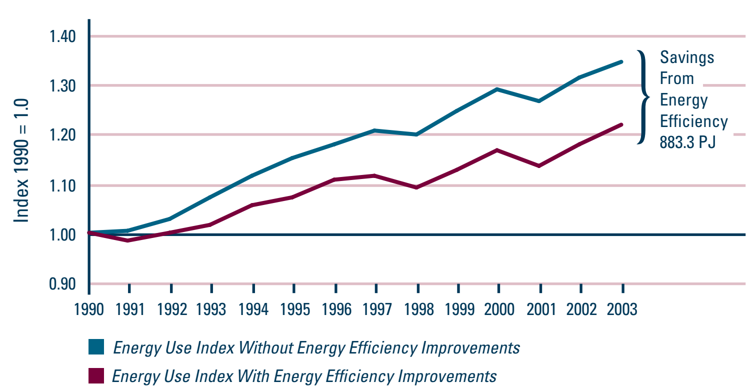
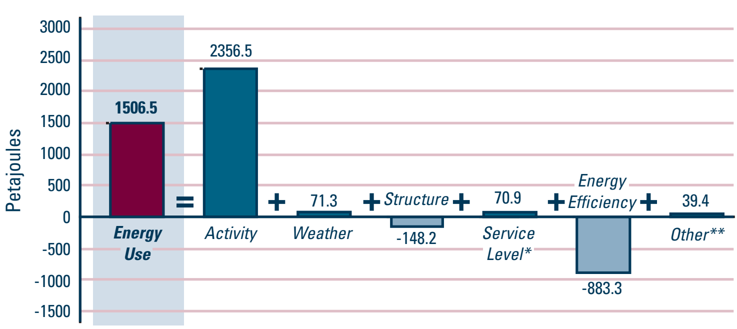


Figure 2.2 indicates that the following influenced the change in energy use and related GHGs:

- a 35 percent increase in activity (comprising commercial/institutional and residential floor space, number of households, passenger- and tonne-kilometres, industrial gross output, physical production and gross domestic product [GDP]) resulted in a 2356.5 PJ increase in energy and a corresponding 136.7 Mt increase in GHG emissions;
- the winter of 2003, which was 5 percent colder than the winter of 1990, and the summer, which was 24 percent warmer, led to a 71.3 PJ increase in secondary energy demand and a resulting 4.0 Mt increase in GHG emissions;
- changes in the structure of most sectors in the economy increased energy use; however, these increases were completely offset by a shift in the industrial sector towards industries that are less energy intensive – the net result was savings of 148.2 PJ and reductions in GHG emissions of 4.6 Mt;
- changes in the auxiliary equipment service level (i.e. increased use of computers, printers and photocopiers in the commercial/institutional sector) raised energy use by 70.9 PJ and increased corresponding GHG emissions by 4.2 Mt; and
- improvements in energy efficiency saved 883.3 PJ of energy and 52.3 Mt of GHG emissions.

Figure 2.2 Impact of Activity, Weather, Structure, Service Level and Energy Efficiency on Energy Use, 1990–2003 (petajoules)

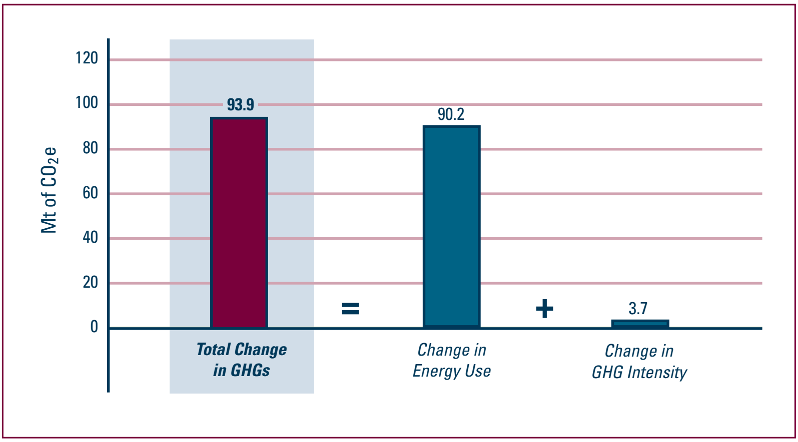


* "Service Level" refers to the service level of auxiliary equipment in the commercial/institutional sector.
** "Other" refers to street lighting, non-commercial airline aviation, off-road transportation and agriculture, which are not included in the factorization analysis but are included in "Energy Use."

Overall, when GHGs related to electricity production are included, increased secondary energy use resulted in increased GHG emissions. The GHG intensity of the energy changed little over the period as fuel switching towards less GHG-intensive fuels offset a higher GHG intensity in electricity production. As Figure 2.3 shows, GHG emissions from secondary energy use were 23 percent, or 93.9 Mt, higher in 2003 than in 1990.

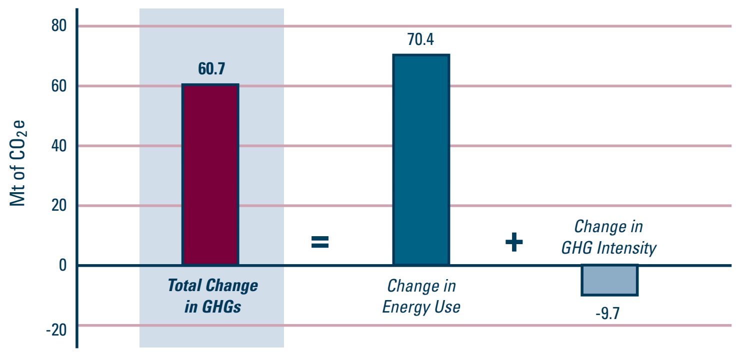
The emissions of one tonne of carbon dioxide (CO_2) would fill the volume of two average-sized houses in Canada – meaning that one megatonne would fill about 2 million average-sized houses.

Figure 2.3 Influence of Secondary Energy Use and GHG Intensity on the Change in GHG Emissions, Including Electricity-Related GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



When electricity-related GHG emissions are excluded, GHG emissions from secondary energy use rose by 19 percent, or 60.7 Mt (Figure 2.4). A 2 percent decrease in the GHG intensity of energy was the result of a relative increase in the consumption of biomass and natural gas and a decline in the use of heavy fuel oil, coke and coke oven gas.

Figure 2.4 Influence of Secondary Energy Use and GHG Intensity on the Change in GHG Emissions, Excluding Electricity-Related GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



Figures 2.5, 2.6 and 2.7 show how the increase in energy use and GHG emissions between 1990 and 2003 was distributed across all end-use sectors of the economy. The increase is to be expected, given the substantial growth of activity (GDP, floor space, etc.) in the various sectors.

Figure 2.5 Energy Use by Sector, 1990 and 2003 (petajoules)

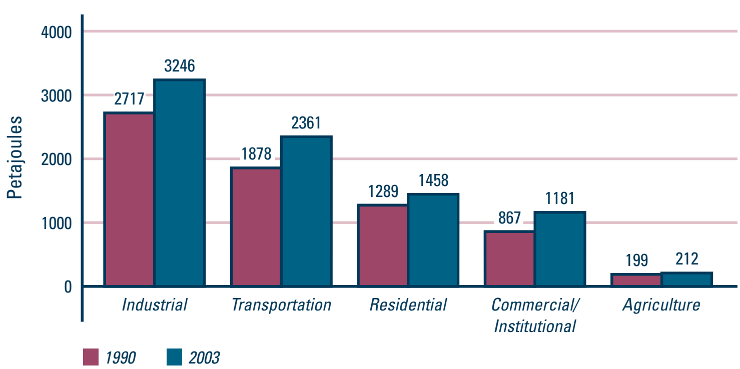


Figure 2.6 GHG Emissions, Including Electricity-Related Emissions, by Sector, 1990 and 2003 (megatonnes of CO_2 equivalent)

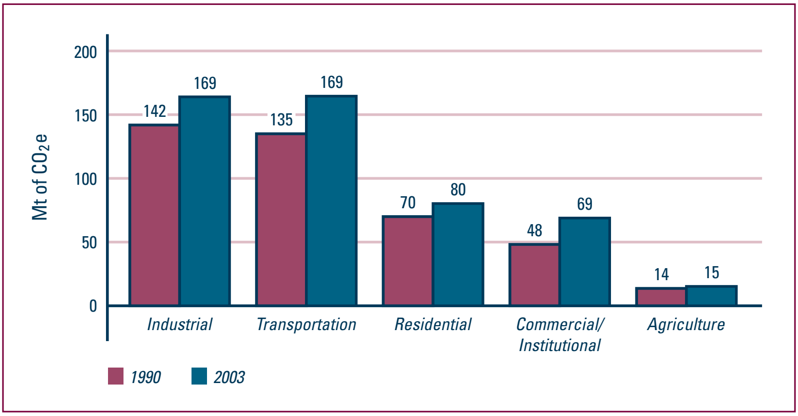
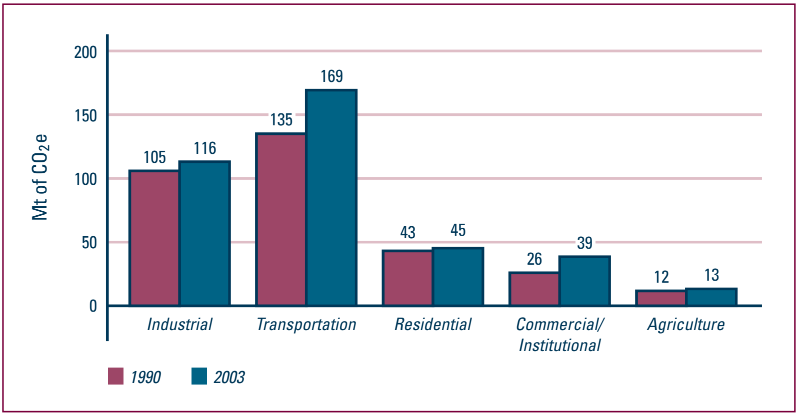


Figure 2.7 GHG Emissions, Excluding Electricity-Related Emissions, by Sector, 1990 and 2003 (megatonnes of CO_2 equivalent)



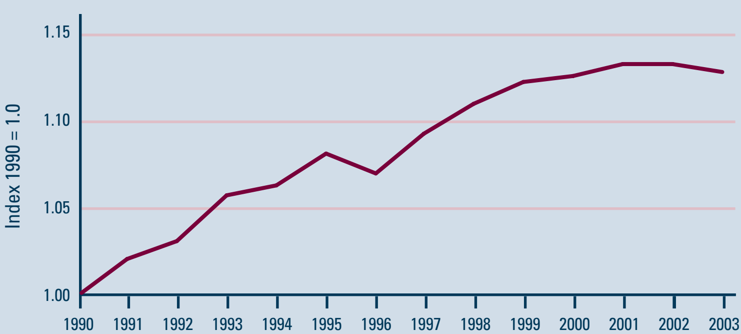
The following chapters describe how changes in activity, weather, structure, service level and energy efficiency influenced changes in energy use, as well as how energy use and the GHG intensity of fuels affected changes in energy-related GHG emissions for each end-use sector.

The OEE Energy Efficiency Index

In this report, the impact of energy efficiency on energy consumption is estimated for the residential, commercial/institutional, industrial[1] and transportation sectors over the 1990–2003 period. These variations in energy efficiency are aggregated into a single index of energy efficiency for Canada, which is called the OEE Energy Efficiency Index.

Over the 1990–2003 period, the Index presented in Figure 2.8 trended upward, growing by about 1 percent per year. As a result, energy efficiency improved by 13 percent over the period. This translates into energy savings of 883.3 PJ and GHG savings of 52.3 Mt in 2003. A flattening of the index between 2001 and 2003 is mainly due to the industrial sector, where energy efficiency improvements were checked by increases in energy intensity in some industries, fuel switching and lower levels of capacity utilization.

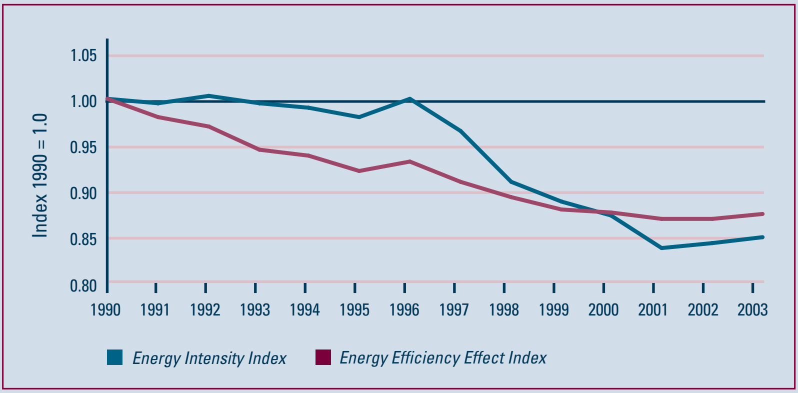
Figure 2.8 The OEE Energy Efficiency Index, 1990–2003 (index 1990 = 1.0)



[1] In the industrial sector, NAICS-based data for some industries are not available from Statistics Canada between 1991 and 1994. For these years, the energy efficiency effect was estimated using analysis (data was based on the Standard Industrial Classification System) from the 2000 report to calculate growth rates, which were then applied to the 1995 data point to backcast missing years. These results were calibrated to NAICS-based activity and intensity data.

The OEE Energy Efficiency Index provides a better estimate of changes in energy efficiency than the commonly used ratio of energy use per unit of GDP (energy intensity). This ratio captures not only changes in energy efficiency, but also other factors such as weather variations and changes in the structure of the economy. Figure 2.9 illustrates the differences between the two indices. The energy efficiency effect is the mirror image of the OEE Index presented in Figure 2.8; the line was transposed so it can be more easily compared to the index for energy intensity.

Figure 2.9 Changes in Energy Intensity and the Energy Efficiency Effect, 1990–2003 (index 1990 = 1.0)



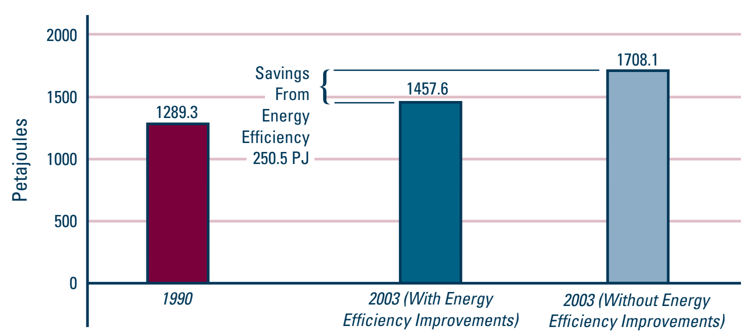
As illustrated in Figure 2.9, intensity underestimates the efficiency effect in Canada in the early 1990s and overestimates its impact in the latter part of the period. Before 1998, intensity improvements appear to be modest because colder weather (1992–1997) and a shift towards more energy-intensive industries (1990–1993) masked energy efficiency progress. In 2000, the intensity index dipped below the index for the energy efficiency effect. A switch to less energy-intensive industries, which began in the mid-1990s, combined with energy efficiency improvements accelerated the observed decline in energy intensity.

Chapter 3
Residential Sector

Definition: The residential sector in Canada includes four major types of dwellings: single detached homes, single attached homes, apartments and mobile homes. Households use energy primarily for space and water heating, the operation of appliances, lighting and space cooling.

Between 1990 and 2003, residential energy use increased by 13 percent, or 168.2 PJ (Figure 3.1). As a result, residential energy-related GHGs (including those related to electricity) increased by 15 percent, or 10.3 Mt. Without energy efficiency improvements, energy use would have risen by 32 percent between 1990 and 2003, instead of the observed 13 percent.

Figure 3.1 Energy Use, With and Without Energy Efficiency Improvements, 1990 and 2003 (petajoules)

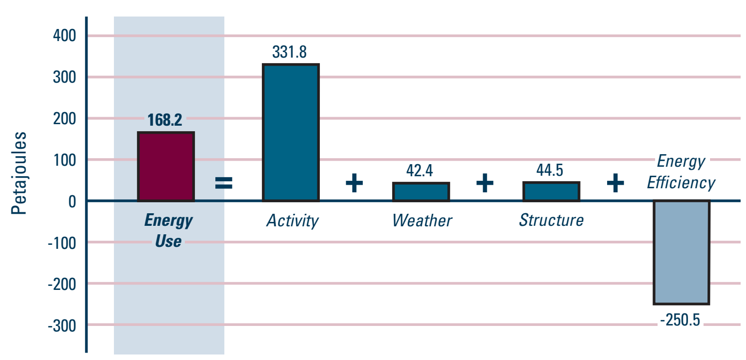


During a typical Toronto summer, a central air conditioner in an average home will use 1969 to 2317 kilowatt-hours. To generate the electricity to operate this unit, roughly 0.5 tonnes of GHGs are emitted at the power plant level.

As Figure 3.2 indicates, the following influenced the change in energy use and related GHGs:

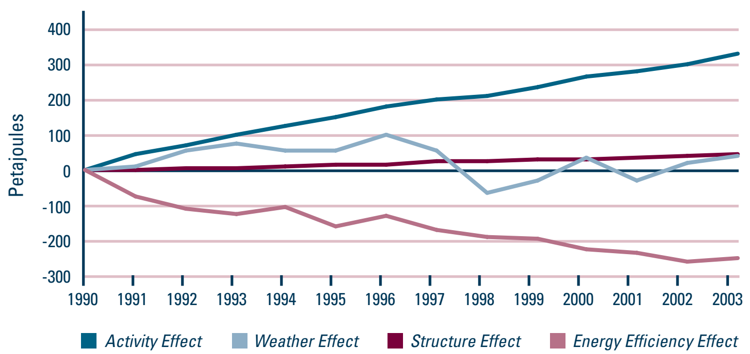
- activity, defined as a mix of households and floor space, increased by 26 percent, resulting in a 331.8 PJ increase in energy and a corresponding 18.2 Mt increase in GHG emissions. Growth in activity was driven by a 29 percent increase in floor area and by a rise of 23 percent in the number of households;
- the winter in 2003 was colder and the summer was warmer than in 1990. As a result, energy demand for space conditioning purposes increased by 42.4 PJ and GHG emissions rose by 2.3 Mt;
- changes in the structure (e.g. mix of end-uses); specifically, increases in the relative energy shares of water heating, lighting and space cooling, resulted in the sector using an additional 44.5 PJ of energy and emitting 2.4 Mt more GHGs; and
- improvements to the thermal envelope of houses and to the efficiency of residential appliances and space and water heating equipment led to an overall energy efficiency gain in the residential sector, saving 250.5 PJ of energy and 13.7 Mt of GHG emissions.

Figure 3.2 Impact of Activity, Weather, Structure and Energy Efficiency on Energy Use, 1990–2003 (petajoules)



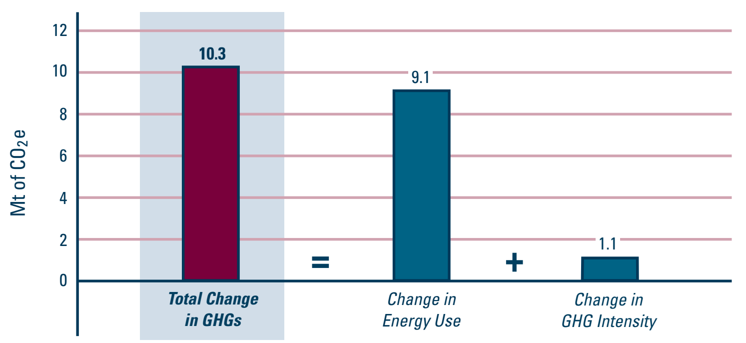
As Figure 3.3 shows, activity and, to a lesser degree, structure (or the mix of end-uses) have steadily contributed to increased energy use over time. Energy efficiency improvements, however, helped to offset much of the impact of activity and structure. Weather is the only factor for which there is no discernible trend over the period.

Figure 3.3 Changes in Energy Use Due to Activity, Weather, Structure and Energy Efficiency, 1990–2003 (petajoules)



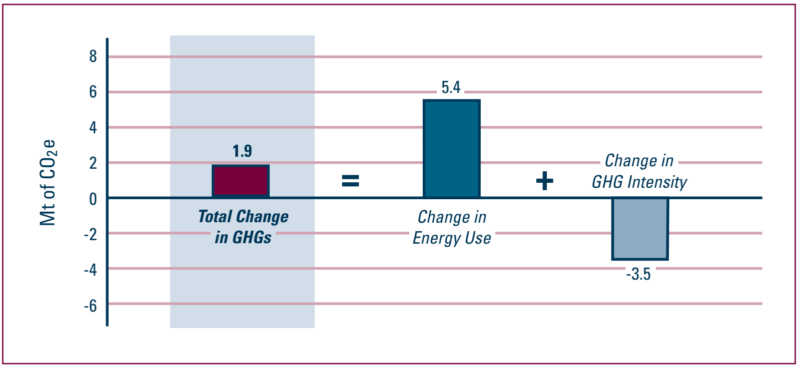
When GHGs related to electricity are included, increased energy consumption and a rise in the average GHG intensity of fuels used to generate electricity were responsible for the overall increase in GHG emissions in the sector. As Figure 3.4 shows, GHG emissions from the residential sector were 15 percent, or 10.3 Mt, higher in 2003 than they were in 1990.

Figure 3.4 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, Including Electricity-Related GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



When electricity-related GHG emissions are excluded, the GHG intensity of energy use decreased by 8 percent (Figure 3.5) between 1990 and 2003. Fuel shifting from heating oil and propane to natural gas and wood reduced GHG intensity in the sector and offset higher GHGs from increased energy use.

Figure 3.5 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, Excluding Electricity-Related Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



Air Conditioning Trends in the Residential Sector

Though better known for cold winters, certain parts of Canada also enjoy short but hot summers. Using an air conditioner during the summer months has become particularly popular in Quebec, Ontario and Manitoba. As a result, energy use for air conditioning increased from 8.3 PJ in 1990 to 17.7 PJ in 2003 (113 percent). Despite this rapid growth, space cooling accounted for just over 1 percent of total residential energy use in 2003.

To keep homes comfortable in the summer, air conditioners in certain regions are used quite intensely. Consider that during a typical cooling season in Toronto, a room air conditioner with a capacity of 8000 British thermal units (Btu) per hour, will use 421 to 502 kilowatt-hours (kWh) (depending on the unit efficiency),[1] or similar to what a new 2003 refrigerator consumes per year. A central air conditioner is used to cool a larger space such as a house. This type of unit (32,000 Btu per hour) can use about 1969 to 2317 kWh in a cooling season – roughly equivalent to the annual energy consumption of a new 2003 refrigerator, range and clothes dryer. Central units currently outnumber smaller, less intensive room units by a ratio of almost 2 to 1 (see Table 3.1).

Why is air conditioning energy use growing so quickly? One reason has been activity; while the number of households increased by 23 percent between 1990 and 2003, the stock of air conditioning units grew by 88 percent (see Table 3.1). Warmer than average summers since 1998 (except for 2000) may have contributed to increased purchases of air conditioning units.

Table 3.1 Stock of Air Conditioning Units, 1990 and 2003 (thousands)

Type of Air Conditioner	1990	2003	Total Growth 1990–2003 (%)
Room	1090	1728	58
Central	1376	2919	112
Total	**2466**	**4647**	**88**

Source: Natural Resources Canada, Residential End-Use Model, February 2005.

Within Canada, there are significant regional differences in space cooling requirements. As would be expected, the provinces with the warmest summers (e.g. Quebec, Ontario and Manitoba), or the most cooling degree-days (CDDs),[2] also had the greatest penetration of air conditioning units (see Table 3.2). Ontario, in particular, possesses 63 percent of all air conditioning units in Canada and accounted for 74 percent of the country's energy use for space cooling in 2003.

[1] Natural Resources Canada, *EnerGuide Room Air Conditioner Directory 2004*, Ottawa, 2004, p. 80.
[2] Consult the Appendix for the definition of CDDs.

continued

continued

Table 3.2 Explanatory Variables for Air Conditioning, Selected Provinces

	Average CDDs per Year	Penetration Rate for Air Conditioners – 2003	Share of Air Conditioners (%) – 2003	Share of Air Conditioning Energy Use (%) – 2003
Quebec	223	0.28	19	13
Ontario	242	0.65	63	74
Manitoba	178	0.65	6	7
Alberta	55	0.10	2	1
Canada	**171**	**0.38**	**100**	**100**

Source: Natural Resources Canada, Residential End-Use Model, February 2005.

Since 1990, there has been a sharp increase in the penetration of air conditioners. To establish the potential for additional energy growth, the following question was considered: How would energy use be affected if every home in Canada owned an air conditioner?[3] It is estimated that instead of 17.7 PJ in 2003, energy use for space cooling would have been 37.4 PJ – more than double the actual level. With its warm summers and low penetration of air conditioners, the impact would have been most noticeable in Quebec where energy use rose from 2.4 to 8.5 PJ in 2003. In the simulation, increases in energy use were marginal in cooler areas, such as the Atlantic provinces and the territories, where, even when all homes possessed "hypothetical" air conditioners, there was little occasion to use them.

Room and central air conditioners have been regulated under Canada's *Energy Efficiency Regulations* since 1995. Due to the increased efficiency of new units and the retirement of older, less efficient units, between 1990 and 2003, growth in space cooling energy use was about 30 percent lower than it otherwise would have been.[4] Stricter regulations for room air conditioners were introduced in April 2003 and new regulations for central air conditioners are expected to come into effect 26 January 2006. Given the rapid penetration of air conditioning units in recent years, and the potential for additional penetration, these regulations should help to moderate future growth in space cooling energy use.

[3] Weather conditions and the splits between room and central air conditioners were assumed to be the same as in 2003.

[4] See the factorization analysis for space cooling in the Analysis Tables for *Energy Efficiency Trends in Canada* at oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablesanalysis2/res_00_1_e.xls.

Chapter 4

Commercial/Institutional Sector

Definition: The commercial/institutional sector in Canada includes activities related to trade, finance, real estate, public administration, education and commercial services (including tourism). These activities have been grouped into ten activity types based on the North American Industry Classification System (see the text box below). Although street lighting is included in total energy use for the sector, it is excluded from the factorization analysis because it is not associated with floor space activity.

Changes to the Estimates for Commercial/Institutional Floor Space

This year, at the request of the OEE, Informetrica Limited redeveloped its commercial/institutional floor space estimates so they would be consistent with the North American Industry Classification System (NAICS). These changes are necessary to ensure that floor space data are compatible with energy and expenditure investment data, which are now collected using NAICS definitions. Due to this change in definitions, in this report, floor space data are reported for ten activity types instead of the nine building types used previously. As well, floor space from industrial facilities, which was previously attributed to commercial building types, has been excluded from the new floor space total.

Between 1990 and 2003, energy use in the commercial/institutional sector rose by 36 percent, or 313.9 PJ (Figure 4.1). As a result, energy-related GHG emissions (including those related to electricity and street lighting) grew by 45 percent, or 21.5 Mt. Without energy efficiency improvements, energy use would have increased by 37 percent between 1990 and 2003, instead of the observed 36 percent.

Health care and social assistance with an energy intensity of 3.1 gigajoules (GJ) per square metre (m^2) in 2003, was the most energy intensive activity type in the commercial/institutional sector. Educational services was the least energy intensive type at 1.3 GJ/m^2.

Figure 4.1 Energy Use, With and Without Energy Efficiency Improvements, 1990 and 2003 (petajoules)

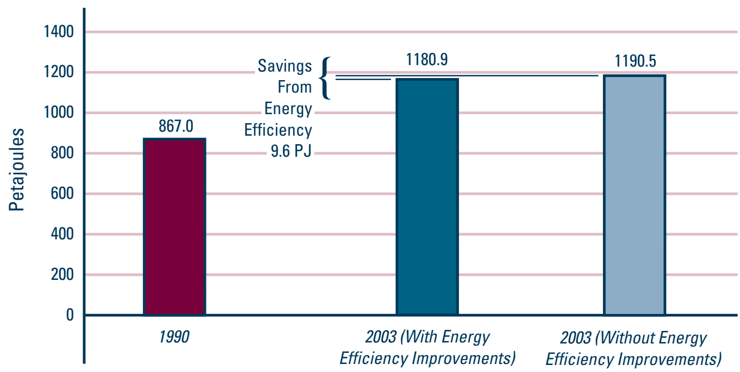
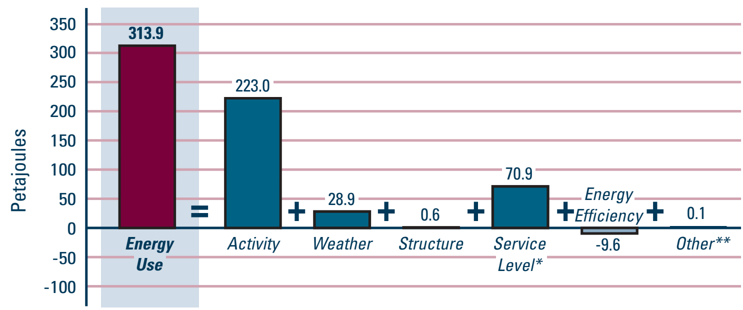


Figure 4.2 shows the various factors influencing changes in energy use and related GHG emissions:

- a 25 percent increase in activity (floor space), a by-product of growth in the Canadian economy,[1] led to an increase of 223.0 PJ in energy use and 13.1 Mt in GHG emissions;
- the winter in 2003 was colder than in 1990, and the summer was warmer than average. As a result, energy demand in the commercial/institutional sector for space conditioning increased by 28.9 PJ; GHG emissions rose by 1.7 Mt;
- structural changes in the sector (the mix of activity types) increased energy use by 0.6 PJ, which resulted in only a marginal change in GHGs;
- an increase in the service level of auxiliary equipment, or the penetration and usage rates of office equipment (e.g. computers, fax machines and photocopiers), led to a 70.9 PJ increase in energy use and a 4.2 Mt increase in GHG emissions; and
- improvements in the energy efficiency of the commercial/institutional sector saved 9.6 PJ of energy and 0.6 Mt of GHG emissions.

[1] There is often a delay of two to three years between the decision to build (determined by economic conditions at that time) and the physical completion of new floor space.

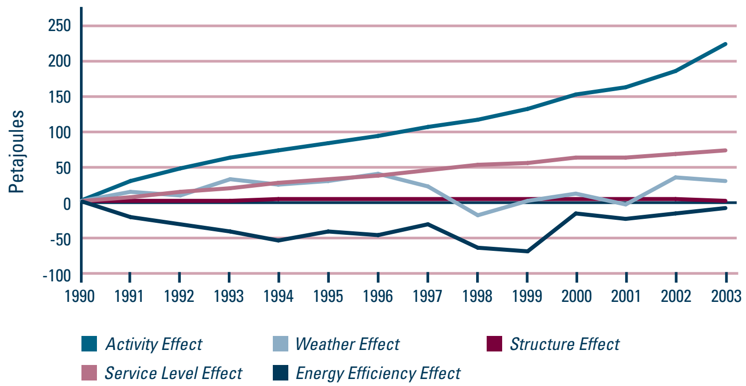
Figure 4.2 Impact of Activity, Weather, Structure, Service Level and Energy Efficiency on Energy Use, 1990–2003 (petajoules)



* "Service Level" refers to the service level of auxiliary equipment.
** "Other" refers to street lighting, which is included in "Energy Use" but is excluded from the factorization analysis.

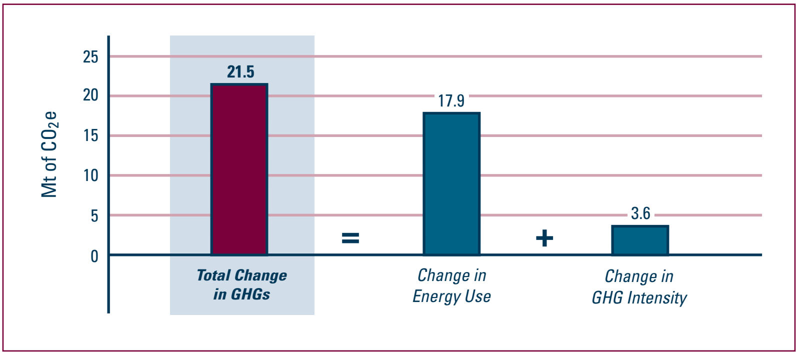
Figure 4.3 shows the effects of activity, weather, structure, service level and energy efficiency on energy use. The impact of structural changes was marginal and there were no clearly defined climate-based trends. Steady increases in activity and, to a lesser degree, service level contributed most to increases in energy use between 1990 and 2003. Energy efficiency has slowed down this rate of increase, but since 1999, this offset has been getting smaller. In the early part of the period, fuel switching away from oil towards natural gas helped to improve energy efficiency. After 1999, due to sharp increases in natural gas prices, there has been some fuel switching back towards light fuel oil, reversing some of these earlier efficiency gains. A spike in heavy fuel oil use between 2002 and 2003 has further contributed to this decline in energy efficiency.

Figure 4.3 Changes in Energy Use Due to Activity, Weather, Structure, Service Level and Energy Efficiency, 1990–2003 (petajoules)



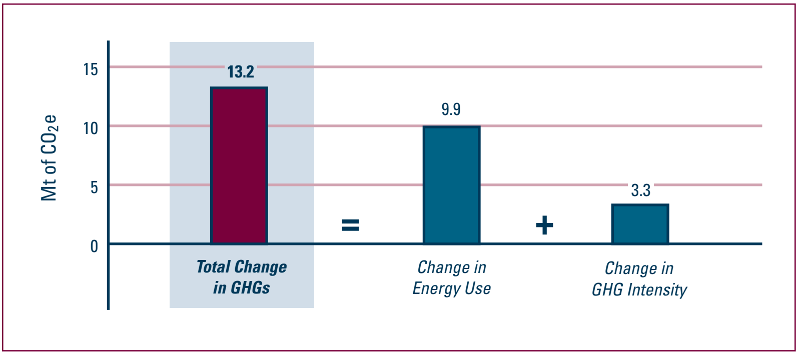
As illustrated in Figure 4.4, the commercial/institutional sector recorded a 45 percent, or 21.5 Mt, increase in GHG emissions, including those related to electricity, between 1990 and 2003. Most of the increase was due to higher energy consumption, though a rise in GHG intensity (caused by an increase in the use of heavy fuel oil) also contributed. Despite a decrease in the electricity share during the analysis period, a higher GHG intensity in electricity production contributed to the increase in GHG intensity in the commercial/institutional sector.

Figure 4.4 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, Including Electricity-Related GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



When electricity-related GHG emissions are excluded, GHG emissions were 51 percent, or 13.2 Mt, higher in 2003 than in 1990 (Figure 4.5). The increase in GHG intensity was due to a shift towards heavy fuel oil in the energy mix.

Figure 4.5 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, Excluding Electricity-Related Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



The Energy and GHG Benefits of Rooftop Gardens

A green roof or rooftop garden, where vegetation is grown on the roof, helps to reduce the heating and space cooling requirements for the building. In Europe, green roofs are an accepted technology that has been used for 20 years. For example, to promote the rooftop garden concept in Germany,[2] more than 40 percent of cities offer incentives to home and building owners. In Canada, however, the idea is fairly new and these types of roofs are less common.

The green roof technology is very flexible. It can be adapted to different climates[3] and is suitable for all types of buildings (i.e. residential, commercial and industrial) where the slope of the roof is up to 40 degrees. There are two types of green roofs: extensive and intensive. The extensive type, which requires little maintenance, involves the installation of a thin layer of soil to support vegetation (e.g. grasses) with a surface root system. The intensive type has a thicker layer of soil that can sustain a variety of plants including trees and bushes, making it ideal for garden terraces and other public areas. An intensive green roof requires an irrigation and drainage system; therefore, plans for an intensive green roof must be incorporated into the initial building design. Retrofitting a building with such a roof, after construction, would be too costly. An extensive roof, on the other hand, can be added onto an existing building.

To quantify the benefits of the green roof technology, the Institute for Research in Construction, a part of the National Research Council Canada (NRC), conducted a study using an NRC experimental facility in Ottawa with a rooftop area of 72 square metres (m^2). The area was divided into two parts: an extensive green roof was installed on one side, while the other side served as a reference for the experiment and was left unchanged. Table 4.1 summarizes the results of the project.

Table 4.1 Comparison of Heat Flows in a Green Roof and a Reference Roof, NRC, Ottawa, 2000–2002

	Reference Roof	Green Roof	Reduction (%)
Heat Gain	19.3 kWh/m²	0.9 kWh/m²	95
Heat Loss	44.1 kWh/m²	32.8 kWh/m²	26
Total Heat Flow	**63.4 kWh/m²**	**33.7 kWh/m²**	**47**

Source: Baskaran, B. and K. Liu, "Thermal Performance of Green Roofs Through Field Evaluation," NRC, Institute for Research in Construction, NRCC-46412, 2003.

[2] Tremblay, Marie-Christine, "Tendance : la toiture-jardin," www.decormag.com/decormag/client/fr/Chroniques/DetailNouvelle2.asp?idNews=2925&idSM=219, downloaded December 2004.

[3] SOPREMA, an international corporation specializing in the fabrication of plastomeric polymer-bitumen waterproof membranes for construction, civil engineering and environmental protection, "SOPRANATURE: Nature Rules the Roof," greenbuilding.ca/soprema/sopran-e.htm, downloaded December 2004.

The extensive green roof was very effective at reducing heat gain in the summer and spring by providing shading, insulation and evaporative cooling (moisture in the soil), which greatly improved energy efficiency. In the fall and early winter, by providing additional insulation, the green roof helped to reduce heat loss; however, once the ground froze and snow cover on the roof was established, there was little difference in energy efficiency performance between the two roofs. Overall, green roof technology reduces energy use and related GHGs for heating and air conditioning; however, as indicated in the study, the potential for energy savings from green roofs is greatest in areas with warmer weather.[4]

In addition to saving energy, a green roof protects a building's roof from the damaging effects of heat, reduces maintenance costs and may extend the service life of the roof underneath. Further, if enough green roofs are installed, they help to mitigate the effects of the "urban heat island," a dome of hot, polluted air covering an urban area that traps heat and raises outdoor air temperatures. According to Environment Canada, if 6 percent of existing rooftops in Toronto had green roofs, summer temperatures in that city would drop by 1° to 2°C. The NRC estimates that a 1°C drop in the urban heat island effect would result in a 5 percent decline in electricity demand per year for air conditioning and refrigeration, which would reduce energy expenditures by about $1 million.[5] Finally, the vegetation on green roofs filters and cleans ambient air and, of course, improves the aesthetic appeal of the immediate area.

Like any new technology, there are drawbacks to installing a green roof. Cost is one issue. Installation costs depend on a number of factors, including soil thickness, type of vegetation, as well as the choice of an irrigation and drainage system. For example, an extensive roof with an impermeable membrane and an irrigation system would cost[6] between US$129–258 per m^2 (US$12–24 per square foot [sq. ft.]), but prices vary. The green roof on the mixed-use Waterfall[7] Building in Vancouver was built in 2000–2001 at a cost of C$538,500, or about C$1615 per m^2 ($150 per sq. ft). The roof supports both intensive and extensive types of vegetation.

[4] Baskaran, B. and K. Liu, "Thermal Performance of Green Roofs Through Field Evaluation," NRC, Institute for Research in Construction, NRCC-46412, 2003.
[5] National Research Council Canada, "Government of Canada Reveals Major Greenhouse Gas Reductions and Air Quality Benefits from Widespread Use of 'GreenRoofs,'" Newsroom at www.nrc-cnrc.gc.ca/newsroom/news/2002/green02-print_e.html), 9 October 2002.
[6] Green Roofs for Healthy Cities, "About Green Roofs," www.greenroofs.org/index.php?page=aboutgreen, downloaded December 2004.
[7] Canada Mortgage and Housing Corporation, "Waterfall Building Green Roof Case Study," www.cmhc-schl.gc.ca/en/imquaf/himu/buin_019.cfm, downloaded February 2005.

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The risk of and associated repair costs due to water infiltration are another drawback of rooftop gardens. When there is a leak, it may not be noticed right away, which increases the risk of damage to the roof. Once detected, it can be difficult to locate the source of the problem, again raising the cost of repairs. These problems could be averted with the installation of an infiltration detection system, which would facilitate the detection and location of leaks, and a high-resistance waterproofing system, which would minimize the risk of a leak in the first place.[8]

The proportion of green roofs in Canada is still low compared with Europe, but there are a few scattered across the country:[9] the Novotel Hotel in Montréal, the Vancouver Library, and the head office of Ducks Unlimited in Winnipeg. Some commercial and residential green roof projects are underway, including 20 or so in the province of Quebec.

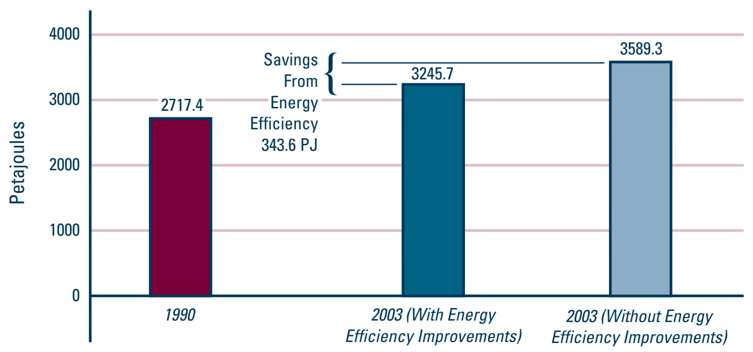
[8]Claudine Léger – roof and waterproofing specialist, 18th Conference of the Association québécoise pour la maîtrise de l'énergie, Sherbrooke, April 2004, downloaded from aqme.org/pros2003/activite/Congres/Congres18_2004/Conferences/ Claudine_Leger.pdf.
[9]Laroche, Dany et al., "Les toits verts aujourd'hui; c'est construire le Montréal de demain," [By building green roofs today, we are building the Montreal of tomorrow], Brief presented to the Office de consultation publique de Montréal, June 2004, downloaded from www2.ville.montreal.qc.ca/ocpm/pdf/41/8aa.pdf.

Chapter 5
Industrial Sector

Definition: The Canadian industrial sector includes all manufacturing industries, all mining activities, forestry and construction.

Between 1990 and 2003, industrial energy use increased by 19 percent, or 528.3 PJ (Figure 5.1). As a result, industrial energy-related GHGs (including those related to electricity) increased by 19 percent, or 27.2 Mt. Without improvements in energy efficiency, energy use would have increased by 32 percent between 1990 and 2003, instead of the observed 19 percent.

Figure 5.1 Energy Use, With and Without Energy Efficiency Improvements, 1990 and 2003 (petajoules)

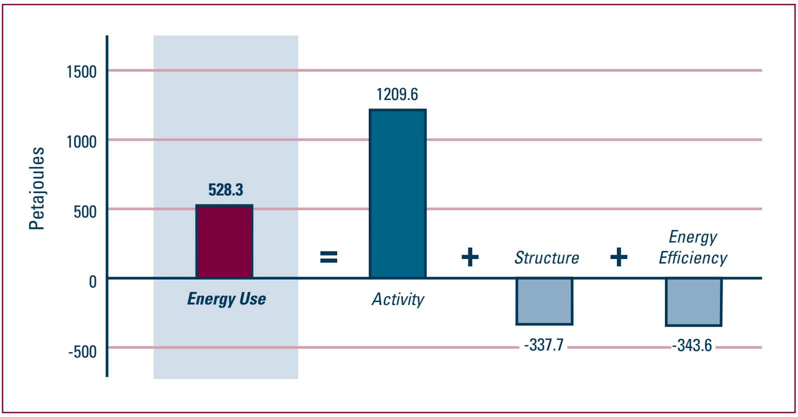


The pulp and paper industry accounted for 26 percent of sectoral energy use in 2003. Yet, due to the large share of biomass in the fuel mix, it was responsible for only 14 percent of energy-related GHG emissions.

As Figure 5.2 indicates, the following influenced the change in energy use and related GHGs:

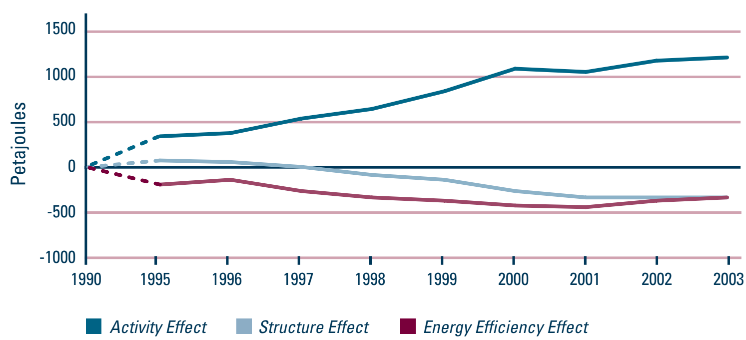
- a 45 percent increase in industrial activity (i.e. a mix of GDP, gross output and production units) resulted in a 1209.6 PJ increase in energy use and a corresponding 62.9 Mt increase in GHG emissions;
- structural changes in the industrial sector; specifically, a relative decrease in the activity share of energy intensive industries helped the sector to reduce its energy use and GHG emissions by 337.7 PJ and 17.6 Mt, respectively. Note that industries that consume more than 6 MJ per dollar of GDP (e.g. pulp and paper, petroleum refining and lime) represented 42 percent of industrial activity in 1990, but accounted for 25 percent in 2003; and
- improvements in the energy efficiency of the industrial sector avoided 343.6 PJ of energy use and 17.9 Mt of GHG emissions.

Figure 5.2 Impact of Activity, Structure and Energy Efficiency on Energy Use, 1990–2003 (petajoules)



Between 1990 and 2003, the impact of activity on energy use in the industrial sector increased substantially (Figure 5.3). Between 1995 and 2003, activity increased in all years except 2001, when Canadian industry faced an economic downturn. From 1995 to 2003, energy efficiency worked as an offset to the increase in energy use due to activity; however, this offset has been eroding since 2001. Between 2000–2003, increases in energy intensity in industries such as upstream mining and smelting and refining (excluding aluminum) have masked the progress made by other industries, helping to explain this decline in energy efficiency. Other contributing factors include a shift towards fuels such as biomass that require more input energy to achieve the same amount of useful energy and lower levels of capacity utilization in the sector as a whole (see text box on page 31). The structure effect shows that growth in Canadian industry favoured energy intensive industries until 1997, when a shift towards less energy intensive industries helped to offset increases in energy use due to activity.

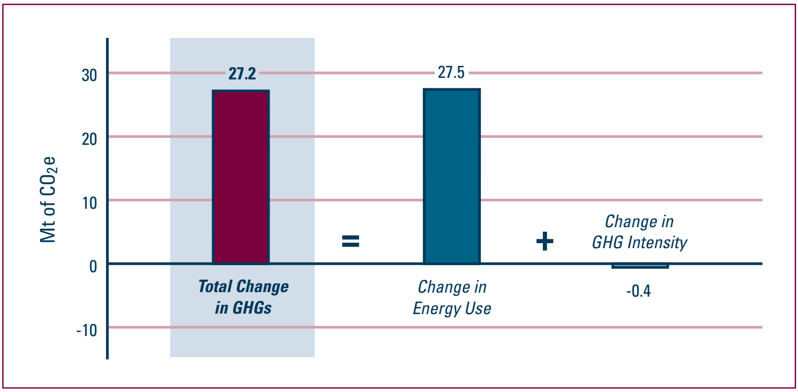
Figure 5.3 Changes in Energy Use Due to Activity, Structure and Energy Efficiency, 1990–2003* (petajoules)



* For the 2001 reporting year, the Industrial Consumption of Energy Survey was converted to NAICS. Statistics Canada, at the request of the OEE, revisited the historical series and developed NAICS-based industrial data for 1990 and 1995 to 2000. NAICS-based data for many industries are not currently available for 1991 to 1994, hence the gap in the analysis for this period.

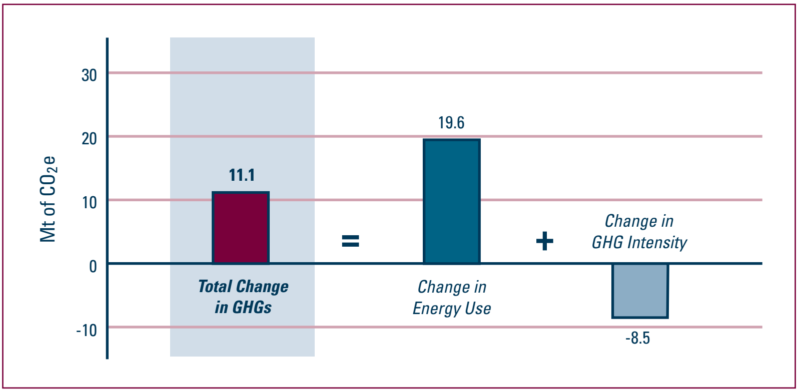
As Figure 5.4 shows, GHG emissions from the industrial sector, including GHGs related to electricity, were 19 percent, or 27.2 Mt, higher in 2003 than in 1990. This increase in GHGs was driven mainly by higher energy consumption. The change in GHG intensity was small because fuel switching towards less GHG intensive fuels in the industrial sector was offset by a higher GHG intensity in electricity production.

Figure 5.4 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, <u>Including</u> Electricity-Related GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



When GHG emissions related to electricity are excluded, GHG emissions increased by 11 percent, or 11.1 Mt, between 1990 and 2003 (Figure 5.5). The relative increase in the use of biomass and declines in the use of heavy fuel oil, coke and coke oven gas led to a 7 percent decrease in GHG intensity between 1990 and 2003.

Figure 5.5 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, <u>Excluding</u> Electricity-Related GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



The Impact of Capacity Utilization on Energy Use

Capacity utilization measures the extent to which an industry is using its existing production capacity. Measured as a percentage of actual output compared with potential output, capacity utilization varies with production levels. In general, increases in capacity utilization are linked with decreases in energy intensity (energy per unit of output). This is because higher production in an existing facility allows the firm to utilize its resources more efficiently.

Energy use in a factory can be divided into two parts. First there is the fixed component to energy use, which does not change with production levels. It includes items such as space heating or lighting on a factory floor. It also includes equipment, such as blast furnaces, which consume a certain amount of energy even when not producing output. The variable component of energy use increases with production levels and includes such things as running production equipment more hours or bringing back into service older machines. In the short run, to meet increased demand for its products, the facility will utilize more of its available capacity. Variable energy use will increase at the same rate or slightly faster than production (older machines can be less efficient than newer models), whereas the fixed portion of energy will be spread out over more output. As a result, energy use should grow more slowly than production levels, lowering energy intensity.

Figure 5.6 displays the average capacity utilization rates for the industrial sector. Note that as the actual output increases towards the theoretical potential output of the existing facilities, capacity utilization levels approach 100 percent. Conversely, when production levels are reduced in existing facilities, capacity utilization falls. From a low in 1991–1992 of 78 percent (due to a recession), capacity utilization levels for industry have been trending upwards, peaking in 2000 at about 85 percent. In 2001, because of an economic slowdown, there was a relatively large decrease in the capacity utilization rate for industry. Rates remained at this level through 2003.

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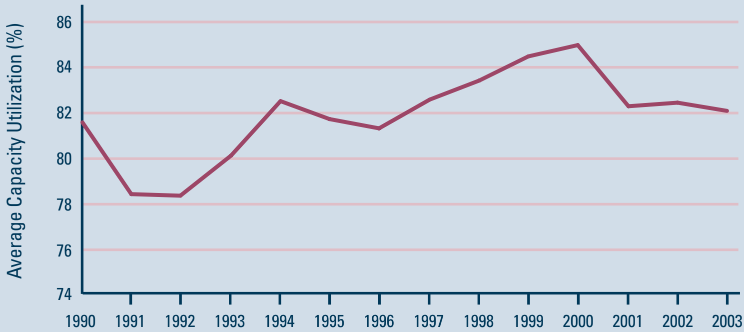
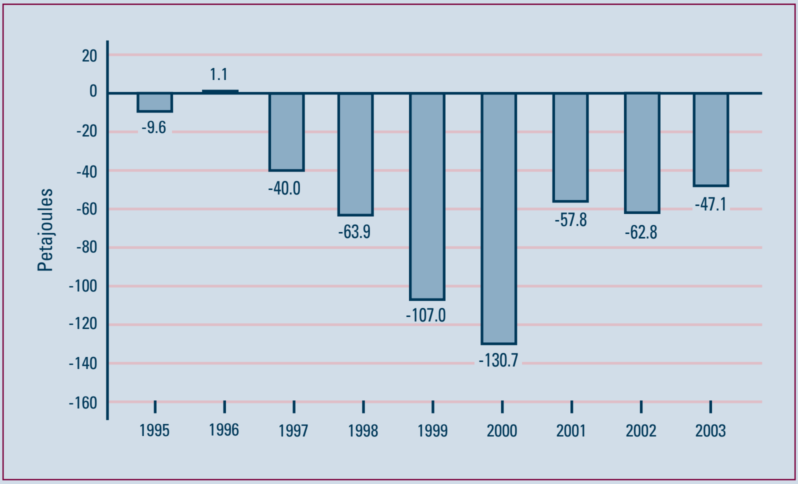
Figure 5.6 Average Capacity Utilization for the Industrial Sector, 1990–2003 (percent)



Source: Statistics Canada, *Canadian Economic Observer: Historical Statistical Supplement*, Ottawa, July 2004 (Cat. No. 11-210-X1B).

A factorization analysis was used to isolate the impact of increases in capacity utilization on changes in energy use relative to 1990 for the period 1995 to 2003 (see Figure 5.7). The findings support the hypothesis outlined earlier in this analysis – increases in capacity utilization have helped to significantly reduce energy use in the industrial sector. Consider, in 2000, when capacity utilization was at its peak, a 3 percentage point increase in capacity utilization since 1990 reduced energy use by 130.7 PJ (assuming all other factors were held constant). Energy savings associated with increases in capacity utilization fluctuate from year to year, illustrating how quickly firms can adjust their production levels. For example, between 1999 and 2000, an additional 23.7 PJ of energy were saved because of incremental capacity utilization. But between 2000 and 2001, the slowing economy lowered levels of production, reducing energy savings from economies of scale by 72.8 PJ.

Figure 5.7 Impact of Changes in Capacity Utilization on Energy Use Since 1990, 1995–2003 (petajoules)



Source: Calculated using information from Natural Resources Canada's Industrial End-Use Model.

In the current factorization methodology, the impact of capacity utilization is included in the measurement of the energy efficiency effect. In 2003, changes in capacity utilization accounted for about 14 percent of energy efficiency gains in the sector.

Chapter 6
Transportation Sector

Definition: The transportation sector includes activities related to the transport of passengers and freight by road, rail, marine and air. It also includes off-road vehicles, such as snowmobiles and lawn mowers.

Non-commercial airline aviation and off-road energy use are included in total transportation figures. However, they are not related to the movement of either freight or passengers and, as such, are not included in the factorization analysis.

Overview

Between 1990 and 2003, the amount of energy used by the transportation sector increased by 26 percent, from 1877.9 PJ to 2361.3 PJ. As a result, energy-related GHGs rose by 25 percent, from 135.0 Mt to 168.8 Mt.

As shown in Figure 6.1, passenger transportation was the transportation sub-sector that consumed the most energy in 2003 with 56 percent, while freight transportation accounted for 40 percent and off-road vehicles accounted for 4 percent. In terms of growth (Figure 6.2), however, freight transportation was the fastest growing sub-sector, accounting for 56 percent of the change in energy use for total transportation. Of interest, light and heavy trucks, with a combined increase of 404.2 PJ, represented 84 percent of all transportation energy growth.

Figure 6.1 Distribution of Transportation Energy Use by Sub-Sector, 2003 (percent)

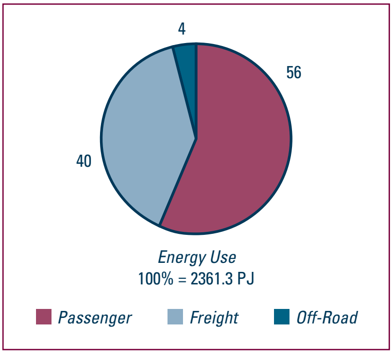
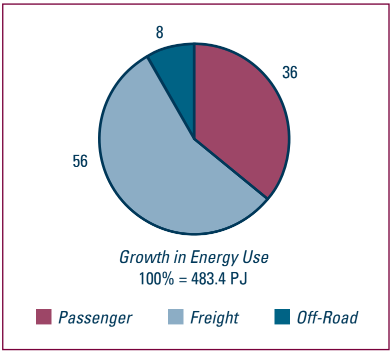


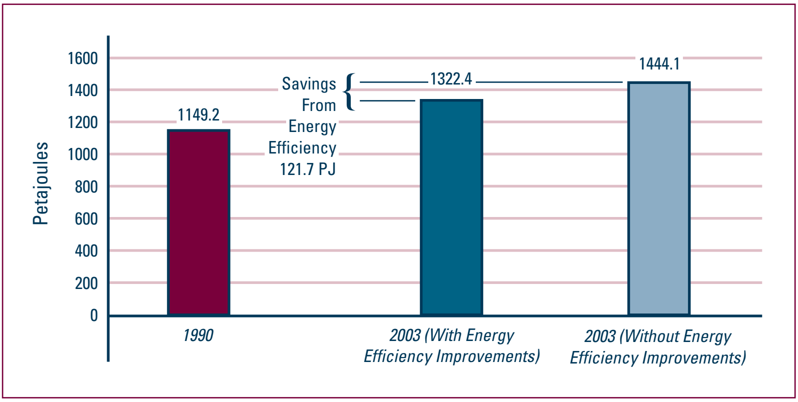
Figure 6.2 Changes in Transportation Energy Use by Sub-Sector, 1990–2003 (percent)



Passenger Transportation

As shown in Figure 6.3, the amount of energy used for passenger travel increased by 15 percent, rising from 1149.2 PJ in 1990 to 1322.4 PJ in 2003. Likewise, energy-related GHG emissions increased by 14 percent, from 81.9 Mt to 93.5 Mt.[1] Without energy efficiency improvements, energy use would have increased by 26 percent between 1990 and 2003, instead of the observed 15 percent.

Figure 6.3 Energy Use, With and Without Energy Efficiency Improvements, 1990 and 2003 (petajoules)



This year, a new historical series for car and light truck occupancy rates was developed. Since occupancy rates are critical for calculating passenger-kilometres (the activity variable for passenger transportation), this change has affected the factorization results presented in Figure 6.4. Compared with previous reports, the activity effect is noticeably larger and, as a result, energy efficiency improvements have also increased.

As Figure 6.4 indicates, the following influenced the change in energy use and related GHGs:

- a 27 percent increase in passenger-kilometres travelled resulted in a 289.2 PJ increase in energy use and a corresponding 20.4 Mt increase in GHG emissions. Light truck and air transportation led growth in passenger-kilometres, with respective increases of 73 percent and 52 percent during the analysis period;

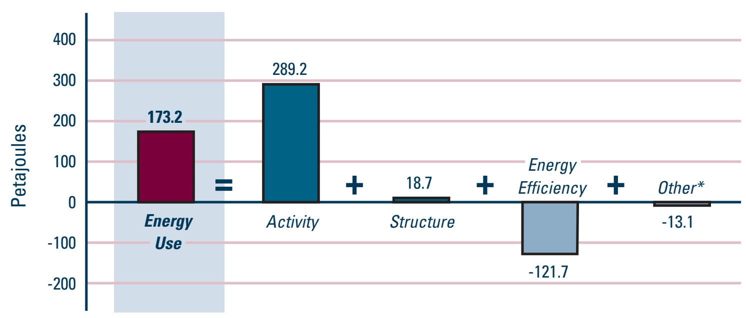
[1]This includes GHG emissions related to electricity use. Electricity accounts for only 0.2 percent of total passenger transportation energy use and is used, for the most part, for urban transit.

- changes to the mix of transportation modes, or the relative shares of passenger-kilometres held by air, rail and road, are used to measure changes in structure. The popularity of minivans and sport utility vehicles (SUVs) has considerably increased the activity share of light trucks compared to other modes, resulting in a 18.7 PJ increase in energy consumption and a 1.3 Mt increase in related GHG emissions; and

If horsepower in car engines had stayed at 1990 levels, today's models would be about 33 percent more efficient, saving owners more than $400 per 20,000 kilometres in fuel costs.

- improvements in the overall energy efficiency of passenger transportation saved 121.7 PJ of energy and 8.6 Mt of related GHGs. Despite the increasing popularity of larger and heavier light-duty vehicles with greater horsepower, the light-duty vehicle segment (e.g. cars, light trucks and motorcycles) of passenger transportation helped save 93.6 PJ, while air transportation avoided 23.2 PJ.

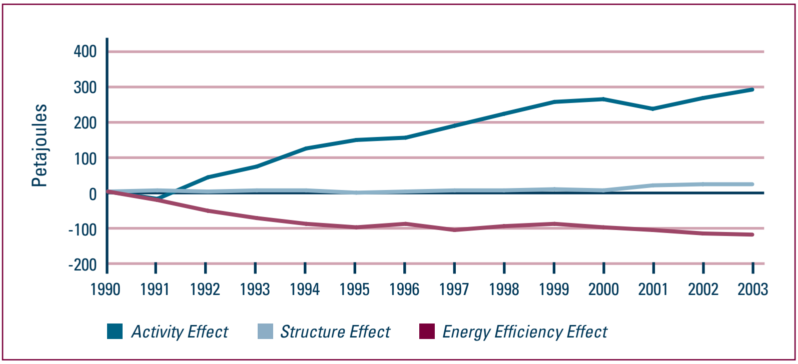
Figure 6.4 Impact of Activity, Structure and Energy Efficiency on Energy Use, 1990–2003 (petajoules)



* "Other" refers to non-commercial airline aviation, which is included in "Energy Use" but is excluded from the factorization analysis.

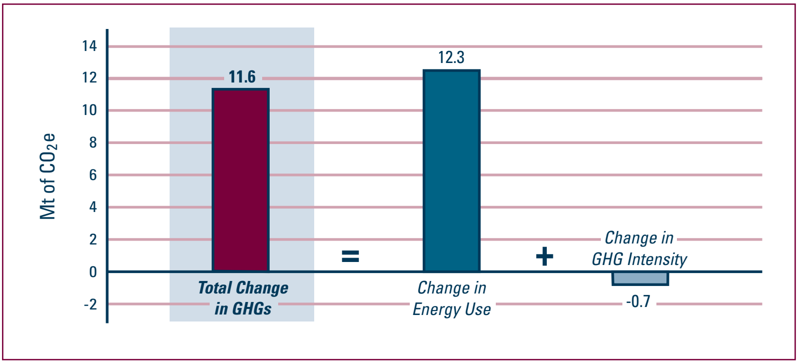
Figure 6.5 shows the evolution of passenger transportation activity, structure and energy efficiency on changes in energy use over the 1990–2003 period. Activity has been the principal reason for increased energy use in the passenger transportation sub-sector. The impact of structure (changes in the share of passenger-kilometres attributed to each mode) was also positive – due to more light truck passenger-kilometres – but smaller than that of activity. Due to the stabilization of lab-tested fuel consumption (litres per 100 kilometres [L/100 km]) for new cars and light trucks since 1985, energy efficiency improvements have changed little since about 1994.

Figure 6.5 Changes in Energy Use Due to Activity, Structure and Energy Efficiency, 1990–2003 (petajoules)



As Figure 6.6 shows, GHG emissions from passenger transportation were 14 percent, or 11.6 Mt, higher in 2003 than in 1990. This increase was driven mostly by increases in energy consumption, as the GHG intensity of the energy used decreased only slightly over the period.

Figure 6.6 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)

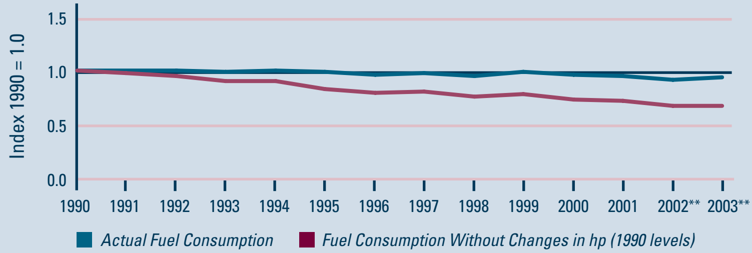


The Role of Fuel Consumption[2] in Choosing a Personal Vehicle

When consumers are choosing a new personal vehicle for purchase or lease, they consider a variety of factors, including performance, comfort, security, price and fuel consumption. Over the last decade, consumers have shown a strong preference for high-performance vehicles. In response, the automotive industry has traded off fuel consumption improvements in new vehicles for more powerful engines. As a result, the average horsepower (hp) of cars produced for the Canadian market increased by 32 percent, growing from 118 hp in the 1990 model year to 156 hp in the 2003 model year.

Lab-tested fuel consumption for cars stayed relatively stable between the 1990 and 2003 model years, improving by about 6 percent (8.1 L/100 km to 7.6 L/100 km). If performance levels (i.e. horsepower) in cars had stayed at 1990 levels, but all other features had evolved in the same way, then today's cars would be about 33 percent more efficient (see Figure 6.7) than current levels.

Figure 6.7 Fuel Consumption for Cars, With and Without Changes in Horsepower in the 1990 to 2003 Model Years* (index 1990 = 1.0)



* Results for light trucks are similar.
** Model Years 2002 and 2003 are estimates.

Source: Transport Canada, *Vehicle Fuel Economy Information System 1979–2001*, Ottawa, October 2003.

[2]In this analysis, fuel consumption refers to how many litres a vehicle will consume to travel 100 kilometres.

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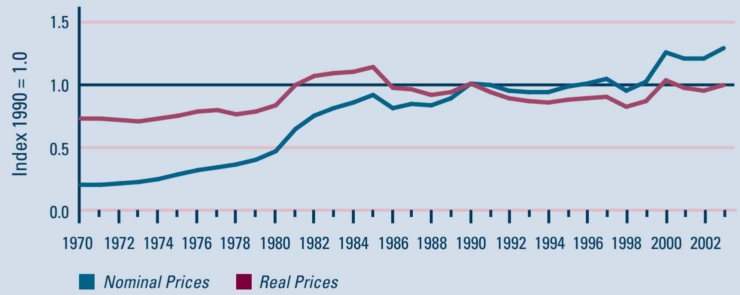
continued

Will fuel consumption become more important than performance to Canadians who are buying vehicles? That remains to be seen – the 2001 and 2002 Canadian Automobile Association (CAA) Vehicle Ownership Surveys[3] ranked reliability, performance and price as the three most important factors considered by consumers when choosing a car. Fuel consumption was ranked fourth in both survey years. This is encouraging, but further analysis shows that this high rating from consumers had more to do with a desire to reduce operating costs than concerns over the environment. In a 2002 Ipsos-Reid survey commissioned by Natural Resources Canada,[4] environmental concerns played only a small part in the decision to purchase or lease a new vehicle. One reason for this is Canadians do not seem to realize the effect that reducing their own fuel consumption has on total Canadian GHG emissions.

Fuel consumption first became important to consumers during the two oil shocks of the 1970s. Nominal gasoline prices, not adjusted for inflation, increased by 130 percent between 1979 and the peak in 1985 (see Figure 6.8). This led consumers to consider compact cars with smaller engines (4 cylinders instead of 6 or 8), which had lower operating costs (see Figure 6.9). These vehicles were first offered by Japanese carmakers, but North American manufacturers soon followed. However, as soon as gasoline prices stabilized in 1986, a strong consumer preference for performance and V6 engines re-emerged (Figure 6.9). There was also a marked shift towards larger vehicles. The minivan, which displaced large cars such as the station wagon, was introduced in 1987 and, shortly afterwards, the SUV began to increase in popularity. During the 1990s, stable gasoline prices kept operating costs low; as a result, to please consumers, manufacturers continued to sacrifice fuel consumption improvements in newer models for size and increased performance.

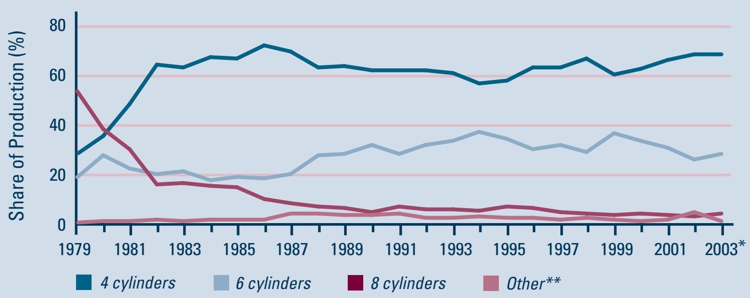
[3] Canadian Automobile Association, "Vehicle Ownership Survey Results," 2002 survey, downloaded from www.caa.ca/e/automotive/vos-results.shtml on 18 January 2005.
Desrosiers Automotive Consultants Inc., "The Need for Dialogue: A Perspective on Vehicle Safety," 2001 CAA survey, downloaded from www.desrosiers.ca/drobservations2002.html on 18 January 2005.
[4] Ipsos-Reid Corporation, *New Vehicle Owners/Lessors – Vehicle Purchase/Lease Behaviour*, preliminary report produced for Natural Resources Canada, 2003, p. 62.

Figure 6.8 Real and Nominal Motor Gasoline Prices, 1970–2003 (index 1990 = 1.0)



Source: Statistics Canada, *Energy Statistics Handbook*, Ottawa, August 2004 (Cat. No. 57-601-XIE) and Informetrica Limited, *TI Model and National Reference Forecast*, Ottawa, January 2005.

Figure 6.9 Number of Engine Cylinders in New Canadian Cars for the 1979 to 2003 Model Years (percent)



* Model Years 2002 and 2003 are estimates.
** "Other" includes 3, 5, 10 and 12 cylinders.

Source: Transport Canada, *Vehicle Fuel Economy Information System 1979–2001*, Ottawa, October 2003.

continued

continued

This trend towards more fuel intensive vehicles, however, is being countered by other factors. To address environmental and air quality concerns, several countries have, in recent years, implemented fuel consumption standards or GHG emissions targets for new vehicles. This has stimulated the development of a variety of new technologies such as electric and hybrid-electric vehicles, which are being introduced to the Canadian market. As well, since 2000, rising fuel prices, which make it more expensive to own and operate bigger, more fuel intensive vehicles, have forced consumers to re-evaluate their vehicle preferences. According to the above-mentioned Ipsos-Reid survey, once consumers have chosen a category or type of vehicle, they become more concerned about fuel consumption. It appears that some consumers are willing to pay a premium for efficient vehicles and lower emissions fuels (such as ethanol and biodiesel) as long as there is no compromise on reliability, comfort or performance.

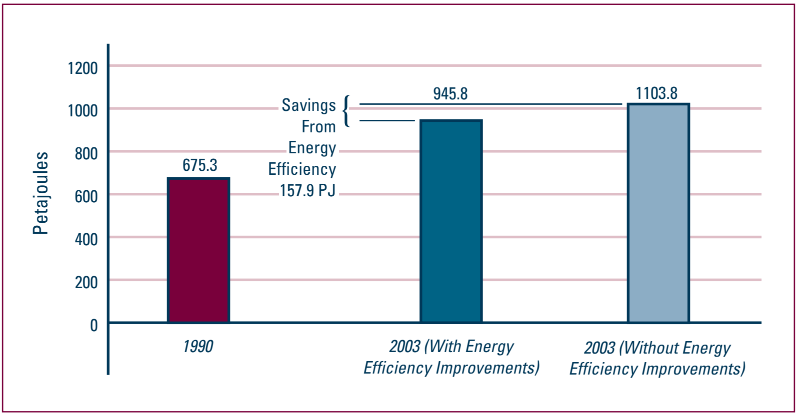
Freight Transportation

The freight sub-sector in Canada includes four modes: road (trucks), rail, marine and air. In 2003, road transportation accounted for 80 percent of the energy used by freight transportation, followed by marine at 11 percent, rail at 8 percent and air at 1 percent. Of the total GHG emissions from freight transportation, road produced 79 percent; marine, 11 percent; rail, 8 percent; and air, 1 percent.

In freight transportation, the share of energy use for trucks increased from 71 to 80 percent between 1990 and 2003. Overall, freight truck energy use (281.0 PJ) grew more than energy use for the freight sub-sector as a whole (270.5 PJ).

Between 1990 and 2003, energy use by freight transportation increased by 40 percent, or 270.5 PJ (Figure 6.10). As a result, energy-related GHGs produced by freight transportation were 40 percent, or 19.5 Mt, higher in 2003 than in 1990. Without energy efficiency improvements, energy use would have increased by 63 percent between 1990 and 2003, instead of the observed 40 percent.

Figure 6.10 Energy Use, With and Without Energy Efficiency Improvements, 1990 and 2003 (petajoules)



As Figure 6.11 indicates, the following influenced the change in energy use and related GHGs:

- a 46 percent increase in activity (the number of tonne-kilometres moved) was spurred by free trade and the deregulation of the trucking and rail industries. Increased activity resulted in a 302.8 PJ increase in energy use and a corresponding 22.1 Mt increase in GHG emissions;
- changes in the structure of freight transportation (shifts in activity between modes) – specifically, an increase in the share of freight moved by heavy trucks relative to other modes – was due to growth in international trade and customer requirements for just-in-time delivery. These changes resulted in the sub-sector using an additional 125.7 PJ of energy and emitting 9.2 Mt more GHGs; and
- improvements in the energy efficiency of freight transportation led to savings of 157.9 PJ of energy and 11.5 Mt of GHGs. Most of the improvements in freight energy efficiency occurred in heavy trucks and rail.

Figure 6.11 Impact of Activity, Structure and Energy Efficiency on Energy Use, 1990–2003 (petajoules)

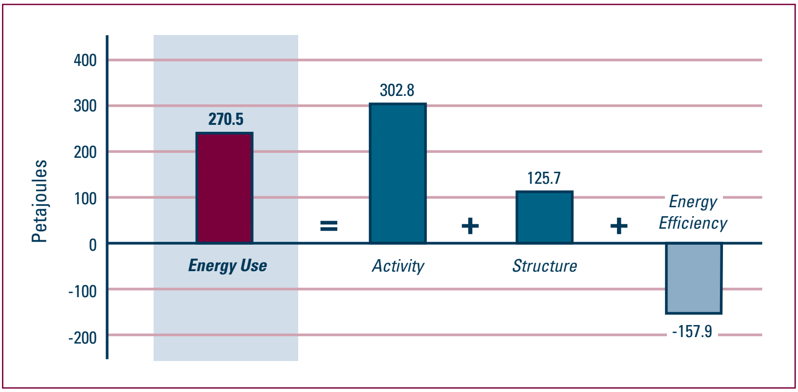
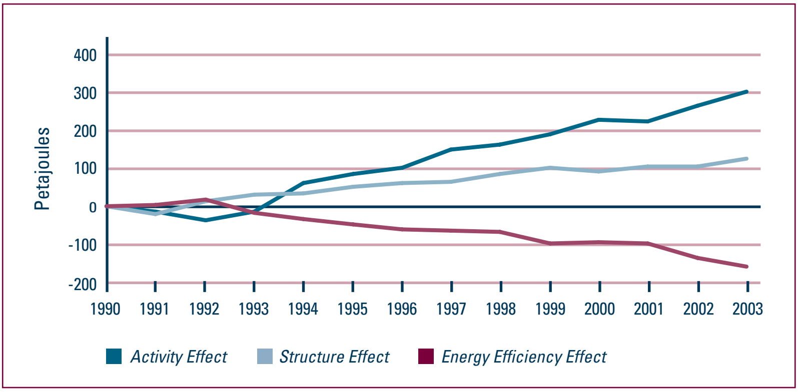


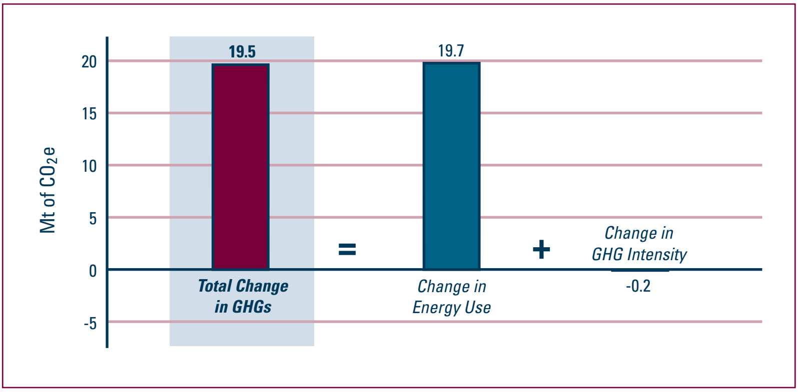
Figure 6.12 shows the evolution of freight transportation activity, structure and energy efficiency on changes in energy use over the 1990–2003 period. Though partially offset by significant improvements in energy efficiency, the steady growth in freight activity and the increased use of heavy trucks to move goods (structure) resulted in an increase in energy use by the freight sub-sector over the period.

Figure 6.12 Changes in Energy Use Due to Activity, Structure and Energy Efficiency, 1990–2003 (petajoules)



Increased energy consumption resulted in higher GHG emissions from freight transportation. This result is almost entirely due to increased energy consumption, since the GHG intensity of the energy used decreased only slightly over the period. As Figure 6.13 shows, GHG emissions from freight transportation were 40 percent, or 19.5 Mt, higher in 2003 than in 1990.

Figure 6.13 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)

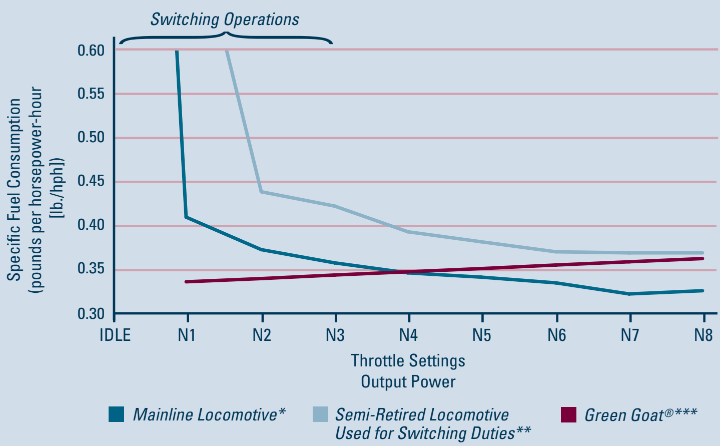


Freight Locomotives: Applications for Hybrid Technology

The Canadian freight rail mode has made significant improvements in energy intensity since 1990. Intensity declined from 0.34 to 0.22 megajoules per tonne-kilometre, or 35 percent, between 1990 and 2003. However, opportunities exist to reduce energy consumption even further. New technologies such as hybrid-electric locomotives, which would reduce energy consumption and related GHG emissions, may have practical applications in rail.

A locomotive typically has eight notches (throttle settings such as gears or speeds). Specific notches are suitable for specific tasks. For example, when hauling goods from point A to B, a train requires speed, so it operates in higher notches. In the switching yards, however, where trains are assembled (cars attached to a locomotive) and railway cars are moved from one track to another, a locomotive will spend about 95 percent of its duty cycle idling or in notches one, two or three. Hybrid locomotive technology is well suited to stop-and-go conditions in rail yards. The engine does not idle and is more efficient than a diesel engine when a locomotive is operating in lower notches (see Figure 6.14).

Figure 6.14 Locomotive Fuel Consumption Characteristics by Throttle Setting and Engine



* GM-EMD SD-75 710G3EC, 16 cylinders and 4300 hp. In idle mode, the specific fuel consumption is 2.3 lb./hph.
** GM-EMD SD-40 645E3, 16 cylinders and 3000 hp. In idle mode, the specific fuel consumption is 2.0 lb./hph.
*** RailPower Technologies Corp. Green Goat®, 2000 hp equivalent Electric Hybrid Switcher.

Source: Dun, Robert and Peter Eggleton, "Influence of Duty Cycles and Fleet Profile on Emissions from Locomotives in Canada," prepared for Transport Canada's Transportation Development Centre, June 2002, and personal communication with Ray Cousineau, RailPower Technologies Corp., February 2005.

On their own, railway switching operations do not generate revenue, but they do play a key role in assembling shipments so loads get to their destinations in a timely manner. For this task, railway companies can use switcher locomotives, which are designed to be heavy to maximize traction. However, yard operators have been reluctant to pay for new (about US$1.2 million) or remanufactured equipment (about US$750,000) built especially for switching work. Instead, they often take old, semi-retired locomotives with zero capital cost and convert them to switching duties (around US$250,000 to maintain for 8 to 10 years).

RailPower Technologies Corp., a Canadian company, has developed and patented hybrid technology for yard and road switcher locomotives that could change current practice. Hybrid models are remanufactured from existing locomotives. The large diesel engine and generator in a locomotive are replaced with a significantly smaller engine (72–96 percent less horsepower), which charges a large battery stack, while power levels are regulated by an energy management system. A 2000 hp equivalent hybrid yard switcher currently sells for about US$750,000. However, a hybrid switcher has a number of advantages over conventional switchers: providing substantially more tractive power, it can do at least 30 percent more work; it is more reliable so maintenance costs are much lower; and the smaller engine significantly reduces fuel costs. Given these benefits, the capital cost of a hybrid locomotive would be recouped in less than three years.[5]

In addition to being cost-effective, the configuration of RailPower's hybrid locomotive leads to significant reductions in energy use and related GHG emissions, when compared to a locomotive converted to switching duties. RailPower's operating data show that one of their hybrid models (the Green Goat®) has the potential to reduce fuel consumption and related GHG emissions by 40 to 70 percent and to decrease criteria air contaminants, such as nitrogen oxides and diesel particulates, by 80 to 90 percent.[6] Reductions are greatest when switching work is heavy-duty in nature or carried out on an on-going basis. If the stock of 500 switchers in Canada was replaced with hybrid models, it would result in GHG savings of approximately 135.5 kilotonnes per year.[7]

[5] Personal communication with Nigel Horsley, RailPower Technologies Corp., 11 January 2005.

[6] RailPower Technologies Corp., "Hybrid Locomotives: Benefits," www.railpower.com/products_hl_benefits.html, downloaded 18 January 2005, and personal communication with Nigel Horsley, RailPower Technologies Corp., 26 January 2005.

[7] The "hybridized" remanufactured units are assumed to reduce GHG emissions by 271 tonnes per unit per year.

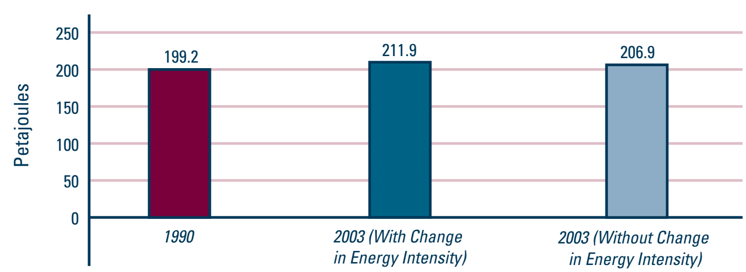
Chapter 7
Agriculture Sector

Definition: The agriculture sector in Canada includes all types of farms, including livestock, field crops, grain and oilseed farms. The agriculture sector also includes activities related to hunting and trapping. The data in this chapter are related to energy used for farm production and include energy use by establishments engaged in agricultural activities and in providing services to agriculture.

The Prairie provinces consumed 52 percent of secondary agriculture energy use in 2003, down from a share of 62 percent in 1990.

Between 1990 and 2003, energy use in the agriculture sector increased by 6 percent, or 12.7 PJ (Figure 7.1). As a result, the sector's energy-related GHGs (including those related to electricity) increased by 9 percent, or 1.2 Mt. Energy efficiency trends are not reported for the agriculture sector due to a lack of sufficiently disaggregated data; instead, trends in energy intensity (the ratio of energy use to activity) are reported.

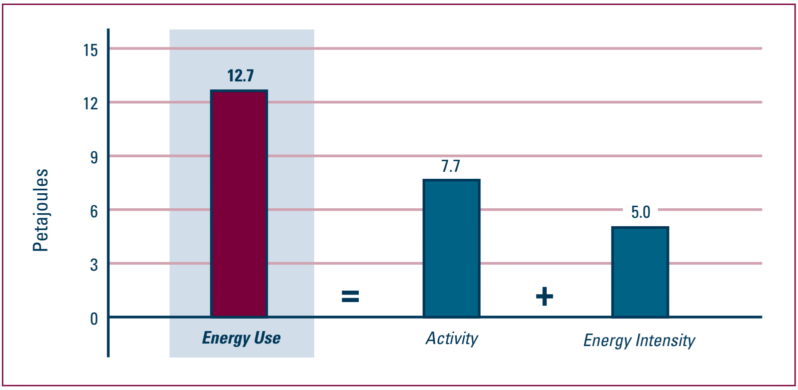
Figure 7.1 Energy Use, With and Without Change in Energy Intensity, 1990 and 2003 (petajoules)



As Figure 7.2 indicates, the following influenced the change in energy use and related GHGs:

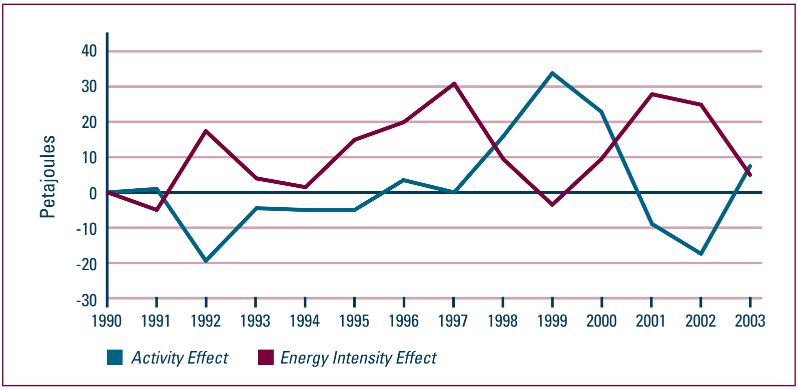
- a 4 percent increase in activity (agriculture GDP in constant 1997 dollars) resulted in a 7.7 PJ increase in energy use and a corresponding 0.5 Mt increase in GHG emissions; and
- a 2 percent increase in the energy intensity of the agriculture sector resulted in a 5.0 PJ increase in energy use and a 0.4 Mt increase in GHG emissions.

Figure 7.2 Impact of Activity and Energy Intensity on Energy Use, 1990–2003 (petajoules)



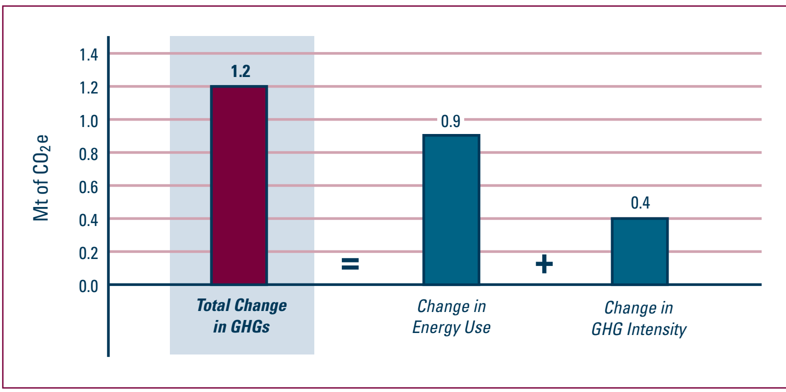
As illustrated in Figure 7.3, there are no clear trends in either activity or energy intensity. In particular, changes in energy intensity appear to be quite volatile, fluctuating sharply from year to year. In 2003, after several years of steady decline, activity rebounded, pulling down energy intensity.

Figure 7.3 Changes in Energy Use Due to Activity and Energy Intensity, 1990–2003 (petajoules)



As Figure 7.4 shows, GHG emissions (including electricity-related GHG emissions) from the agriculture sector were 9 percent, or 1.2 Mt, higher in 2003 than in 1990. This rise was driven by increases in both energy consumption and in the GHG intensity of the energy used. A higher GHG intensity was due to an increase in the GHG intensity of electricity production and a relative increase in the consumption of more GHG-intensive fuels. For example, diesel increased its share of energy use from 36 percent in 1990 to 41 percent in 2003.

Figure 7.4 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)

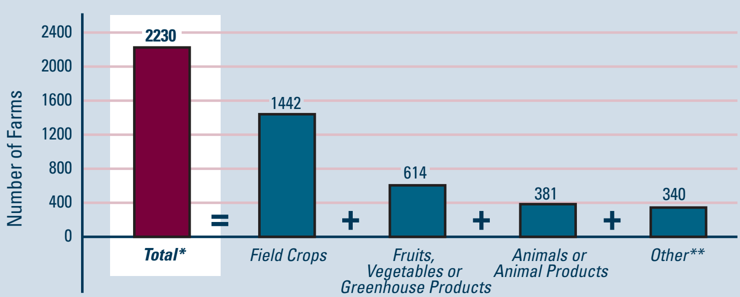


The Energy Use Impacts of Organic Agriculture

Organic agriculture is a farming method that minimizes the use of chemicals in the production process. It aims to produce crops with a high nutritional value and to improve the long-term fertility and sustainability of farmland. Organic farms must meet voluntary standards established by the Canadian General Standards Board, which include, among other principles, halting the use of synthetic pesticides, fertilizers that contain prohibited synthetic substances, and Genetically Modified Organisms.[1]

In Statistics Canada's *2001 Census of Agriculture*, organic farming was surveyed for the first time. It was found that 2230 farms produced at least one type of certified organic agricultural product. Field crops (e.g. grains, oilseeds, etc.) were the most popular category of organic farming, followed by fruits, vegetables or greenhouse products, animal or animal products and other (e.g. maple syrup, herbs, etc.) [see Figure 7.5]. Retail sales in the organic sector have grown 20 percent per year for the past 10 years, and are expected to reach $3.1 billion by 2005.[2] Though the number of organic producers increased by 176 percent between 1992 and 2001,[3] organic farms made up less than 1 percent of total farms in 2001.[4]

Figure 7.5 Number of Certified Organic Farms by Product, 2001



* The total is not additive because some farms produce more than one type of organic product.
** "Other" includes maple syrup, herbs, etc.

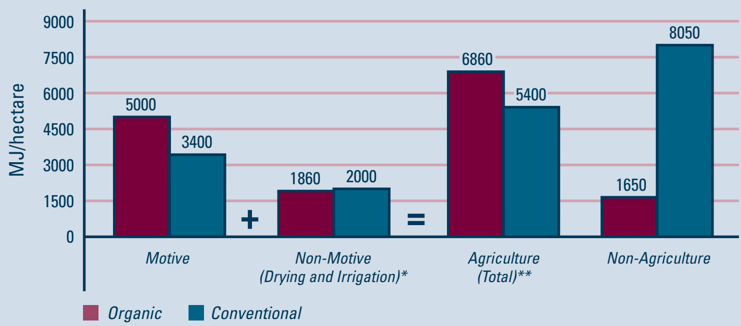
Source: Statistics Canada, *2001 Census of Agriculture*, Ottawa, May 2002 (Cat. No. 95FO301XIE).

[1] Canadian General Standards Board, *Organic Production Systems Part 1: General Principles*, Ottawa, June 2004.
[2] Agriculture and Agri-Food Canada, "Canada's Agriculture, Food and Beverage Industry, Canada's Organic Industry," Factsheet Series, ats-sea.agr.gc.ca/supply/3313_e.htm, downloaded November 2004.
[3] Organic Agriculture Centre of Canada, "Organic Statistics 2003," www.organicagcentre.ca/DOCs/CANADA%20Organic%20Stats%202003.pdf, downloaded November 2004.
[4] Agriculture and Agri-Food Canada, downloaded November 2004.

On organic farms, when the use of synthetic pesticides and fertilizers is halted, the land may be tilled more intensively, with additional crop rotations to control weeds. This has implications for energy use, as tractors and other farm machinery are used more often to till the fields. The elimination of machinery passes to apply fertilizers and pesticides, however, will partially offset this rise. In addition to increased energy costs, organic farms producing fruits and vegetables have reported lower crop yields. However, some organic products command higher prices, which partially or fully compensate the producer for this reduced output. As a result, about half of the organically grown fruit and vegetable crops in Canada generate a higher gross return per hectare than conventional methods.[5]

To evaluate differences in energy use on organic and conventional farms, consider the production of spring barley on Danish organic farms (see Figure 7.6). The organic system uses mechanical weed control instead of pesticides, and spreads slurry[6] instead of using synthetic fertilizers. Compared to conventional methods, it uses more energy per hectare for motive[7] and less for drying and irrigation purposes (non-motive agriculture energy use). Though total energy use was higher, yields were 28 percent lower, indicating a higher energy intensity, or energy per unit of GDP (assuming similar prices), on this organic farm.

Figure 7.6 Energy Use for Spring Barley Grown on Irrigated Sandy Soil in Denmark, 2002 (megajoules per hectare)



* Includes energy used for the production of electricity.
** Excludes lubricants.

Source: Dalgaard et al., "Energy Balance Comparison of Organic and Conventional Farming," *Organic Agriculture: Sustainability, Markets and Policies*, OECD, 2003.

[5]Statistics Canada, "Organic Fruit and Vegetable Production: Is it For You?," *Vista on the Agri-Food Industry and the Farm Community*, Ottawa, September 2002 (Cat. No. 21-004-XIE).
[6]A thick, liquid mixture of water and manure.
[7]Dalgaard et al., "Energy Balance Comparison of Organic and Conventional Farming," *Organic Agriculture: Sustainability, Markets and Policies*, OECD, 2003.

continued

continued

Organic farming also has impacts on energy use in non-agriculture sectors such as industrial and transportation (see Figure 7.6). Decreased demand for pesticides and fertilizers will lower production levels and energy use related to the manufacture (includes feedstocks and energy to operate the machinery) and transport of these conventional agriculture inputs. Note that these reductions in non-agriculture energy use completely offset increases in agriculture energy use due to additional tillage.

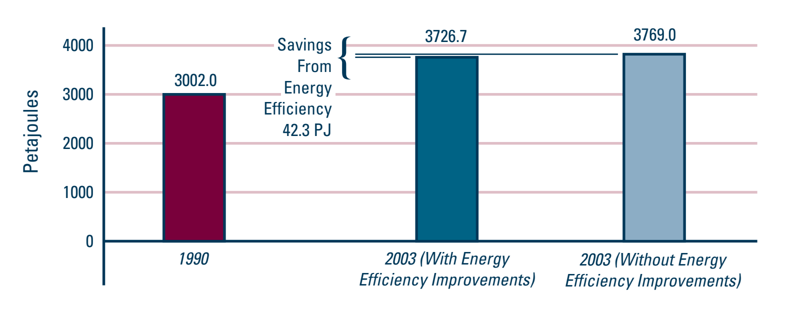
Organic farming accounts for a small segment of the market in Canada, and the impact on total agriculture energy use is limited. However, based on the Danish example, continued growth in the size and number of organic farms could increase agriculture energy use and intensity. Reductions in energy used to produce and transport fertilizers and pesticides may offset increased energy use in agriculture production, which could result in a net decline in secondary energy use. Making generalizations about organic agriculture is difficult, because there are many different farms producing a wide variety of crops using a wide variety of techniques. This analysis gives an idea of the differences between organic and conventional farming with respect to energy use, but more information needs to be collected before definite conclusions are drawn.

Chapter 8
Electricity Generation Sector

Definition: The electricity generation sector includes the transformation of other forms of energy (fossil fuels, hydro, nuclear, etc.) into electrical energy by utilities and industrial generators.

Between 1990 and 2003, energy used to generate electricity increased by 24 percent, or 724.8 PJ (Figure 8.1). As a result, energy-related GHGs increased by 38 percent, or 35.8 Mt. Without improvements in energy efficiency, energy use would have increased by 26 percent between 1990 and 2003, instead of the observed 24 percent.

Figure 8.1 Energy Use, With and Without Energy Efficiency Improvements, 1990 and 2003 (petajoules)

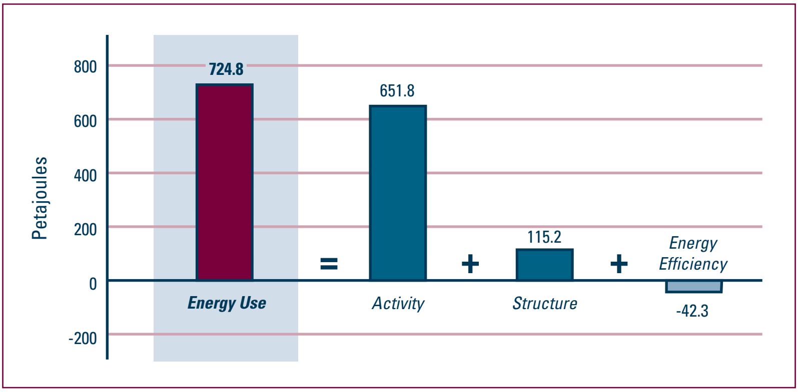


As Figure 8.2 indicates, the following influenced the change in energy use and related GHGs:

- a 21 percent increase in the amount of electricity generated led to a 651.8 PJ increase in energy and a corresponding 22.8 Mt increase in GHG emissions;
- structural changes in the electricity generation sector (the mix of energy sources used to generate electricity) – in particular, a relative decrease in the share of hydro production combined with higher shares for more energy-intense coal and natural gas generation – resulted in an 115.2 PJ increase in energy use and a corresponding 4.0 Mt rise in GHG emissions; and
- improvements in the energy efficiency of the electricity generation sector saved 42.3 PJ of energy and 1.5 Mt of GHG emissions.

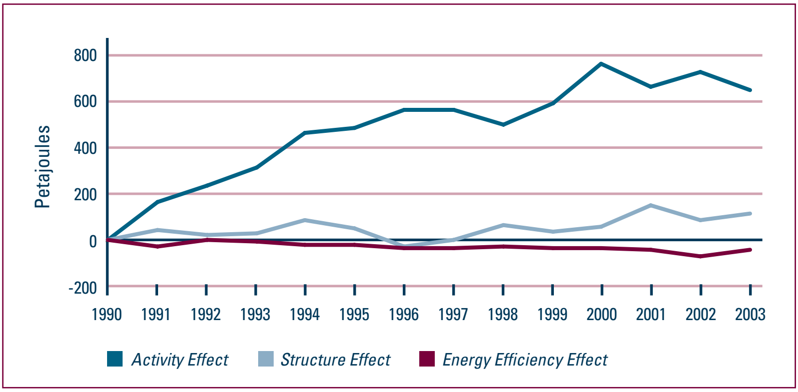
Natural gas increased its share of fuels used to generate electricity from 3 to 9 percent between 1990 and 2003.

Figure 8.2 Impact of Activity, Structure and Energy Efficiency on Energy Use, 1990–2003 (petajoules)



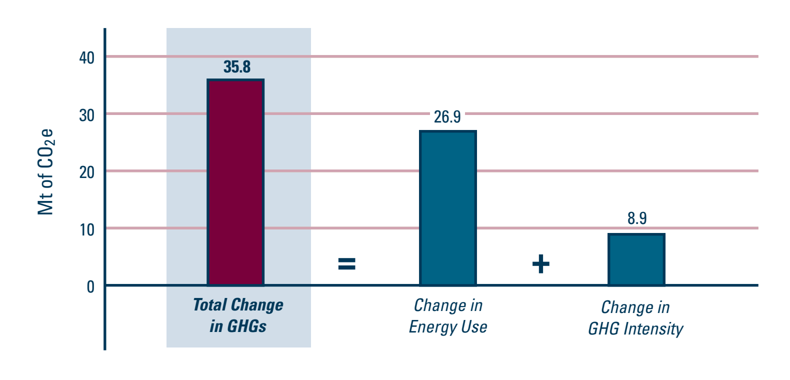
Overall, as Figure 8.3 shows, the increase in energy consumption between 1990 and 2003 was largely driven by the increase in activity, or the amount of electricity generated to meet the needs of the end-use sectors. The effect of structure on energy use in the electricity generation sector has varied with changes to the fuel mix; that is, the use of relatively more or less energy-intense fuels. For instance, a slight increase in the structure effect between 2002 and 2003 reflects a decrease in the share of hydro combined with relative increases in the use of natural gas and heavy fuel oil to generate electricity. The change in the energy efficiency effect reflects a decline in the efficiency with which most source fuels are converted to electricity.

Figure 8.3 Changes in Energy Use Due to Activity, Structure and Energy Efficiency, 1990–2003 (petajoules)



As Figure 8.4 shows, GHG emissions from the electricity generation sector were 38 percent, or 35.8 Mt, higher in 2003 than in 1990. The increase was driven by higher energy consumption combined with an increase in the GHG intensity of energy used. A relative increase in electricity produced from coal and natural gas, and a relative decrease in nuclear and hydro, resulted in a 13 percent rise in GHG intensity. This intensity effect is higher than in last year's report because of an increase in the relative share of heavy fuel oil between 2002 and 2003.

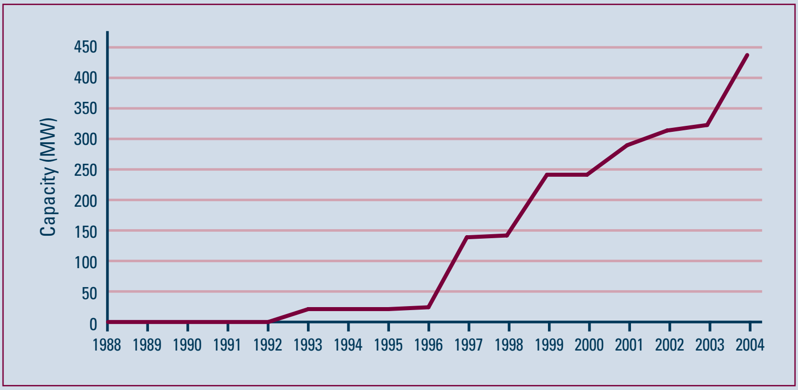
Figure 8.4 Influence of Energy Use and GHG Intensity on the Change in GHG Emissions, 1990–2003 (megatonnes of CO_2 equivalent)



Wind Power: A Small But Growing Component of the Canadian Electricity Supply

In 1988, the Northwest Territories Power Corporation installed a small 20 kilowatt (kW) wind-powered generator, the first in Canada, to service the electricity needs of the Hamlet of Igloolik, Nunavut. Installed capacity for wind energy, a renewable and pollution-free source of electricity, grew from this single generator in Nunavut to 23 megawatts (MW) across Canada in 1996, and then to 436 MW by 2004 (see Figure 8.5). In 2004 alone, wind-powered generation increased by about 36 percent. Despite the progress made since 1996, in 2002, wind-generated electricity still represented about 0.1 percent of total electricity production in Canada. Among International Energy Agency (IEA) countries, the average was about 0.5 percent.[1]

Figure 8.5 Installed Wind Capacity in Canada, 1988 to 2004 (megawatts)



Source: Compiled from the Canadian Industrial Energy End-Use Data and Analysis Centre's Renewable Energy Database and the Canadian Wind Energy Association's listing of Canadian Wind Farms.

Although there has been significant growth in wind-powered electricity, there are still some drawbacks to its use in Canada. Wind, by definition, is an intermittent power source (i.e. it does not blow all of the time). Since it is unreliable, wind cannot be used to meet peak electricity demand. As well, wind power has not always been well received by the public; some consider wind turbines to be noisy and damaging to the natural views of an area. Both of these perceived characteristics, disputed by wind advocates, create a "not in my backyard" mentality.

[1] Calculated using IEA Energy Balances, Paris, 2004 edition.

The economics of wind generation have improved in recent years. First, the cost of installing wind generation capacity has fallen. According to the American Wind Energy Association (AWEA), advances in electronic monitoring and wind blade designs, and the increased physical size of the towers have contributed to a decrease in wind power installation costs. A typical wind-powered generator in 1981 had a rated capacity of 25 kW and cost about US$2600 per kW installed. By 2000, the typical generator installed was 66 times bigger with a rated capacity of 1650 kW and cost 70 percent less at US$790 per kW installed.[2]

The second trend is with respect to the size of the facilities. Firms are taking advantage of economies of scale by installing more turbine generators per wind farm. In Canada, from 1988 to 1996, 18 percent of wind power projects had more than five generators installed. By 2004, this figure had increased to about 31 percent of wind power projects. According to AWEA, larger wind farms decrease the average cost per kilowatt-hour of electricity by about 40 percent because of the economic efficiencies gained in sharing maintenance costs and other resources among many wind generators.[3]

As to future prospects for wind generation in Canada, initiatives from Natural Resources Canada are expected to add 1000 MW of new capacity between 2002 and 2007.[4] The Canadian Wind Energy Association (CANWEA) is even more ambitious; it would like to add 10,000 MW by 2010. If renewable, non-GHG producing wind power was to displace conventional fuels used for electricity generation – in particular, coal, oil and natural gas – it would result in significant energy and GHG savings.[5] For example, if CANWEA's goal of 10,000 MW were achieved, it would result in energy savings of up to 170.7 PJ and avoid 10.9 Mt of associated GHGs.[6]

[2] American Wind Energy Association, "The Economics of Wind Energy," AWEA Wind Energy Fact Sheets, February 2005.

[3] *Ibid.*

[4] Natural Resources Canada, *Wind Power Production Incentive: 1000 Megawatts over 5 years*, Ottawa, 2001.

[5] The GHG benefits of displacing hydro or nuclear-produced electricity with wind energy would be neutral as these sources do not emit GHGs.

[6] It is assumed that wind has a capacity factor of 0.29673. Energy and GHG savings were calculated using average electricity generated energy (6560.9 GJ/GWh) and GHG (63.8 tonnes/TJ) intensities for Canada in 2003.

Appendix
Glossary of Terms

Activity: Term used to characterize major drivers of energy use in a sector (e.g. floor space area in the commercial/institutional sector).

Biomass: Includes wood waste and pulping liquor. Wood waste is a fuel consisting of bark, shavings, sawdust and low-grade lumber and lumber rejects from the operation of pulp mills, sawmills and plywood mills. Pulping liquor is a substance primarily made up of lignin and other wood constituents and chemicals that are by-products of the manufacture of chemical pulp. It can produce steam for industrial processes when burned in a boiler and/or produce electricity through thermal generation.

Capacity Utilization: The rates of capacity use are measures of the intensity with which industries use their production capacity. It is the ratio of an industry's actual output to its estimated potential output.

Carbon Dioxide (CO_2): A compound of carbon and oxygen formed whenever carbon is burned. Carbon dioxide is a colourless gas that absorbs infrared radiation, mostly at wavelengths between 12 and 18 microns. It behaves as a one-way filter, allowing incoming, visible light to pass through in one direction, while preventing outgoing infrared radiation from passing in the opposite direction. The one-way filtering effect of carbon dioxide causes an excess of the infrared radiation to be trapped in the atmosphere; thus it acts as a "greenhouse" and has the potential to increase the surface temperature of the planet.

Central Air Conditioner: Powered by electricity, this device removes heat from an indoor living space to maintain comfortable conditions during hot, humid weather and conveys it to the outdoors. Designed to cool a house, the large compressor and outdoor coil are located outdoors and are connected by refrigerant lines to an indoor coil mounted in the furnace. The same duct system is used for both heating and cooling air distribution.

Cooling Degree-Day (CDD): A measure of how hot a location was over a period of time, relative to a base temperature. The base temperature is 18.0°C and the period of time is one year. If the daily average temperature exceeds the base temperature, the number of cooling degree-days for that day is the difference between the two temperatures. However, if the daily average is equal to or less than the base temperature, the number of cooling degree-days for that day is zero. The number of cooling degree-days for a longer period of time is the sum of the daily cooling degree-days for the days in the period.

Economies of Scale: Occurs when there are advantages to large-scale production for a firm. Long-run average costs fall as production levels increase, reducing the per unit cost of the output.

End-Use: Any specific activity that requires energy (e.g. refrigeration, space heating, water heating, manufacturing processes and feedstocks).

Energy Intensity: The amount of energy used per unit of activity. Examples of activity measures in this report are households, floor space, passenger-kilometres, tonne-kilometres, physical units of production and constant dollar value of gross domestic product.

Energy Source: Any substance that supplies heat or power (e.g. petroleum, natural gas, coal, renewable energy and electricity, including the use of fuel as a non-energy feedstock).

Factorization Method: A statistical method, based on the Laspeyres index, used in this report to separate changes in energy use into five factors: activity, weather, structure, service level and energy efficiency.

Floor Space (area): The area enclosed by exterior walls of a building. In the residential sector, it excludes parking areas, basements or other floors below ground level; these areas are included in the commercial/institutional sector. It is measured in square metres.

Greenhouse Gas (GHG): A greenhouse gas absorbs and radiates heat in the lower atmosphere that otherwise would be lost in space. The greenhouse effect is essential for life on this planet, since it keeps average global temperatures high enough to support plant and animal growth. The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFCs) and nitrous oxide (N_2O). By far the most abundant greenhouse gas is CO_2, accounting for about 70 percent of total greenhouse gas emissions (see Carbon Dioxide).

Greenhouse Gas Intensity of Energy: The amount of greenhouse gases emitted per unit of energy used.

Green Roof, Extensive Type: Involves the installation of a thin layer of soil to support vegetation with a surface root system; requires little maintenance.

Green Roof, Intensive Type: Uses a thicker layer of soil, which can sustain a variety of plants including trees and bushes; requires an irrigation and drainage system.

Gross Domestic Product (GDP): The total value of goods and services produced within Canada during a given year. Also referred to as annual economic output or, more simply, output. To avoid counting the same output more than once, GDP includes only final goods and services – not those that are used to make another product. GDP figures are reported in constant 1997 dollars.

Heat Island: Dome of warm and polluted air that covers an urban area and in which the temperature is higher than in surrounding areas.

Heavy Truck: A truck with a gross vehicle weight that is more than, or equal to, 14,970 kg (33,001 lb.). The gross vehicle weight is the weight of the empty vehicle plus the maximum anticipated load weight.

Horsepower (hp): A unit of power commonly used for vehicle engines, equal to 75 metre kilograms-force per second; equal to 735.49875 watts.

Household: A person or a group of people occupying one dwelling unit is defined as a household. The number of households will, therefore, be equal to the number of occupied dwellings. The person or people occupying a private dwelling form a private household.

Idling: Occurs when power is delivered by an engine but is not used for any useful work.

Kilowatt-hour (kWh): The commercial unit of electricity energy equivalent to 1000 watt-hours. A kilowatt-hour can best be visualized as the amount of electricity consumed by ten 100-watt bulbs burning for an hour. One kilowatt-hour equals 3.6 million joules (see Watt).

Light Truck: A truck of up to 3855 kg (8500 lb.) of gross vehicle weight. The gross vehicle weight is the weight of the empty vehicle plus the maximum anticipated load weight. This class of vehicles includes pickup trucks, minivans and sport utility vehicles.

Liquefied Petroleum Gases (LPG) and Gas Plant Natural Gas Liquids (NGL): Propane and butane are liquefied gases extracted from natural gas (i.e. gas plant NGL) or from refined petroleum products (i.e. LPG) at the processing plant.

Model Year: An annual period (beginning in September and ending in August) in which a national automotive industry organizes its operations and within which new models are announced. For example, if the "model year" is 2003, it begins 1 September 2002 and ends 31 August 2003.

Motive Fuel: Includes motor gasoline and diesel fuel oil.

North American Industry Classification System (NAICS): A classification system that categorizes establishments into groups with similar economic activities. The structure of NAICS, adopted by Statistics Canada in 1997 to replace the 1980 Standard Industrial Classification (SIC), has been developed by the statistical agencies of Canada, Mexico and the United States.

Notch(es): One of several preset settings on a power control system (throttle, switch, etc.) for a rail locomotive.

Organic Farming: A farming method that minimizes the use of chemicals in the production process. It aims to produce crops with a high nutritional value and to improve the long-term fertility and sustainability of farmland.

Passenger-kilometre (Pkm): The transport of one passenger over a distance of one kilometre.

Petajoule (PJ): One petajoule equals 1 x 10^{15} joules. A joule is the international unit of measure of energy – the energy produced by a power of one watt flowing for a second. There are 3.6 million joules in one kilowatt-hour (see Kilowatt-hour).

Room Air Conditioner: Powered by electricity, this device removes heat from an indoor living space to maintain comfortable conditions during hot, humid weather and conveys it to the outdoors. Unlike a central air conditioner, no ductwork is required. All components are built into a single package that is mounted in a window opening or through the wall. It is a smaller version of a central unit and is intended to cool a small area, such as a room.

Sector: The broadest category for which energy consumption and intensity are considered within the Canadian economy (e.g. residential, commercial/institutional, industrial, transportation, agriculture and electricity generation).

Service Level: Term used to characterize the increased penetration of auxiliary equipment in commercial/institutional buildings.

Space Cooling: Conditioning of room air for human comfort by a refrigeration unit (e.g. air conditioner or heat pump) or by circulating chilled water through a central- or district-cooling system.

Space Heating: The use of mechanical equipment to heat all or part of a building. Includes the principal space heating unit and any supplementary equipment.

Standard Industrial Classification (SIC): A classification system that categorizes establishments into groups with similar economic activities.

Structure: Structure refers to change in the makeup of each sector. For example, in the industrial sector, a relative increase in output from one industry over another is considered a structural change; in the electricity generation sector, a relative increase in one fuel over another is considered a structural change.

Tonne-kilometre (Tkm): The transport of one tonne over a distance of one kilometre.

Water Heating: The use of energy to heat water for hot running water, as well as the use of energy to heat water on stoves and in auxiliary water heating equipment for bathing, cleaning and other non-cooking applications.

Watt (W): A measure of power; for example, a 40-watt light bulb uses 40 watts of electricity (see Kilowatt-hour).