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Energy Efficiency Trends in Canada
1990 to 2008

September 2010

Canada

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Preface

This 14th edition of *Energy Efficiency Trends in Canada* delivers on Canada's commitment to provide a comprehensive summary of secondary energy use and related greenhouse gas (GHG) emissions in Canada. It also tracks trends in energy efficiency. This year's edition is produced electronically and in paper format.

For more secondary energy use statistics, see the comprehensive energy use database. The database includes most of the historical energy use and GHG emissions data used by Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE).

This database can be viewed at: oee.nrcan.gc.ca/tables08.

This report covers the five sectors analysed by the OEE, which are the residential, commercial/institutional, industrial, transportation, and agriculture sectors. The 2008 period is the most recent year for which data is available.

For more information about this product or the services that the OEE offers, contact us by e-mail at euc.cec@nrcan.gc.ca.

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Introduction

Chapter 1

Chapter 1: Introduction

Canadians spent $189 billion on energy in 2008.

Energy accounts for a large segment of spending by households, businesses and industries alike. In 2008, Canadians spent about $189 billion on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes. This amount is equivalent to almost 13 percent of the country's gross domestic product.

This report provides an overview of Canada's secondary energy use and related GHG emissions. In addition to providing detailed information about energy intensity and energy efficiency levels in 2008, this report also analyses the energy intensity and efficiency trends between 1990 and 2008. Such monitoring aids the OEE in promoting energy efficiency in all aspects of Canadian life. It contributes toward the goal of making Canada a world leader in environmental responsibility in the development and use of natural resources.

Measurement of energy

To compare sources of energy, all energy consumption data presented in this report are expressed in joules. One joule is equivalent to the work required to produce one watt of power continuously for one second. One petajoule (PJ), or 10^{15} joules, is equivalent to the energy required by almost 9,000 households (excluding transportation requirements) over one year.

Two types of energy use

There are two general types of energy use: primary and secondary. Primary energy use (Figure 1.1) encompasses the total requirements for all users of energy. This includes secondary energy use. Additionally, primary energy use refers to the energy required to transform one form of energy to another (e.g. coal to electricity).

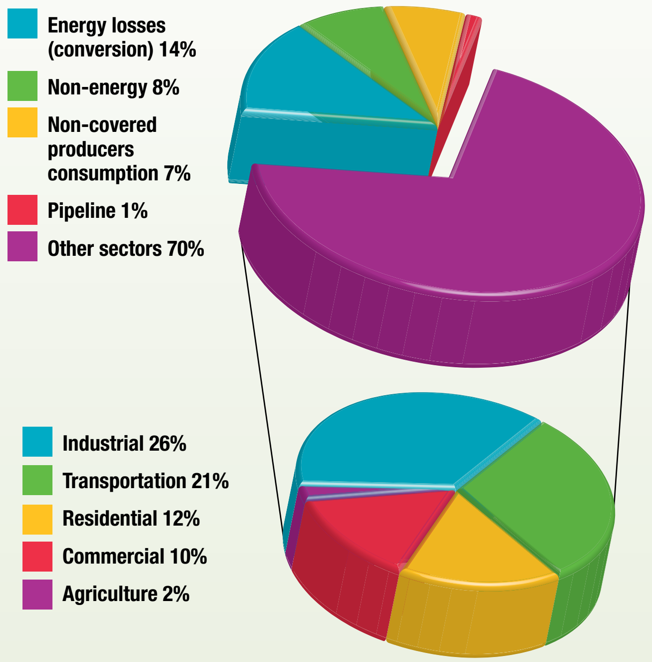
It also includes the energy used to bring energy supplies to the consumer (e.g. pipeline). Further, it entails the energy used to feed industrial production processes (e.g. the natural gas used by the chemical industries). In 2008, the total amount of primary energy consumed was estimated at 12,510.5 PJ (see Appendix A, "Reconciliation of data" for more details).

Secondary energy use[1] (Figure 1.1) is the energy used by final consumers in various sectors of the economy. This includes, for example, the energy used by vehicles in the transportation sector. Secondary energy use also encompasses energy required to heat and cool homes or businesses in the residential and commercial/institutional sectors. In addition, it comprises energy required to run machinery in the industrial and agricultural sectors. Secondary energy use accounted for almost 70 percent of the primary energy use in 2008, or 8,720.2 PJ.

This report focuses on secondary energy use and assesses trends in this category. The energy used to generate electricity is also included, to allow the link of electricity emissions to the appropriate final user of electricity. This mapping of GHG emissions to appropriate electricity consumers is discussed in more detail in the section GHG emissions.

[1] Secondary energy use covered in this report excludes pipeline energy use, producer consumption, non-energy use (feedstock) and energy losses (conversions).

Figure 1.1 — Primary and secondary energy use by sector, 2008 (percent)



All subsequent references in this report to "energy" should be interpreted as secondary energy.

GHG emissions

This report also analyses energy-related GHG emissions, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). CO_2 represents more than 98 percent of Canada's energy-related GHG emissions.

Total Canadian GHG emissions are estimated to have been 733.9 megatonnes (Mt) in 2008; 66 percent of this total (or 487.8 Mt) resulted from secondary energy use (including electricity-related GHG emissions).[2]

Unlike other end-use energy sources, electricity use does not produce any GHG emissions at the source of consumption. GHG emissions related to electricity are emitted at the point of generation. These are sometimes referred to as indirect emissions.

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

Environment Canada's *National Inventory Report, 1990–2008 — Greenhouse Gas Sources and Sinks in Canada* has more information about total Canadian GHG emissions. This GHG inventory was prepared according to the specifications of the Intergovernmental Panel on Climate Change, accounting for all types of GHG emissions in Canada. However, NRCan's OEE developed a sectoral mapping that is more suited to energy end-use analysis.

All subsequent references in this report to GHG emissions are expressed in tonnes of carbon dioxide equivalent (CO_2e). They include only emissions directly attributable to secondary energy use and indirect emissions attributable to electricity used as final demand, unless otherwise specified.

Energy intensity and energy efficiency

The term energy intensity is used frequently throughout this report. Energy intensity is the ratio of energy use per unit of activity. Because energy intensity is a simple calculation for which data are readily available, it is often used as a proxy for energy efficiency. However, this practice can be misleading: in addition to pure energy efficiency, energy intensity captures the impact of many factors that influence energy demand, such as weather or structural change.

[2] These figures are OEE estimates; Environment Canada is responsible for Canada's official GHG inventory.

1 Introduction

Because of this inherent short-coming in the energy intensity measure, the OEE tracks energy efficiency in a way that gauges changes in energy demand due to changes in activity, economic structure, service level and weather. In summary, the energy efficiency measure factors out these items from the energy intensity calculation.

The methodology of this factorization — the Log-Mean Divisia Index I (LMDI I) methodology — is an internationally recognized factorization analysis technique. It decomposes changes in energy use into the various drivers in each sector so that energy efficiency can be assessed.[3]

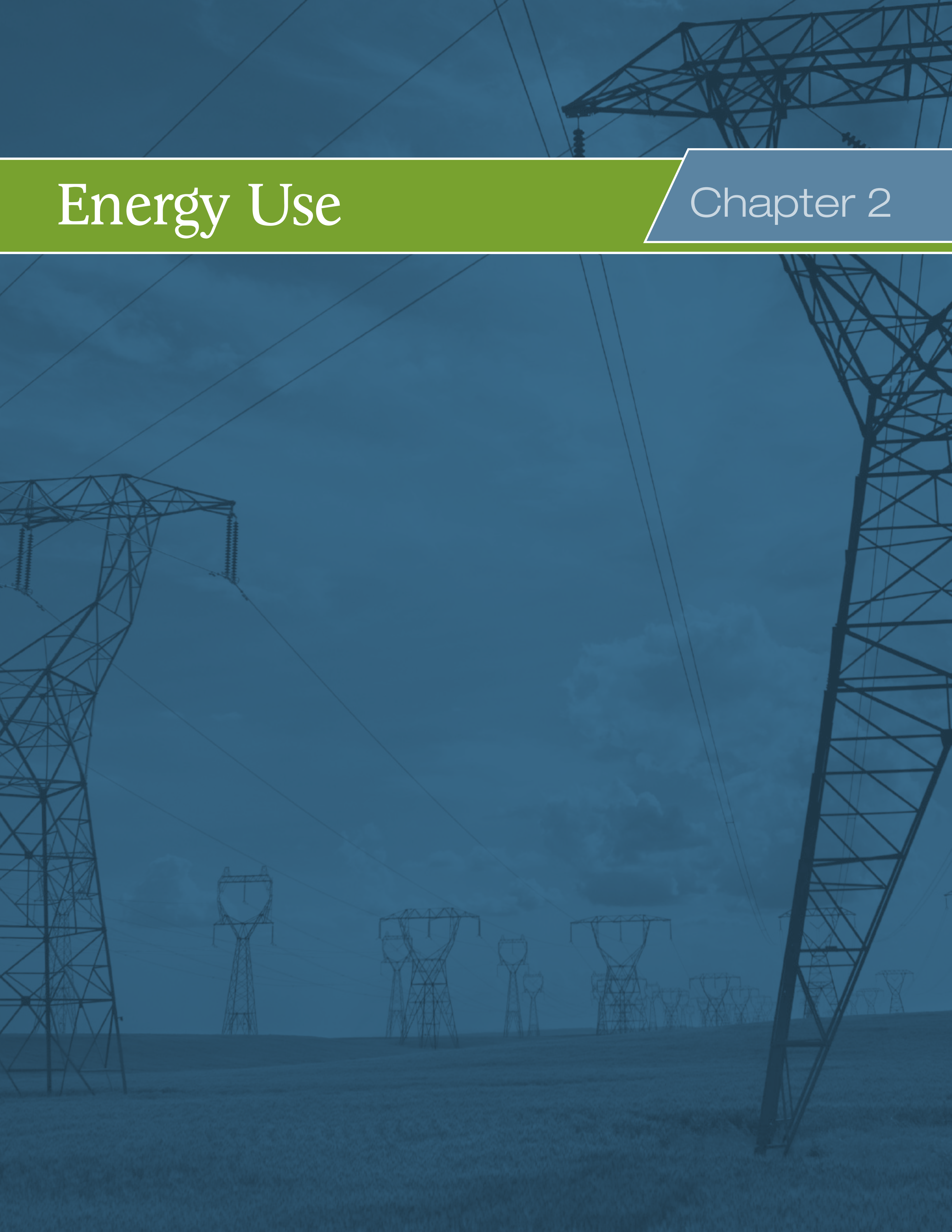
In this report

This report describes secondary energy use in Canada, overall, and also at a sectoral level. For each sector, the status in 2008 of energy use and GHG emissions is described, followed by the trends in energy use and GHG emissions from 1990 to 2008. Finally, the overall and sector analysis provides the results of the factorization analysis and a detailed discussion of the trends in energy efficiency and energy intensity over the sample period.

[3] Contact us at euc.cec@nrcan.gc.ca to obtain further information regarding the LMDI I methodology from the report prepared by M. K. Jaccard and Associates for OEE, *Improvement of the OEE/DPAD Decomposition Methodology*, 2005.

Energy Use

Chapter 2



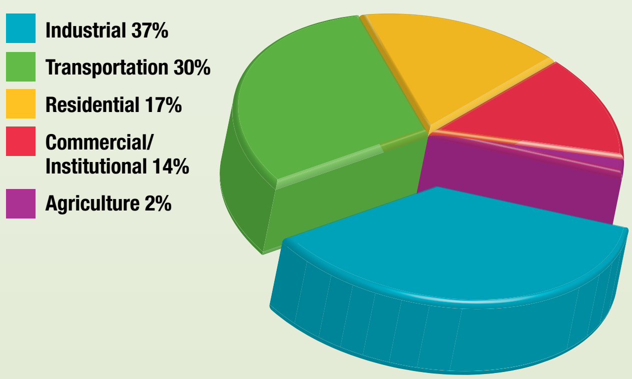
Overview — Energy use and GHG emissions

The industrial sector accounts for the largest share of energy use and is second in terms of GHG emissions in Canada.

Energy is used in all five sectors of the economy: residential, commercial, industrial, transportation, and agriculture. In 2008, these sectors used a total of 8,720.2 PJ of energy. The industrial sector accounted for the largest share of energy followed by transportation, residential, commercial/institutional and agriculture. Total GHG emissions associated with the energy use of the five sectors was 487.8 Mt in 2008.

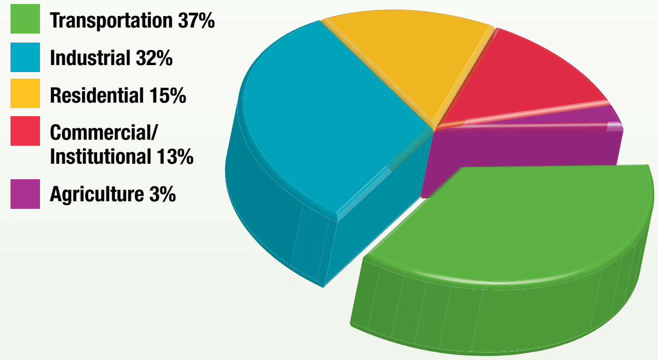
Figures 2.1 and 2.2 show the distribution of secondary energy use and GHG emissions by sector. Energy consumed by transportation and agriculture sectors is relatively more GHG intensive than the other sectors.

Figure 2.1 — Secondary energy use by sector, 2008 (percent)



One petajoule is approximately equal to the energy used by almost 9,000 households in one year (excluding transportation).

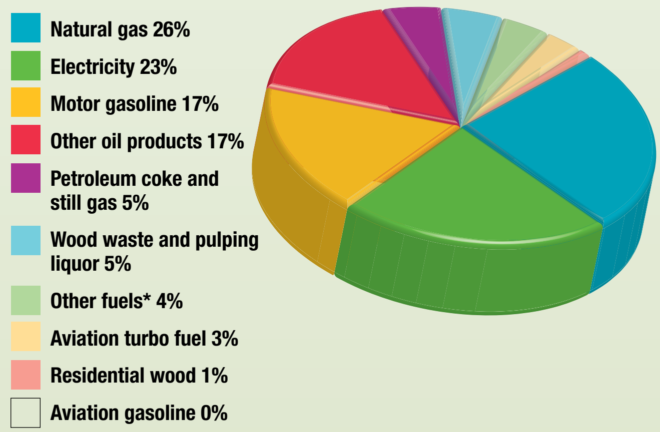
Figure 2.2 — GHGs by sector, 2008 (percent)



Natural gas and electricity are the main types of end-use energy purchased in Canada.

Natural gas and electricity are used in all sectors of the economy while motor gasoline is mainly used in the transportation and agriculture sectors. In 2008, natural gas and electricity accounted for almost half the energy used in Canada (Figure 2.3). Motor gasoline and other oil products (diesel fuel oil, light fuel oil, kerosene and heavy fuel oil), represented approximately 33 percent of energy usage.

Figure 2.3 — Secondary energy use by fuel, 2008 (percent)



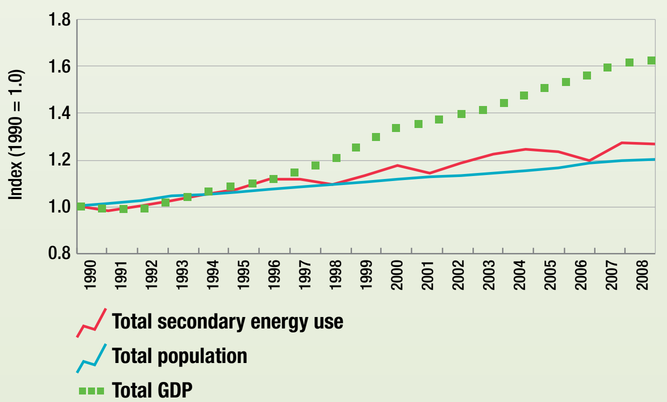
* Other fuels include coal, coke, coke oven gas, liquefied petroleum gases and gas plant natural gas liquids, and waste fuels from the cement industry.

Trends — Energy use and GHG emissions

Energy use grew less rapidly than the economy, but more rapidly than the population.

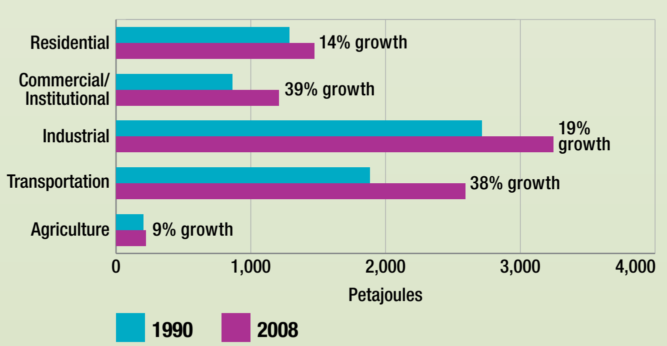
Between 1990 and 2008, energy use in Canada increased by 26 percent, from 6,936.2 PJ to 8,720.2 PJ (Figure 2.4). At the same time, the Canadian population grew 20 percent (approximately 1 percent per year), and GDP increased 62 percent (about 3 percent per year). More generally, energy use per unit of GDP declined, while energy use on a per capita basis increased.

Figure 2.4 — Total secondary energy use, Canadian population and GDP, 1990–2008



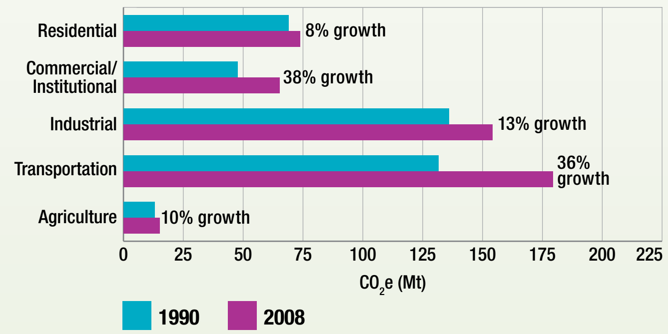
Energy use has been growing at the fastest rate in the transportation and commercial/institutional sectors.

Figure 2.5 — Total secondary energy use and growth by sector, 1990 and 2008



The industrial sector uses the most energy in our economy, consuming 3,237.8 PJ of energy in 2008. However, energy use growth in the commercial/institutional and transportation sectors outpaced all other sectors.

Figure 2.6 — Total GHG emissions and growth by sector, 1990 and 2008



Over the 1990–2008 period, the commercial/institutional sector registered a 39 percent increase in energy use (Figure 2.5), driven mainly by a 179 percent increase in auxiliary equipment energy use. Transportation energy use grew by 38 percent primarily due to a 71 percent growth in freight energy use.

Growth in energy use was reflected in the growth of GHG emissions. Consequently, the commercial/institutional sector experienced the highest growth in emissions at 38 percent followed closely by the transportation sector at 36 percent (Figure 2.6).

The transportation sector accounted for the largest proportion, 37 percent, of energy related emissions (179.4 Mt carbon dioxide equivalent [CO_2e]), followed by the industrial sector, 32 percent (154.0 Mt CO_2e), including electricity-related emissions. This difference in the shares of energy and emissions is driven by the dominance of refined petroleum products in the transportation sector providing for a more GHG-intensive energy mix.

Energy intensity and efficiency

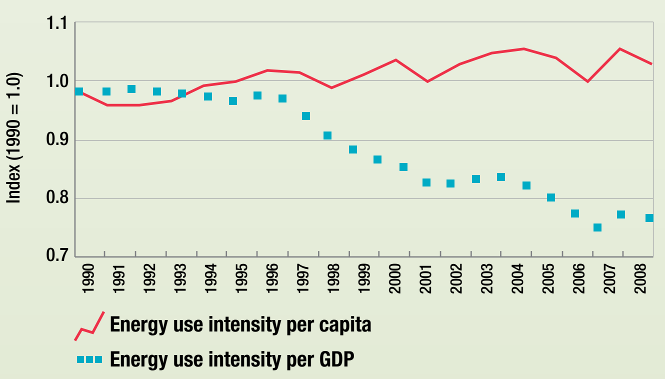
Canada improved its energy efficiency between 1990 and 2008. The following section discusses two indicators of energy efficiency: energy intensity and an energy efficiency measure using factorization.

Energy intensity

Canada's energy intensity improved 22 percent between 1990 and 2008. Despite this improvement, per capita energy use increased 5 percent.

Energy intensity, when defined as the amount of energy required per unit of activity (GDP), improved 22 percent between 1990 and 2008 (Figure 2.7). This reduction in energy intensity reflects an overall improvement in energy efficiency, which is how effectively energy is being used in producing one unit of GDP. More simply, if the economy in 2008 had produced the same level of GDP that it did in 1990, it would have used much less energy.

Figure 2.7 — Total secondary energy use intensity per capita and unit of GDP, 1990–2008



Conversely, the amount of energy required per capita, which is the energy intensity for each individual, increased 5 percent between 1990 and 2008 (Figure 2.7). This upward trend in part reflects the increasing use of electronic goods, increasing ownership of passenger light trucks and increasing distance and weight of goods transported by heavy trucks. In other words, although Canada is producing economic value more efficiently, each household is using a greater number of energy-consuming goods and services per capita compared to 1990. This is despite the fact that many electronic goods have become increasingly energy-efficient since 1990.

Energy efficiency

Energy efficiency improved 18 percent since 1990. These improvements reduced energy use by approximately 1,205.9 PJ, decreased GHG emissions by 67.3 Mt and saved Canadians $26.9 billion in 2008.

One of the greatest sources of untapped energy is the energy we waste. Isolating and tracking energy efficiency in the Canadian economy is carried out in a conscious effort to publicize this energy resource. This analysis examines all areas of the economy to determine what would have happened had there been no improvements and to identify, from the underlying data, areas that can continue to improve energy efficiency.

Energy efficiency refers to how effectively energy is used to provide a certain level of service or output. To isolate the effect of energy efficiency in the economy, as well as in individual sectors, the analysis uses a factorization method. Factorization separates the changes in the amount of energy used into five effects: activity, structure, weather, service level, and energy efficiency.

- **activity effect** — Activity is defined differently in each sector. For example, in the residential sector, it is defined as the number of households and the floor space of residences. In the industrial sector, it is defined as industrial GDP, gross output (GO) and physical industrial output, such as tonnes of steel.
- **structure effect** — Structure refers to changes in the makeup of each sector. For example, in the industrial sector, a relative increase in activity in one industry over another is considered a structural change.
- **weather effect** — Fluctuations in weather lead to changes in heating and cooling requirements. This is

measured in terms of heating and cooling degree-days. 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.

- **service level effect** — Service level refers to the penetration rate of devices and equipment. For example, the term denotes use of auxiliary equipment in commercial/ institutional buildings and appliances in homes, or the amount of cooled floor space. Although these devices are becoming more efficient, the addition of more devices would represent an increase in service levels, which has tended to offset these gains in efficiency.
- **energy efficiency effect** — Energy efficiency refers to how effectively energy is being used, that is, using less energy to provide the same level of energy service. Energy efficiency gains occur primarily with improvements in technology or processes. An example would be insulating a home to use less energy for heating and cooling or replacing incandescent lights with fluorescent lights.

As Figure 2.8 indicates, without significant ongoing improvements in energy efficiency in end-use sectors, energy use would have increased 43 percent between 1990 and 2008, instead of 26 percent. These energy savings of 1,205.9 PJ are equivalent to the energy use of about 20 million cars and passenger light trucks in 2008.

Figure 2.8 — Secondary energy use, with and without energy efficiency improvements, 1990–2008

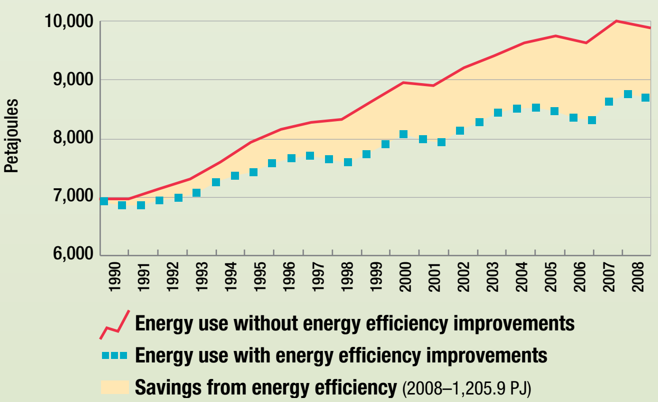
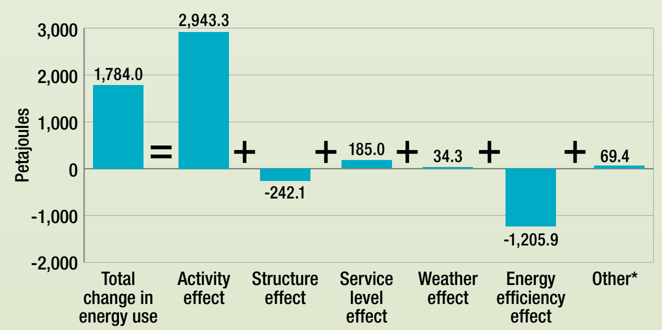


Figure 2.9 illustrates the relative impact of each effect on energy use over the 1990–2008 period for the economy as a whole.

The following is a summary of and rationale for the results:

- **activity effect** — Canada's GDP grew 62 percent between 1990 and 2008. The overall growth in activity effect is estimated to have increased energy use by 42 percent, or 2,943.3 PJ, with a corresponding 161.4 Mt increase in GHG emissions.
- **structure effect** — Over the 1990–2008 period, a shift in production toward industries that are less energy intensive resulted in a decrease of 242.1 PJ and a 6.5-Mt decrease in GHG emissions.
- **weather effect** — In 2008, the winter was colder but the summer was warmer than that of 1990. The result was an overall increase in energy demand for temperature control of 34.3 PJ and a 1.8-Mt increase in GHG emissions.
- **service level effect** — From 1990 to 2008, changes in service level (e.g. increased use of computers, printers and photocopiers in the commercial/institutional sector) raised energy use by 185.0 PJ, and increased GHG emissions by 9.8 Mt.
- **energy efficiency effect** — As noted above, improvements in energy efficiency saved 1,205.9 PJ of energy and 67.3 Mt of GHG emissions from 1990 to 2008.

Figure 2.9 — Impact of activity, structure, service level, weather and energy efficiency effects on the change in energy use, 1990–2008



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

Residential Sector

Chapter 3

Overview — Residential energy use and GHG emissions

In Canada, 80 percent of all residential energy use was for space and water heating in 2008.

In 2008, Canadians spent $30.6 billion on household energy needs. Total household energy use was 17 percent of all energy used (Figure 3.1), and total household GHG emissions were 15 percent of all GHGs emitted in Canada (Figure 3.2). Specifically, residential energy use was 1,465.3 PJ, emitting 74.2 Mt of GHGs.

Figure 3.1 — Energy use by sector, 2008 (percent)

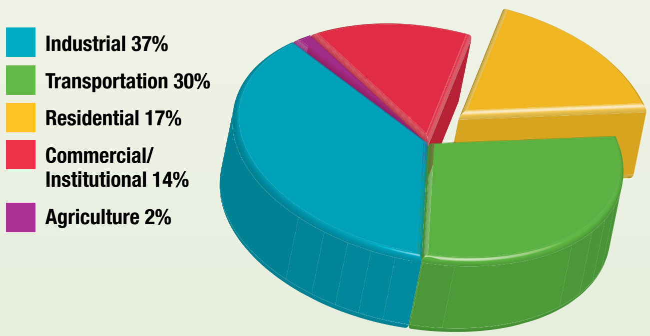
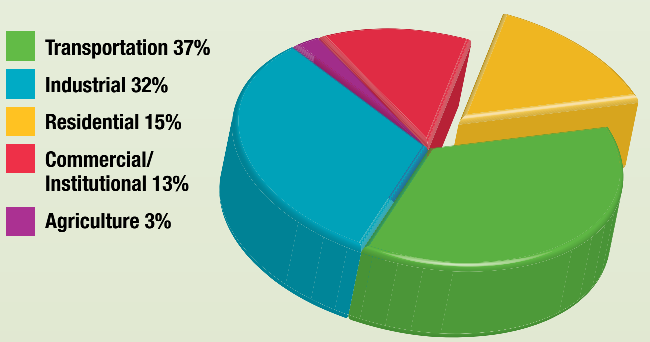
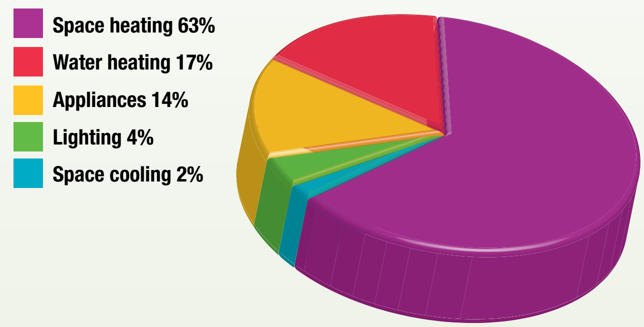


Figure 3.2 — GHG emissions by sector, 2008 (percent)



Natural gas, electricity, wood, heating oil and propane were the sources of energy being used. Within a household, these forms of energy were used for a variety of activities, as seen in Figure 3.3. Space and water heating accounted for 80 percent of Canada's residential energy use in 2008, followed by appliances, lighting and air conditioning.

Figure 3.3 — Distribution of residential energy use by end-use, 2008 (percent)



Trends — Residential energy use and GHG emissions

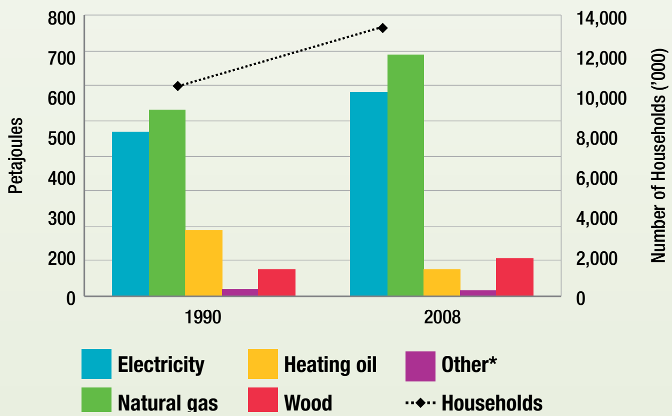
Population growth and fewer people per household led to a 33 percent rise in the number of households, which contributed to a 14 percent increase in residential energy use from 1990 to 2008.

> The 3.3 million households added in Canada since 1990 represents approximately one-third of the total number of households in Canada in 1990 or the number of households in Quebec in 2008.

Between 1990 and 2008, the population grew 20 percent (5.6 million people) and the number of households increased 33 percent (3.3 million). The rise in the number of households, combined with increased average living space, contributed to the increase of 14 percent, or 183.1 PJ, in residential energy use from 1,282.2 PJ to 1,465.3 PJ. As homeowners gradually switched to cleaner energy sources, the associated GHG emissions grew only 8 percent, from 68.8 Mt to 74.2 Mt during the same period.

The mix of energy used in the residential sector changed slightly over the period. Specifically, natural gas and electricity became even more dominant while the use of heating oil declined (Figure 3.4). Natural gas and electricity together accounted for 87 percent of all residential energy use in 2008, compared to 78 percent in 1990. These increases were largely the result of increased availability of natural gas and lower natural gas prices relative to oil.

Figure 3.4 — Residential energy use by fuel type and number of households, 1990 and 2008



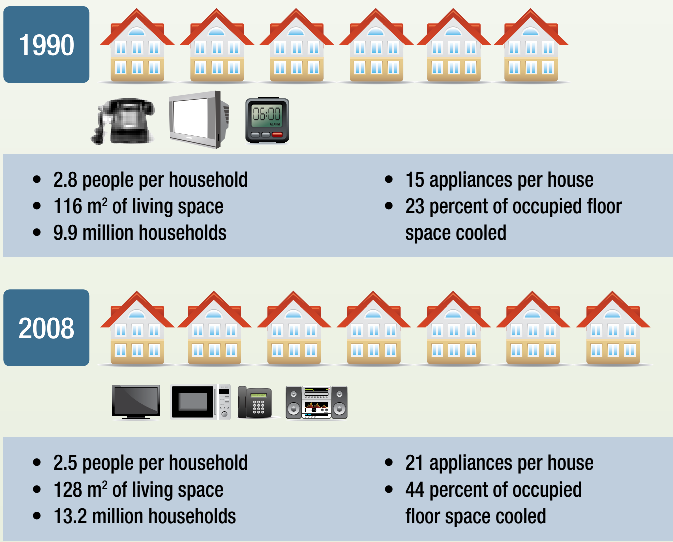
* Other includes coal and propane.

Canadians have bigger homes with fewer people living in them.

The choices Canadians made with respect to their living space also contributed to an increase in energy use. Average living space in 2008 was 10 percent greater than that in 1990. Specifically, average occupied living space in 1990 was 116 square metres (m²), compared to 128 m² of living space in 2008 (Figure 3.5). At the same time, the number of individuals per household fell to 2.5 in 2008 from 2.8 in 1990. This trend, coupled with population growth, has meant more dwellings built and therefore more energy consumed.

Since 1990, Canadians use more devices that consume energy. In addition, more Canadians choose to cool their homes during the summer months. These choices increased residential energy use. The impact of these changes and the choices made by Canadians are further discussed in the following section, where each end-use is examined.

Figure 3.5 — Residential energy indicators, 1990 and 2008

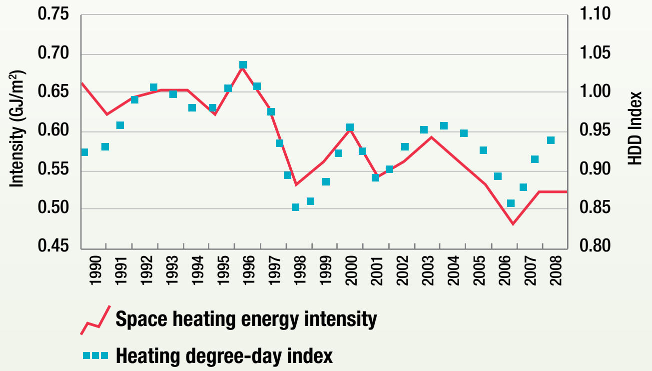


Trends — Residential space heating energy use

Despite a 20 percent decline in space heating energy intensity, total space heating energy use increased 16 percent between 1990 and 2008.

The amount of energy used by the residential sector to heat each square metre of living space decreased significantly between 1990 and 2008. The decrease in space heating intensity from 0.66 gigajoules per square metre (GJ/m²) to 0.52 GJ/m² (Figure 3.6) was mainly driven by energy efficiency gains, despite heating degree-days in 2008 being marginally higher than in 1990.

Figure 3.6 — Space heating energy intensity and heating degree-day index, 1990–2008



Energy efficiency gains were realized, to a large extent, by the replacement of less efficient systems with regulated medium- and high-efficiency systems. From 1990 to 2008, medium- and high-efficiency gas systems increased their share of the gas market from 10 percent to 83 percent. While few medium-efficiency oil heating systems were in the market in 1990, almost all oil heating systems were medium efficiency in 2008.

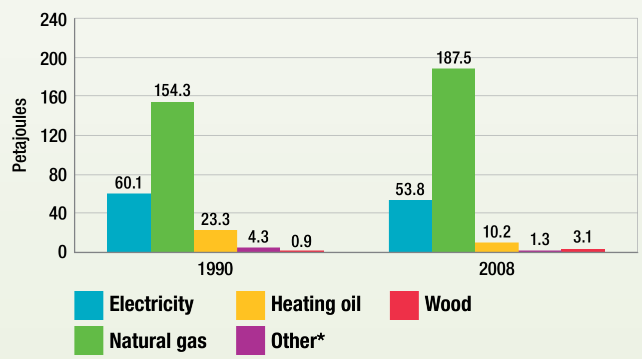
While space heating intensity decreased 20 percent, this was not enough to compensate for the fact that the number of households increased 33 percent. Additionally, the average Canadian home was larger in 2008 than it was in 1990. Consequently, the energy required to heat all the dwellings in Canada increased 16 percent, from 794.6 PJ in 1990 to 920.8 PJ in 2008.

Trends — Residential water heating energy use

Less energy is required per household for hot water due to increased penetration of newer and more efficient natural gas water heaters.

Canadians shifted from using oil-fired water heaters to those that use natural gas and that are, on average, more energy efficient (Figure 3.7). In addition, current minimum energy performance standards mean that new water heaters use less energy than older models. As older stock is replaced by new stock, energy efficiency gains are realized. These changes resulted in a 21 percent decrease in the energy used per household for heating water (from 24.5 GJ per household in 1990 to 19.4 GJ per household in 2008).

Figure 3.7 — Water heating energy use by fuel type, 1990 and 2008



* Other includes coal and propane.

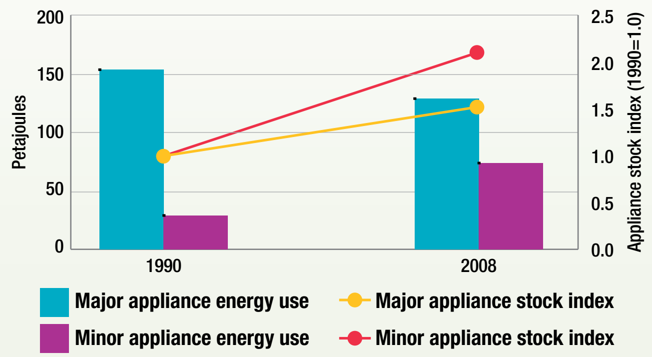
Although there was a decrease in per household energy used to heat water, the total number of households grew more quickly than energy efficiency improvements from new equipment. The result was an overall increase of 5 percent in residential water heating energy use, from 242.9 PJ to 255.9 PJ.

Trends — Residential appliance energy use

The increased number of minor appliances offset the benefits of the energy efficiency gains of major appliances.

The number of major appliances operated in Canada between 1990 and 2008 increased 46 percent (Figure 3.8). However, the total amount of energy that households used to power major appliances decreased 16 percent over the same period. In fact, the average unit energy use of all major household appliances decreased noticeably from 1990 to 2008.

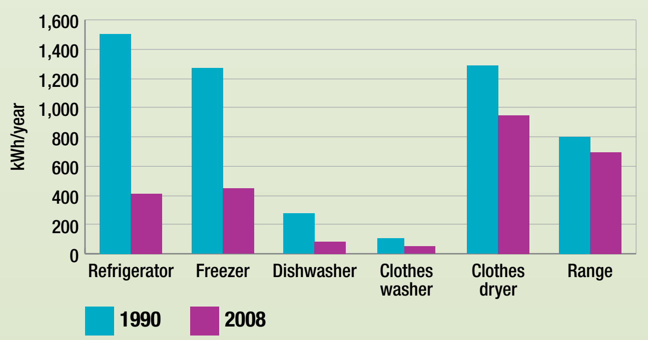
Figure 3.8 — Residential energy use and appliance stock index by appliance type, 1990 and 2008



The largest percentage decrease was in the unit energy use of dishwashers (Figure 3.9), which in 2008 used 71 percent less energy than in 1990 (from 277 kilowatt hours [kWh] per year to 82 kWh per year).[4] A new fridge in 1990 used an average of 956 kWh per year versus 467 kWh per year in 2008, a decrease of 51 percent. These improvements in efficiency were due mainly to the introduction of minimum efficiency standards in the 1990s.

Energy use for powering all household minor appliances more than doubled between 1990 and 2008. This increase of 44.3 PJ was equivalent to the energy required to provide lighting to all the Canadian homes in mid-1980s.

Figure 3.9 — Unit energy consumption of major electric appliance stock, 1990 and 2008



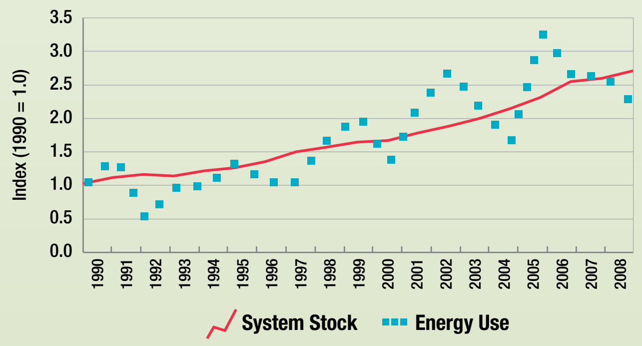
In contrast to trends for major appliances, energy use for smaller appliances such as televisions, VCRs, DVDs, stereo systems and personal computers more than doubled (+150 percent). This increase more than outweighed the energy use reduction from major appliances. One example of the rapid growth in minor appliances is the increased penetration of personal computers. In 1990, computers were present in less than one out of six households, but by 2008 they were present in more than four out of five households in Canada. Furthermore, the rapid penetration of digital TVs, DVDs and digital cable boxes also contributed to the increase.

Trends — Space cooling energy use

More Canadians lived in bigger and air-conditioned homes.

The amount of occupied floor space with air conditioners rose to 749 million m^2 in 2008, from 267 million m^2 in 1990. The percentage of cooled occupied floor space rose from 23 percent in 1990 to 44 percent in 2008. As a result, although also influenced by variations in cooling degree-days, the energy required to cool Canadian homes rose 119 percent (Figure 3.10), from 10.4 PJ to 22.9 PJ over the same period.

Figure 3.10 — Space cooling system stock and energy use, 1990–2008



[4] Excludes hot water requirements.

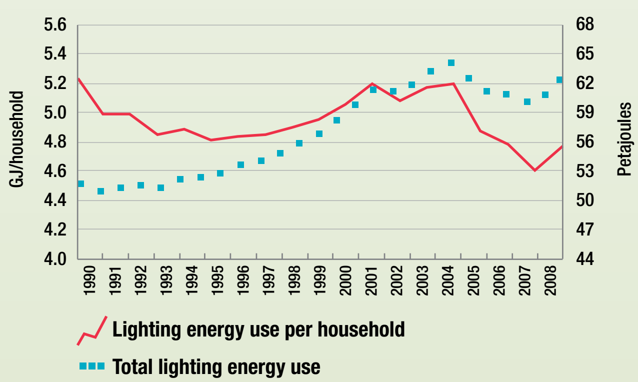
The increase in energy used for space cooling would have been more pronounced if not for efficiency improvements associated with room and central air conditioners. Compared to 1990, the stock of room and central air conditioners in 2008 were 36 percent and 24 percent more efficient, respectively.

Trends — Lighting energy use

The market share of energy-efficient lighting alternatives increased significantly between 1990 and 2008.

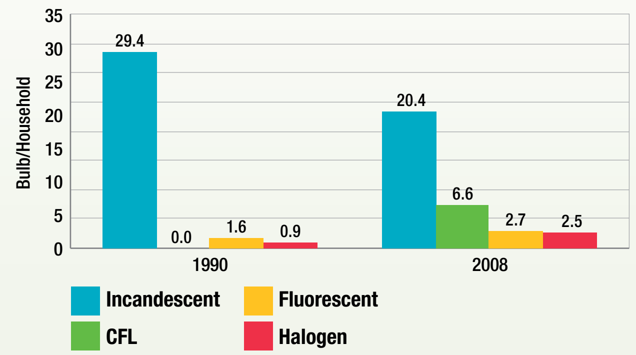
Despite a drop in lighting energy use per household, the energy required to light all the households in Canada increased 21 percent, from 51.8 PJ to 62.7 PJ (Figure 3.11). This was entirely due to the 33 percent increase in the number of households, as the energy required to light each household in Canada decreased 9 percent, from 5.2 GJ to 4.8 GJ.

Figure 3.11 — Lighting energy use per household and total lighting energy use, 1990–2008



Some of the decrease in lighting energy use per household can be associated with the increased use of compact fluorescent lamps (CFLs), also known as compact fluorescent light bulbs (Figure 3.12), which use less energy to produce a certain level of light. The use of CFLs was marginal in the residential lighting market in 2000, but CFLs represented around 21 percent of light bulbs used in 2008.

Figure 3.12 — Number of light bulbs per household by bulb type, 1990 and 2008



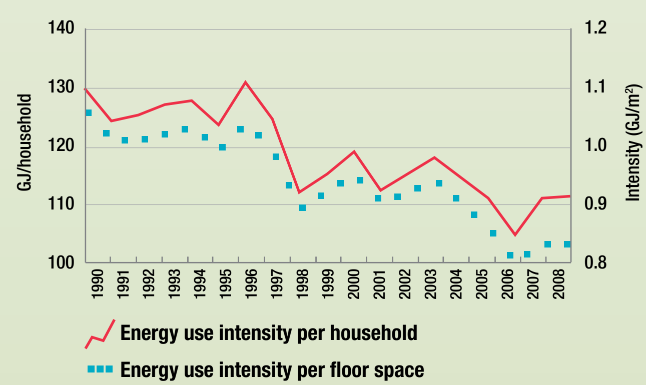
Residential energy intensity and efficiency

Energy intensity

The average household reduced its energy use by 14 percent.

In the residential sector, energy intensity is usually expressed as energy consumed per household. It can also be expressed as energy consumed per square metre of house area. Energy intensity decreased 14 percent, from 129.6 GJ per household in 1990 to 111.3 GJ per household in 2008 (Figure 3.13). This occurred despite the average household operating more appliances, its living space becoming larger, and increasing its use of space cooling. Energy use per square metre decreased 21 percent from 1.06 GJ to 0.83 GJ.

Figure 3.13 — Residential energy intensity per household and floor space, 1990–2008



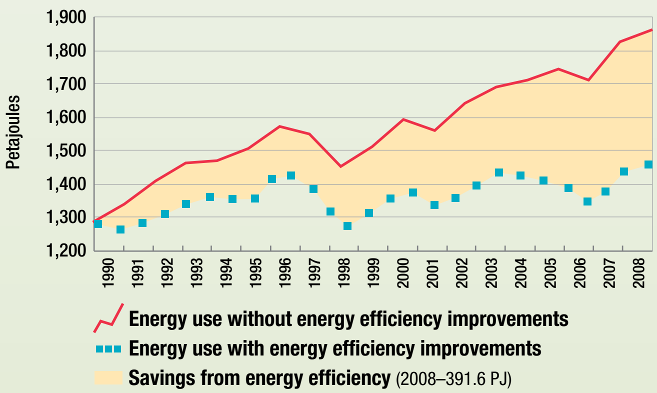
Energy efficiency

Energy efficiency improvements resulted in energy savings of $8.2 billion in the residential sector in 2008.

Energy efficiency improvements in the residential sector have resulted in significant savings between 1990 and 2008. These improvements include changes to the residential thermal envelope (insulation, windows, etc.) and changes to the efficiency of energy-consuming items in the home, such as furnaces, appliances, lighting and air conditioning.

Energy efficiency in the residential sector improved 31 percent from 1990 to 2008, allowing Canadians to save 391.6 PJ of energy (Figure 3.14) and $8.2 billion in energy costs in 2008.

Figure 3.14 — Residential energy use, with and without energy efficiency improvement, 1990–2008

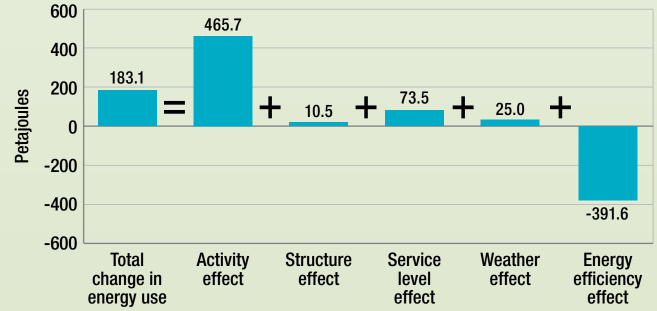


These energy efficiency savings translate into an average saving of $622 per Canadian household in 2008.

Figure 3.15 illustrates the influence that various factors had on the change in residential energy use between 1990 and 2008. These effects are as follows:

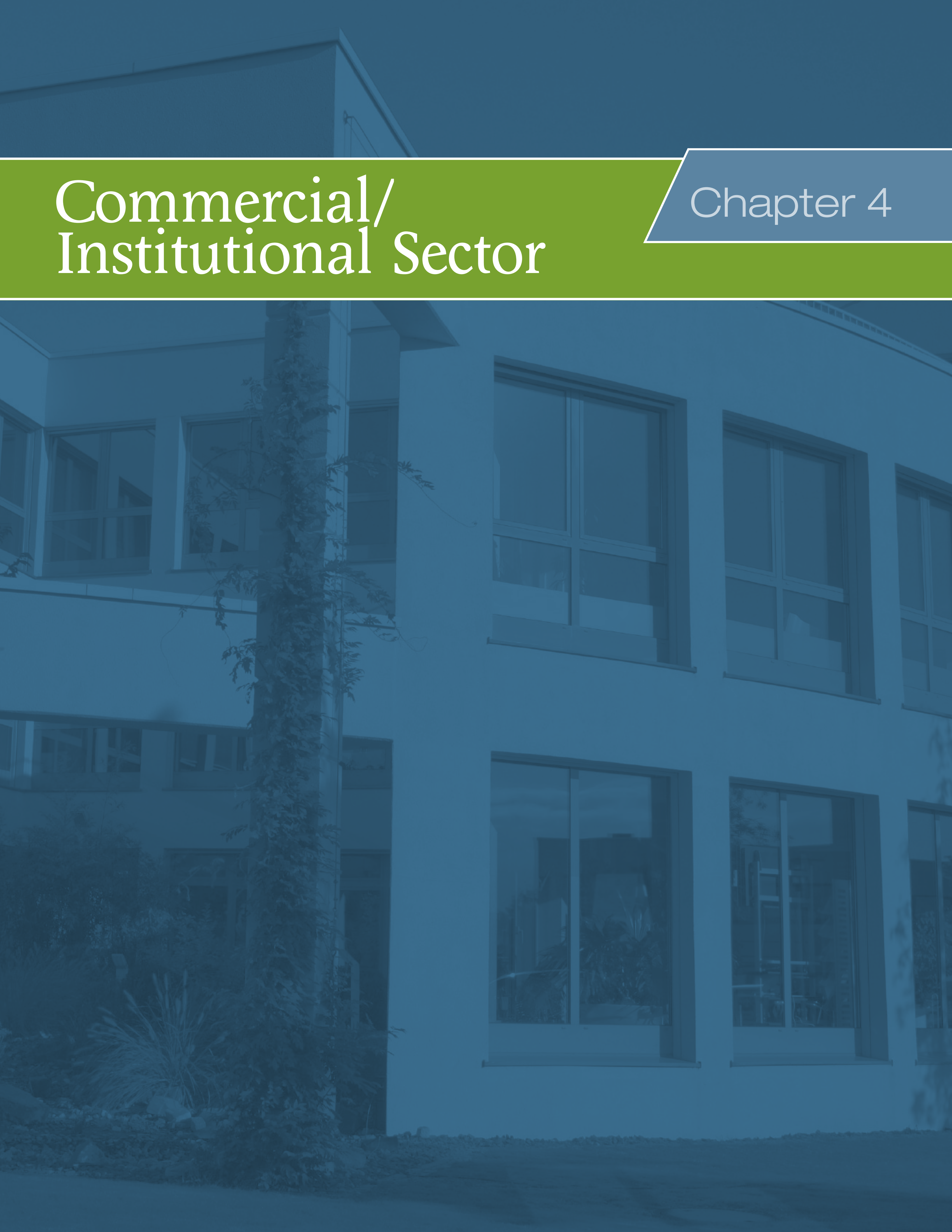
- **activity effect** — As measured by combining a mix of households and floor space, energy use increased 36 percent (465.7 PJ). Growth in activity was driven by a 45 percent increase in floor area and by a rise of 33 percent in the number of households.
- **structure effect** — The increase in the relative share of single-family houses resulted in the sector using an additional 10.5 PJ of energy.
- **weather effect** — In 2008, the winter was colder but the summer was warmer than that of 1990. The net result was an overall increase in energy demand of 25.0 PJ.
- **service level effect** — The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 73.5 PJ of the increase in energy.
- **energy efficiency effect** — Improvements to the thermal envelope of houses and to the efficiency of residential appliances and space and water heating equipment led to an overall energy efficiency gain in the residential sector. This saved 391.6 PJ of energy.

Figure 3.15 — Impact of activity, structure, weather and energy efficiency on the change in residential energy use, 1990–2008



Commercial/ Institutional Sector

Chapter 4



4 Commercial/Institutional Sector

Overview — Commercial/ Institutional energy use and GHG emissions

In Canada, floor space for the entire commercial/institutional sector is equivalent to about 40 percent of the total residential floor space.

In 2008, commercial business owners and institutions spent $28.0 billion on energy to provide services to Canadians. This represents approximately 3 percent of the value of GDP related to this sector. In 2008, this sector was responsible for 14 percent of the total energy use (Figure 4.1) in Canada and produced 13 percent of the associated GHG emissions (Figure 4.2).

Figure 4.1 — Total energy use by sector, 2008 (percent)

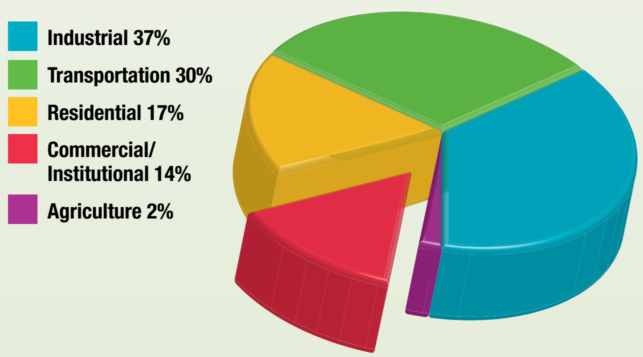
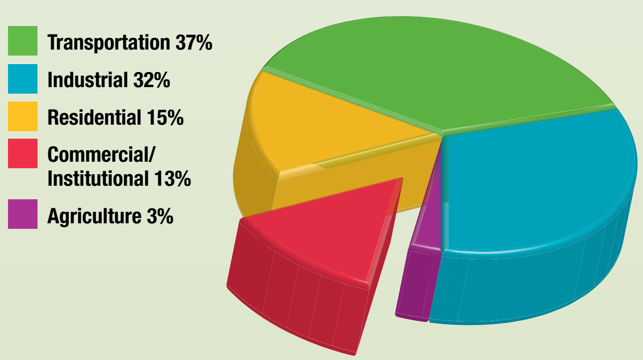
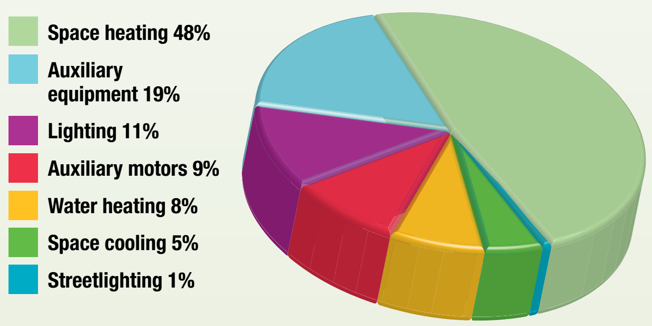


Figure 4.2 — Total GHG emissions by sector, 2008 (percent)



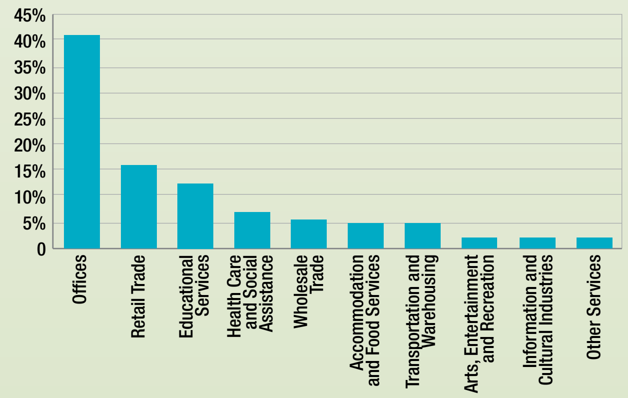
In the commercial/institutional sector,[5] energy is used for space heating, cooling, lighting, water heating, as well as operating auxiliary equipments (such as computers) and motors. Space heating accounts for the largest share of energy use with about half of the total energy used (Figure 4.3). Street lighting included in total energy use is excluded from the factorization analysis because it is not associated with floor space activity.

Figure 4.3 — Commercial/Institutional energy use by end-use, 2008 (percent)



The commercial/institutional sector includes activities related to trade, finance, real estate, public administration, educational and commercial services. These activities have been grouped into 10 subsectors (see Figure 4.4 for a complete listing of activities). Of these activities, offices, retail trade and educational services account for 70 percent of the total Canadian commercial/institutional floor space, which in 2008 was estimated at 698.3 million m^2.

Figure 4.4 — Commercial/Institutional floor space by activity type, 2008 (percent)



5 Among the sectors presented in this document, the commercial/institutional sector has the most significant data limitations.

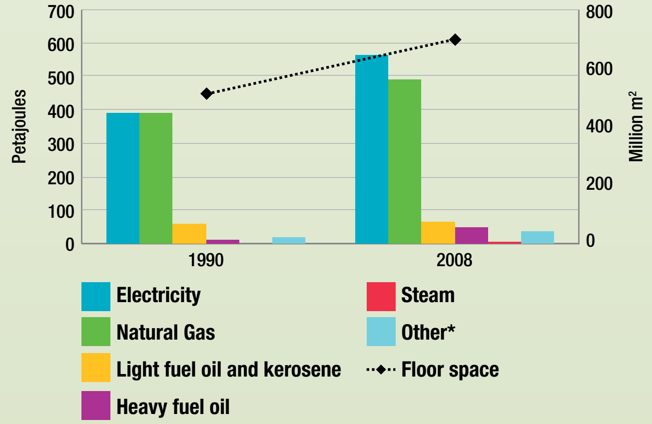
Trends — Commercial/ Institutional energy use and GHG emissions

Between 1990 and 2008, the commercial/ institutional sector was the fastest growing sector with respect to energy use and GHG emissions.

From 1990 to 2008, total commercial/institutional energy use increased 39 percent, from 867.0 PJ to 1,205.9 PJ, including street lighting. At the same time, GDP for the commercial/institutional sector grew 73 percent and floor space grew 37 percent. The GHG emissions, including electricity-related emissions, associated with the sector's energy use increased 38 percent over the same period.

While natural gas and electricity continue to be the main energy sources for the commercial/institutional sector, accounting for 87 percent of total energy use (Figure 4.5), rapid growth in petroleum products has been observed since 1999 — especially in consumption of heavy fuel oil, which increased 179 percent. One reason for these product increases may be secondary distribution of fuel marketers who are included in the commercial/institutional sector but find their way out of the sector through re-sellers to industry and transportation. A special survey is currently being conducted by Statistics Canada to help account for this activity.

Figure 4.5 — Commercial/Institutional energy use by fuel type and floor space, 1990 and 2008



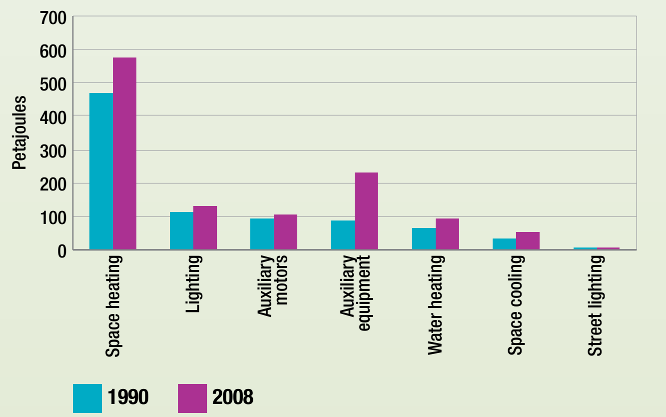
* Other includes coal and propane.

The proliferation of auxiliary equipment such as computers, faxes and printers added to energy use in Canada since 1990.

As shown in Figure 4.6, seven end-uses were responsible for the growth in commercial/institutional energy use. This growth is consistent with the overall increase in commercial/institutional floor space in Canada, except for street lighting, which does not relate to floor space activity.

Energy used for space heating increased 22 percent between 1990 and 2008. While space heating continues to be the primary end-use in the sector, two other end-uses have shown large increases in energy requirements: auxiliary equipment, resulting from increasing computerization of work spaces; and space cooling, resulting from a higher cooling rate of commercial/institutional buildings (Figure 4.6).

Figure 4.6 — Commercial/Institutional energy use by end-use, 1990 and 2008



Office activities drove most of the increased demand for energy in Canada's commercial/institutional sector.

As shown in Figure 4.7, the office subsector accounted for the largest share of energy use in 2008 (35 percent). Retail trade (17 percent) and educational services (13 percent) were the next largest users. Offices also had the largest increase in energy consumption, using 149.9 PJ more energy in 2008 than in 1990, followed by retail trade and educational services which saw increases of 61 and 40 PJ, respectively.

Figure 4.7 — Commercial/Institutional energy use by activity type, 1990 and 2008

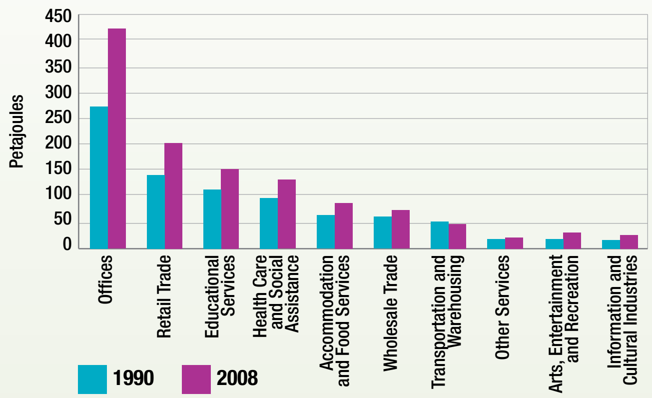
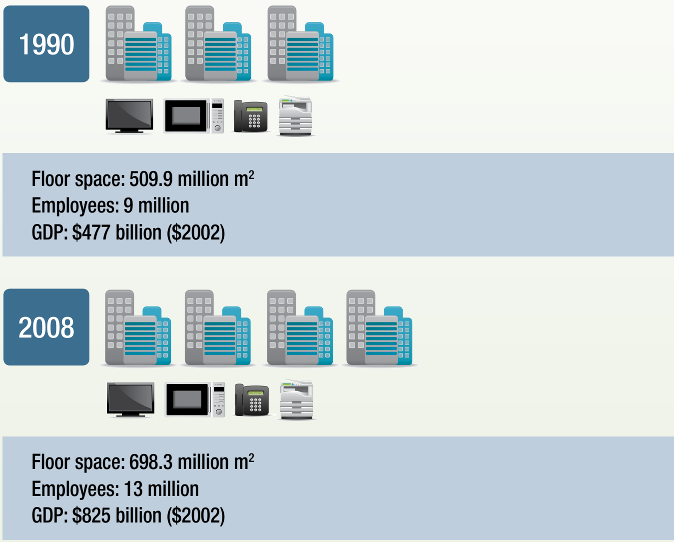


Figure 4.8 — Commercial/Institutional energy indicators, 1990 and 2008



Thirteen million people worked in Canada's commercial/institutional sector in 2008.[6]

Several indicators can help describe the growth of energy use in the commercial/institutional sector, including the number of employees, floor space and GDP. Figure 4.8 shows that floor space increased 37 percent from 1990 and the number of employees in this sector increased 40 percent.

While some gains in energy efficiency were made in terms of overall energy per floor space, this was offset by an increase in energy requirements for auxiliary equipment. Not only was there an overall increase in computerization of the work environment in the commercial/institutional sector during this period, but the actual number of devices required increased per employee.

Commercial/Institutional energy intensity and efficiency

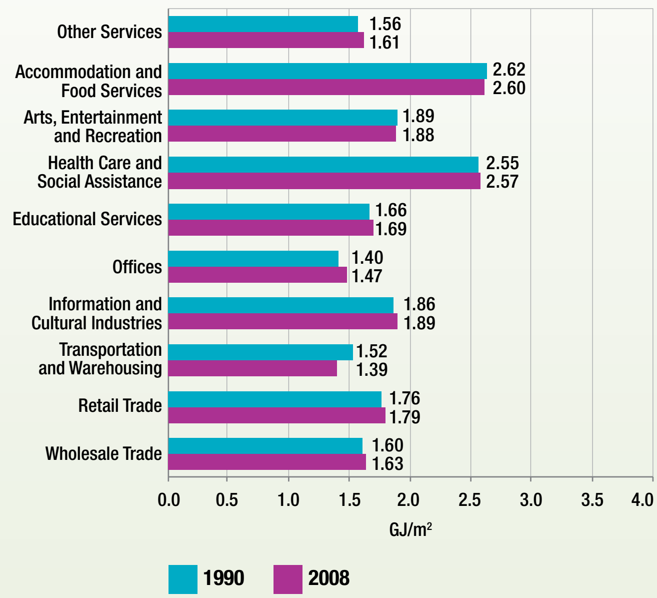
Energy intensity

Accommodation and Food Services is the most energy-intensive commercial/institutional activity.

In the commercial/institutional sector, energy intensity refers to the amount of energy used per unit of floor space (GJ/m^2).

[6] Commercial/Institutional sector encompasses all services-producing industries in Canada, NAICS 41-91.

Figure 4.9 — Commercial/Institutional energy intensity by activity type, 1990 and 2008



As shown in Figure 4.9, accommodation and food services consumed 2.60 GJ/m^2 in 2008, followed by health care and social assistance, which consumed 2.57 GJ/m^2. They are the most energy-intensive activity types despite a slight decrease observed in the energy intensity related to the accommodation and food services subsector. This may be attributable to the energy-demanding nature of their activities (restaurants, laundry) and services (extensive hours of operation), as well as the proliferation of electronic equipment with high energy requirements (such as medical scanners).

The commercial/institutional sector as a whole experienced a small increase in energy intensity of 2 percent in terms of energy consumed per unit of floor space (GJ/m^2). However, the sector reduced its energy intensity by 20 percent when measured against economic activity (PJ/GDP).

Energy efficiency

Energy efficiency improvements in Canada resulted in energy savings of $2.4 billion in the commercial/institutional sector since 1990.

Energy efficiency improvements in the commercial/institutional sector were very similar to those in the residential sector. They include changes to the thermal envelope of buildings (insulation, windows, etc.) and increased efficiency of various energy-consuming items in commercial/institutional buildings such as furnaces, auxiliary equipment and lighting. The estimated energy efficiency improvements have resulted in a 103.6 PJ energy savings for this sector between 1990 and 2008 (Figure 4.10).

Figure 4.10 — Commercial/Institutional energy use, with and without energy efficiency improvements, 1990–2008

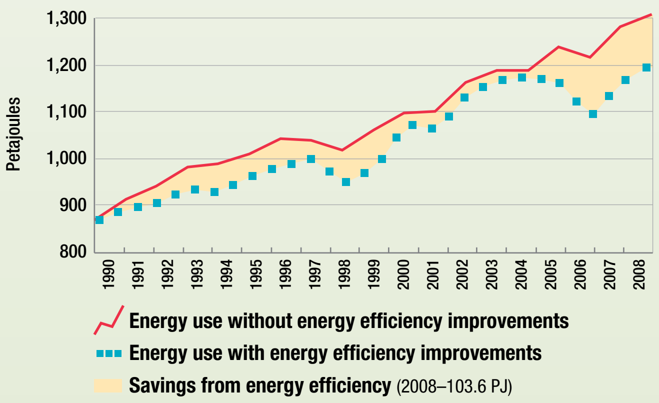
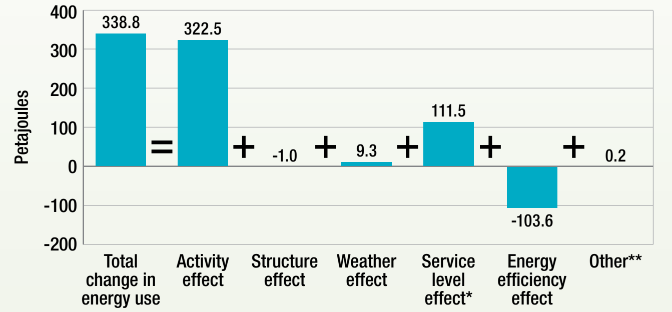


Figure 4.11 illustrates the influence that various factors had on the change in commercial/institutional sector energy use between 1990 and 2008. These effects are as follows:

- **activity effect** — A 37 percent increase in floor space led to 38 percent (322.5 PJ) growth in energy use and an increase of 17.5 Mt in GHG emissions.
- **structure effect** — The effect of structure changes in the sector (the mix of activity types) was small and thereby had marginal effect on change in GHG emissions.
- **weather effect** — In 2008, the winter was colder but the summer was warmer than that of 1990. The net result was a 9.3-PJ increase in energy demand in the commercial/institutional sector, mainly for space conditioning, which had the effect of increasing GHG emissions by 0.5 Mt.
- **service level effect** — An increase in space cooling and in the service level of auxiliary equipment, which is the penetration rate of office equipment, (e.g. computers, fax machines and photocopiers), led to a 111.5-PJ increase in energy use and a 6.0-Mt increase in GHG emissions.
- **energy efficiency effect** — Improvements in the energy efficiency of the commercial/institutional sector saved 103.6 PJ of energy and 5.6 Mt of GHG emissions.

Figure 4.11 — Impact of activity, structure, weather, service level and energy efficiency on the change in commercial/institutional energy use, 1990–2008



* The service level effect refers to the increased use of auxiliary equipment and office equipment.

** Other refers to street lighting, which is included in total energy use but excluded from the factorization results.

Industrial Sector

Chapter 5

Overview — Industrial energy use and GHG emissions

The industrial sector used the most energy of any sector in Canada but had fewer GHG emissions than the transportation sector.

The industrial sector includes all manufacturing, mining, forestry and construction activities. In 2008 alone, these industries spent $39.9 billion for energy. Total energy use by industry accounted for 37 percent of the total energy use (see Figure 5.1) and 32 percent of end-use GHG emissions (see Figure 5.2).

Figure 5.1 — Energy use by sector, 2008 (percent)

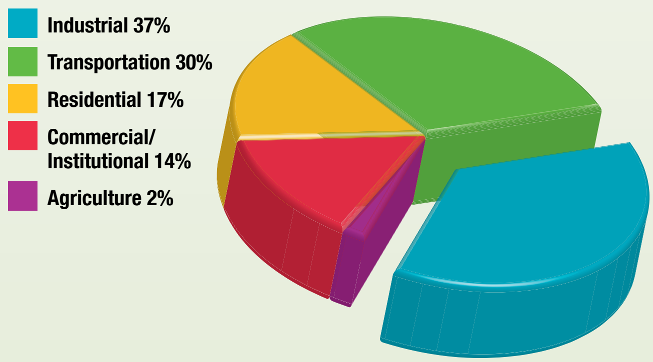
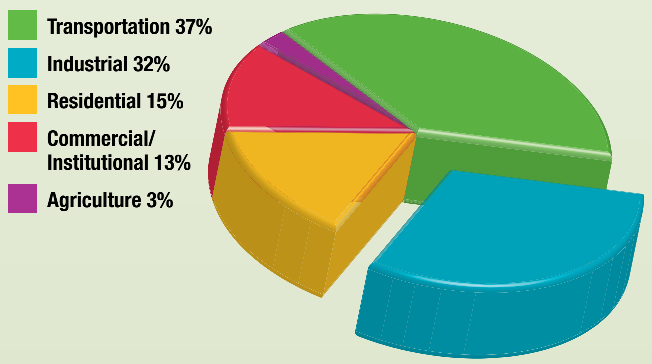


Figure 5.2 — GHG emissions by sector, 2008 (percent)

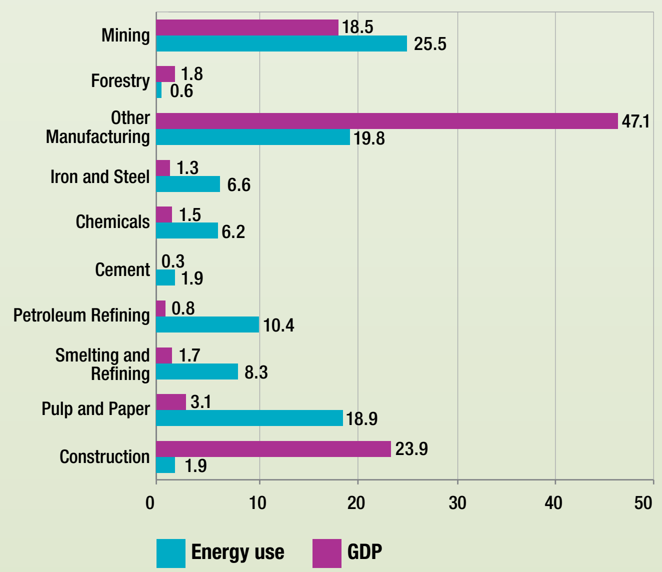


The energy use of an industry is not necessarily proportional to its level of economic activity.

In 2008, the industrial sector's share of GDP accounted for 25 percent of the Canadian total (excluding agriculture). The main contributor to industrial GDP was "other manufacturing," which includes a variety of activities such as food and beverage, textile, computer and electronic industries. Construction and mining were the only other two industries that contributed more than 10 percent to the industrial sector's GDP (see Figure 5.3).

Although GDP is an indicator of economic activity, a notable characteristic of the industrial sector is that the industries with the highest activity level do not necessarily use the most energy. For example, the pulp and paper industry is responsible for 19 percent of industrial energy use, but only 3 percent of economic activity. In contrast, an industry such as construction is responsible for 24 percent of the economic activity, but only 2 percent of industrial energy use (see Figure 5.3).

Figure 5.3 — Distribution of energy use and activity by industry, 2008 (percent)



Variation of fuel use by industry

In the industrial sector, energy is used primarily to produce heat, to generate steam or as a source of motive power. For example, coal is one of the types of energy used by the cement industry to heat cement kilns. Many other industries use natural gas to fuel boilers for steam generation and electricity to power motors for pumps and fans.

Natural gas and electricity were the main fuels used in the industrial sector in 2008, meeting 32 percent and 24 percent, respectively, of the energy needs of the sector. Wood waste and pulping liquor (14 percent) and still gas and petroleum coke (14 percent) were the other most used fuel types.

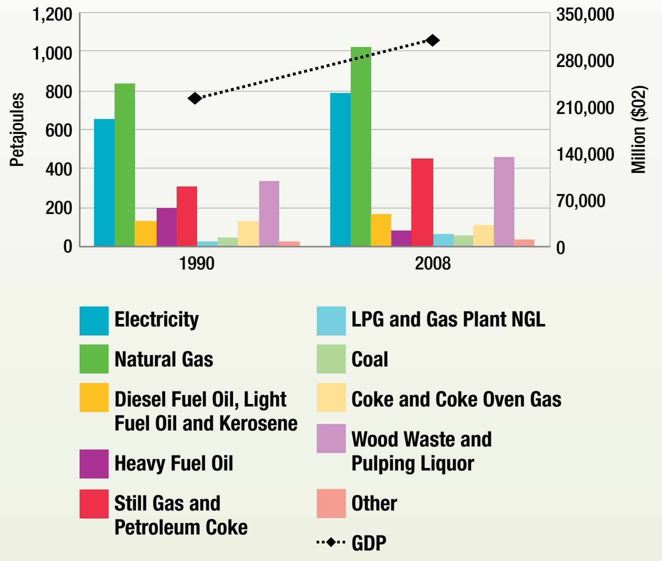
The type of energy used varies greatly depending on the industries in which it is used. Although electricity is used across the entire sector, it is the pulp and paper and the smelting and refining industries that require the most electricity. Combined, these two industries account for more than 49 percent of the sector's electricity use.

Wood waste and pulping liquor are primarily used in the pulp and paper industry since they are recycled materials produced by this industry. However, some of the electricity produced from these materials is sold to other industries.

Trends — Industrial energy use and GHG emissions

From 1990 to 2008, industrial energy use increased 19 percent, from 2,710.0 PJ to 3,237.8 PJ. The associated end-use GHGs increased 13 percent, from 136.0 Mt to 154.0 Mt. GDP increased 40 percent from $221 billion ($2002) in 1990 to $310 billion ($2002) in 2008 (see Figure 5.4).

Figure 5.4 — Industrial energy use by fuel type and GDP, 1990 and 2008



In most cases, fuel shares remained relatively constant between 1990 and 2008 as fuel consumption increased for most fuel types during this period. The exceptions were heavy fuel oil (HFO), which experienced a 58-percent decrease, and coke and coke oven gas, which decreased 17 percent.

One reason for the decline in use of HFO was that the pulp and paper industry, the largest user of HFO, adopted alternate forms of fuels such as pulping liquor. Fuel switching was facilitated by the use of interruptible contracts, with energy suppliers allowing the industry to react to changes in relative prices of fuels. In 2009, the Government of Canada created the Pulp and Paper Green Transformation Program (PPGTP),[7] which offers pulp and paper mills funding of $0.16/litre of black liquor burned.

[7] The PPGTP provides pulp and paper mills with one-time access to $1 billion in funding for capital investments that make environmental improvements to their facilities. Pulp mills located in Canada that produced black liquor between January 1 and December 31, 2009 are eligible for funding. Mills will receive funding based on $0.16/litre of black liquor burned until the $1 billion in funding is fully allotted.

Forestry, mining, smelting and refining, and other manufacturing have all experienced large growth in energy use since 1990. However, forestry consumes proportionately less energy than the other three sectors (mining, smelting and refining, and other manufacturing). The trends for four of the main contributors to energy demand are now described in greater detail.

Trends — Mining energy use and GHG emissions

The mining industry comprises industries engaged in oil and gas extraction, coal mining, metal ore mining, non-metallic mineral mining, quarrying and support activities for mining and oil and gas extraction[8].

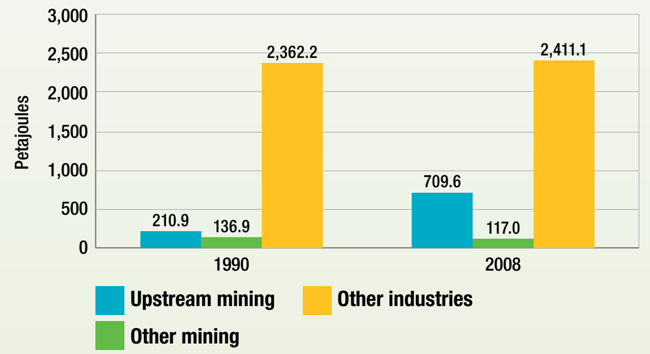
Between 1990 and 2008, the mining industry's energy consumption grew 138 percent and its associated end-use emissions grew 126 percent. The GDP of the mining industry increased 48 percent over the same period, from $38.9 billion ($2002) to $57.3 billion ($2002), compared to a 40 percent increase for the entire industrial sector.

Upstream mining was the biggest contributor to GDP, representing $50.4 billion ($2002) of mining's GDP in 2008. Activity in the oil sands was the main driver in the increase in energy demand from the mining industries.

Upstream mining includes oil sands mining operations. Since the late 1990s, production from non-conventional resources (oil sands) increased. Driven by technological advances, which have lowered production costs, and by additional revenue from higher crude oil prices, investment in oil sands projects has become much more attractive.

The production of bitumen and synthetic crude oil in 1985 was 35,000 cubic metres per day (m^3/day). It reached 71,000 m^3/day by 1996 and climbed to 192,000 m^3/day by 2008. This increase is the principal factor explaining the increase of 236 percent in the energy used by the upstream mining industry since 1990 (see Figure 5.5).

Figure 5.5 — Industrial energy use by selected industry, 1990 and 2008



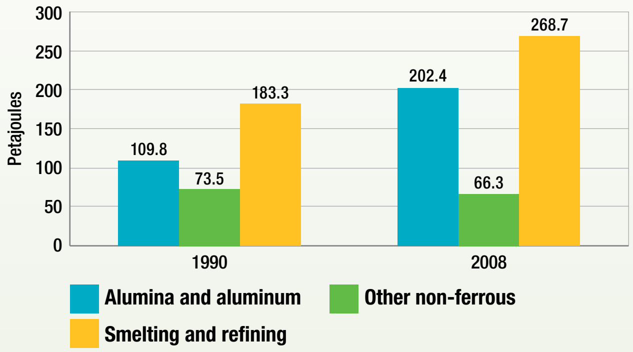
Trends — Smelting and refining energy use and GHG emissions

The smelting and refining industries are primarily engaged in the production of aluminum, nickel, copper, zinc, lead and magnesium.

The smelting and refining subsector is the third-largest contributor to growth in energy demand. This was mainly driven by economic growth, as the GDP increased from $2.8 billion ($2002) in 1990 to $5.1 billion ($2002) in 2008 — an 84 percent increase. During the same period, associated GHG emissions increased 43 percent.

[8] NAICS code 21 excluding 213118, 213119 and part of 212326.

Figure 5.6 — Smelting and refining energy use by selected industry, 1990 and 2008



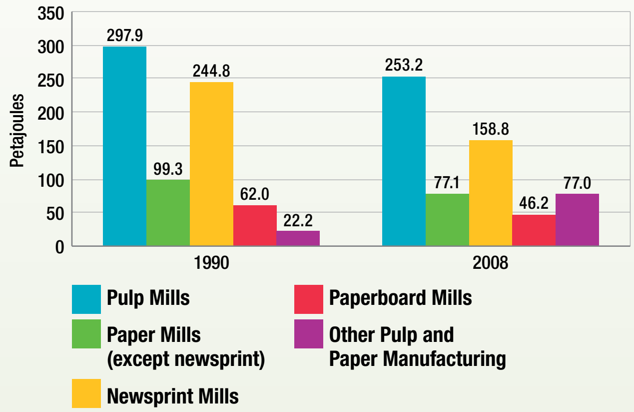
The production of aluminum grew 99 percent between 1990 and 2008, and is responsible for most of the 47 percent growth in energy use in this subsector since 1990 (see Figure 5.6).

Trends — Pulp and paper energy use and GHG emissions

The pulp and paper industry is engaged in the manufacturing of pulp, paper and paper products, and is the main user of biomass as a source of energy.

Pulp and paper production decreased its energy use by 16 percent since 1990, and now represents 19 percent of the sectoral energy use. The largest decline came from the newsprint mill industry, with a 35 percent decrease since 1990 (see Figure 5.7). GHG emissions decreased 42 percent since 1990 for the sector as a whole.

Figure 5.7 — Energy consumption by subsector of the pulp and paper industry, 1990 and 2008



Trends — Other manufacturing energy use and GHG emissions

Other manufacturing is a residual category of manufacturing industries not classified elsewhere in the industrial sector definition used in this analysis. This category includes many industries, such as wood products, food and beverage, and motor vehicle manufacturing.

Other manufacturing energy use increased from 553.2 PJ to 640.7 PJ between 1990 and 2008. GHG emissions were 28 Mt in both 1990 and 2008, while GDP increased from $102.3 billion ($2002) to 145.8 billion ($2002).

The biggest energy consumer in the other manufacturing category is the wood products industry. These establishments are engaged in:

- sawing logs into lumber and similar products, or preserving these products
- making products that improve the natural characteristics of wood, for example, by making veneers, plywood, reconstituted wood panel products or engineered wood assemblies
- making a diverse range of wood products such as millwork

The wood products industry represented 8 percent of the other manufacturing subsector's energy use, with 49.8 PJ. Its average annual increase is 0.7 percent.

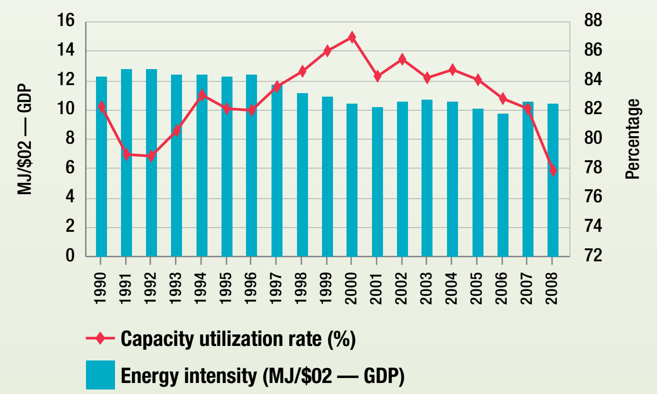
Detailed energy use data are taken from the *Industrial Consumption of Energy* survey for 1990 and from 1995 onward. Data for 1991–1994 are from the Canadian Industrial End-Use Energy Data and Analysis Centre's (CIEEDAC) report *Energy Intensity Indicators for Canadian Industry 1990–2008*. Previously, all detailed energy use data came from the CIEEDAC report. This means that detailed industry categories will not compare exactly to previous years.

Industrial energy intensity and efficiency

Energy intensity

Several factors influenced the trends in energy use and energy intensity. Since 1990, energy intensity decreased at an average annual rate of 0.8 percent, from 12.3 MJ/$2002 — GDP in 1990 to 10.5 MJ/$2002 — GDP in 2008 (see Figure 5.8).

Figure 5.8 — Capacity utilization and energy intensity per year



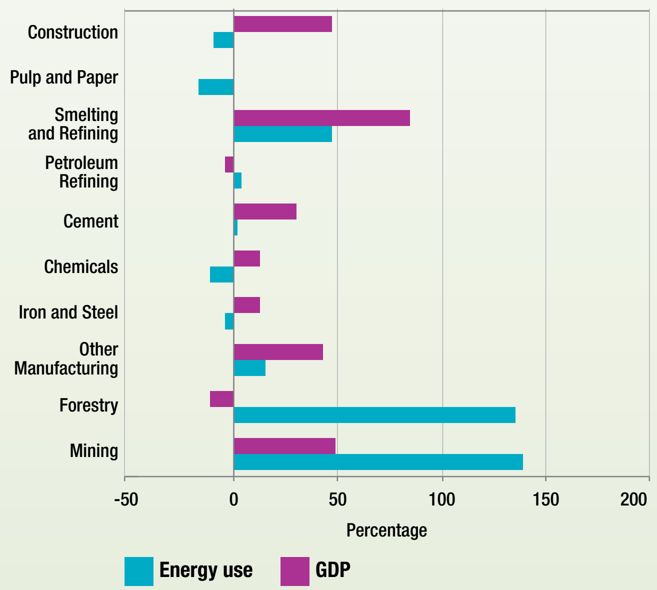
Energy efficiency improvements in the form of more efficient capital and management practices are important factors. Another key variable linked to energy intensity is the capacity utilization rate. This rate is calculated by dividing the actual production level for an establishment (measured in dollars or units) by the establishment's maximum production level under normal conditions.

At the aggregate industry level, seven of the 10 industries reduced their energy intensity[9] over the 1990 to 2008 period. Three industries experienced an increase: mining, petroleum refining, and forestry. The biggest increase in energy intensity was 164 percent in forestry. Figure 5.9 illustrates that energy use in forestry increased 134 percent, while GDP fell 11 percent. Diesel fuel made up 90 percent of energy use in the industry. In the mining sector, the move toward unconventional crude oil production contributed to the increase in the energy intensity.

[9] MJ/($2002) – GDP

Gains in energy efficiency and a shift toward less energy-intensive activities were contributing factors in the sub-sectors that decreased their energy. For example, chemical industries that improved their energy intensity between 1990 and 2008 saw their share of the industry's GDP grow from 68 percent to 77 percent over the same period.

Figure 5.9 — Change in GDP and energy use, 1990–2008



Energy efficiency

Since 1990, energy efficiency in the industrial sector improved 10 percent. In 2008 alone, Canadian industry saved $4.3 billion in energy costs and 332.5 PJ of energy or 15.8 Mt of GHG emissions. The improvement in energy efficiency was largely the result of improvements in energy intensity. The energy savings due to the energy efficiency improvements made by some industries were offset by increases in consumption by the upstream mining, fertilizer and forestry subsectors.

In previous years, the energy intensity for upstream mining was calculated by dividing energy use by GDP. As the upstream mining sector grows, so does the need to find a better way to quantify its energy efficiency gains. This year, upstream mining was divided into its components (coal mining, crude oil production, natural gas production and processing, upgrading, synthetic and bitumen production, as well as well drilling, testing, and servicing) and production was used to measure energy intensiveness. This allowed us to better quantify the energy efficiency gains achieved by the sector. However, over time the industry has experienced a switch to more energy-intensive unconventional oil production. So, even if we account for energy savings due to technological advances, the increased difficulty in extracting upstream mining resources translates into an increasingly energy-intensive process.

Figure 5.10 — Industrial energy use, with and without energy efficiency improvements, 1990–2008

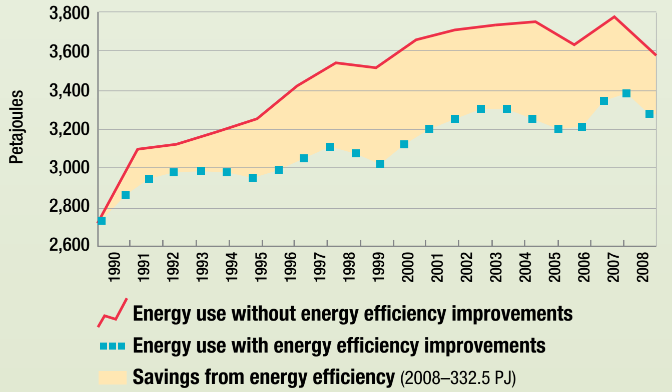
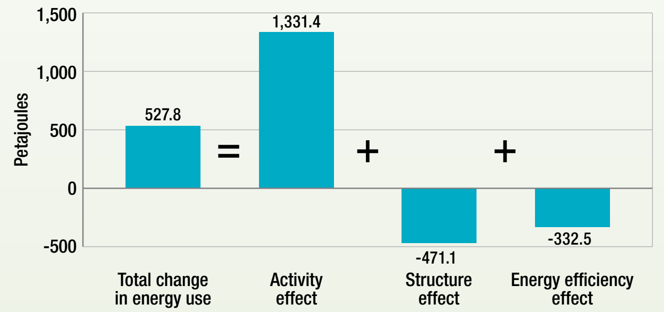


Figure 5.11 illustrates the influence that various factors had on the change in industrial energy use between 1990 and 2008. These effects are as follows:

- **activity effect** — Activity (the mix of GDP, GO and production units) increased the energy use by 49 percent or 1,331.4 PJ.
- **structure effect** — The structural changes in the industrial sector, specifically, a relative decrease in the activity share of energy-intensive industries, helped the sector to reduce its energy use by 471.1 PJ. Note that industries consuming more than 6 megajoules (MJ) per dollar of GDP (e.g. pulp and paper, petroleum refining, upstream mining) represented 28 percent of industrial GDP in 1990 and accounted for 27 percent in 2008.
- **energy efficiency effect** — Improvements in the energy efficiency of the industrial sector avoided 332.5 PJ of energy use and 15.8 Mt of GHG emissions.

Figure 5.11 — Impact of activity, structure and energy efficiency on the change in industrial energy use, 1990–2008



Transportation Sector

Chapter 6

6 Transportation Sector

Overview — Transportation energy use and GHG emissions

Transportation was second to the industrial sector in terms of energy use, but was first in terms of the amount spent on energy in 2008.

The transportation sector is a diverse sector that includes several modes: road, air, rail and marine transport. Canadians use these modes to move passengers and freight. This chapter describes the energy consumed for both.

In 2008, Canadians (individuals and companies) spent $82.2 billion on transportation energy, the most of any sector in Canada and 95 percent more than the industrial sector. This high level of spending is a result of the notably higher price of transportation fuels compared with the price of energy used in other sectors.

The transportation sector also ranked highly in terms of energy use (Figure 6.1) and GHG emissions (Figure 6.2). It accounted for the second largest amount of energy in Canada (30 percent of the total) and the largest amount of energy-related GHG emissions (36 percent). This sector produces a larger share of the GHG emissions because the main fuels used for transportation are more GHG intensive compared with other areas of the economy.

Figure 6.1 — Energy use by sector, 2008 (percent)

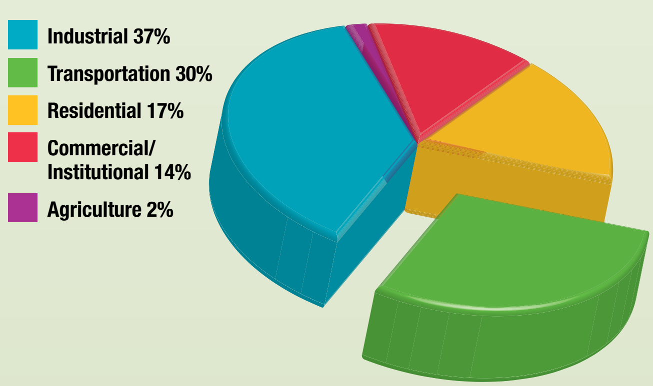
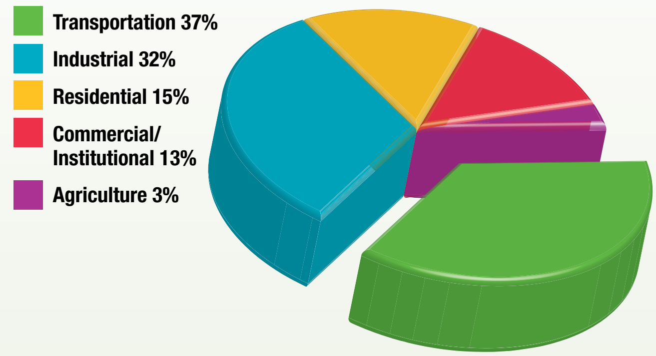
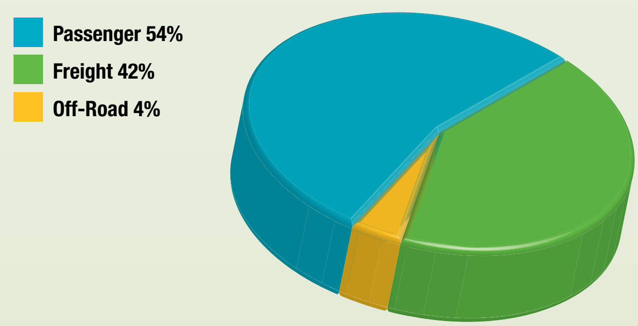


Figure 6.2 — GHG emissions by sector, 2008 (percent)



In the transportation sector, passenger modes consumed 54 percent of total energy use, while the freight subsector accounted for 42 percent and off-road vehicles used the remaining 4 percent (Figure 6.3). Off-road vehicles include all vehicles that are principally used off public roads, such as snowmobiles and lawnmowers. Off-road transportation is not analyzed in this report because few data are available for these vehicles, and their share of energy consumption is small.

Figure 6.3 — Energy use by subsector, 2008 (percent)



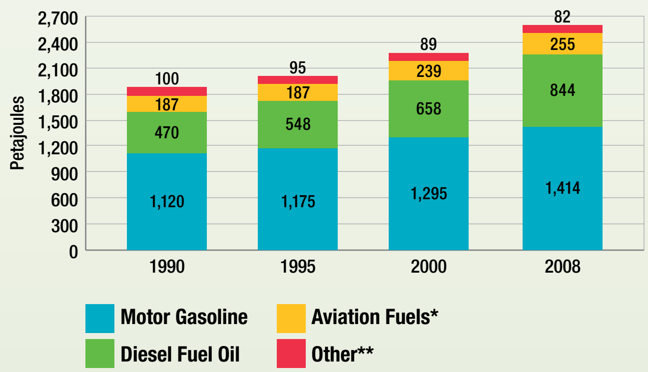
Trends — Transportation energy use and GHG emissions

Growth in freight transport drove energy demand in the transportation sector.

Between 1990 and 2008, total transportation energy use increased 38 percent, from 1,877.9 PJ to 2,594.1 PJ, and the associated GHG emissions rose 36 percent, from 131.6 Mt to 179.4 Mt.

Freight was the fastest growing subsector, accounting for 63 percent of the change in total transportation energy use. The increased use of heavy trucks, which are relatively more energy-intensive when compared to the other modes, accounts alone for 79 percent of this increase in freight energy use and 50 percent of the increase in total transportation.

Figure 6.4 — Transportation sector energy use by energy source, selected years



* Aviation fuels include aviation turbo fuel and aviation gasoline.
** Other includes electricity, natural gas, heavy fuel oil and propane.

Growth in freight transportation contributed to an 80 percent increase in the demand for diesel fuel.

Motor gasoline and diesel fuel oil, as seen in Figure 6.4, are the main fuels used in the transportation sector, accounting for 87 percent of the total energy use. In order of amount used, aviation turbo fuel, heavy fuel oil, propane, aviation gasoline, electricity and natural gas are also reported. Motor gasoline dominates the market with 54 percent of the total transportation energy, followed by diesel at 33 percent and finally by other energy sources, which account for 13 percent.

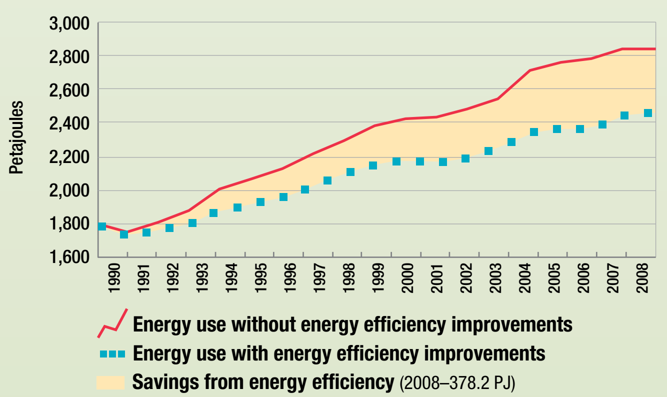
Between 1990 and 2008, diesel fuel consumption increased by 80 percent due to more widespread use of heavy trucks on Canadian roads, which alone accounts for 96 percent of this increase. However, motor gasoline use has increased by 26 percent, of which more than a half (163.0 PJ) can be attributed to passenger vehicles and about a third (86.7 PJ) to freight transportation. Aviation gasoline, propane and electricity are transportation fuels whose consumption decreased over the period.

Transportation energy efficiency

Energy efficiency improvements in transportation resulted in energy savings of 378.2 PJ, or $12 billion, for Canada in 2008.

Between 1990 and 2008, energy efficiency in the transportation sector improved 21 percent, leading to savings of $12 billion, or 378.2 PJ of energy (Figure 6.5). These savings were largely a result of improvements in the energy efficiency of heavy trucks and passenger light-duty vehicles. Savings generated by the improvement of both of these types of vehicles had a significant impact on the total energy use since they comprise the majority of vehicles on the road.

Figure 6.5 — Transportation energy use, with and without energy efficiency improvements, 1990–2008 (petajoules)



* The presented data do not include off-road vehicles and non-commercial airlines.

Trends — Passenger transportation energy use and GHG emissions

Light-duty vehicles (small cars, large cars, light trucks and motorcycles) represent the main type of transport used by Canadians for passenger transportation. Air, bus and rail modes are also used, but to a lesser extent.

For the passenger transportation subsector, energy use is related to passenger-kilometres (Pkm). A passenger-kilometre is calculated by multiplying the number of passengers carried by the distance travelled. Therefore, two passengers travelling in a car for 10 km equals 20 Pkm. As the passenger-kilometres increase, a rise in energy use usually occurs, unless sufficient energy efficiency improvements have taken place to offset the growth in activity.

The number of light-duty vehicles per capita has increased slightly.

Figure 6.6 — Passenger transportation energy indicators,* 1990 and 2008

1990

- 14.2 million vehicles
- 19.4 percent are light trucks
- 17,230 km/year on average per vehicle
- 375.9 billion Pkm travelled
- 0.68 vehicles per person aged 18 years and older

2008

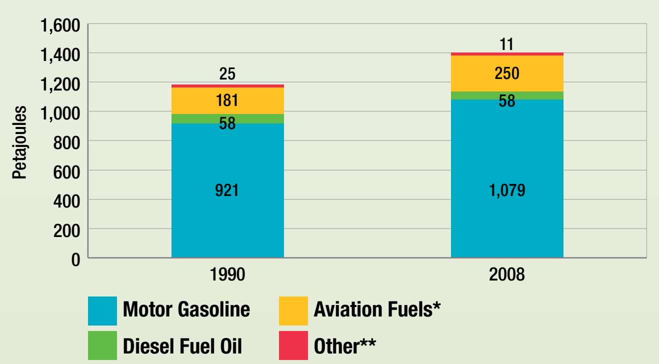
- 18.8 million vehicles
- 33.1 percent are light trucks
- 16,753 km/year on average per vehicle
- 511.9 billion Pkm travelled
- 0.71 vehicles per person aged 18 years and older

* The presented data do not include air travel, bus and rail transportation.

Figure 6.6 shows a slight increase in the number of vehicles per person aged 18 years and older, from 0.68 in 1990 to 0.71 by 2008. The distance in passenger-kilometres accumulated by light-weight vehicles for the purpose of passenger transportation (excluding urban transportation and buses) increased on average by 1.7 percent per year. The distance in passenger-kilometres for urban transportation and buses increased on average by 1.2 percent per year between 1990 and 2008. There is therefore a relative decrease in the share of public transit. The energy use for passenger transportation rose by 18 percent, from 1,184.5 PJ to 1,396.9 PJ between 1990 and 2008. The associated GHG emissions increase was 15 percent, from 82.3 to 94.9 Mt.

The mix of fuels for passenger transport has remained relatively constant. Motor gasoline was the main source of energy, representing 77 percent of the fuel mix in 2008, followed by aviation turbo fuel and diesel fuel (Figure 6.7).

Figure 6.7 — Passenger transportation energy use by fuel type, 1990 and 2008



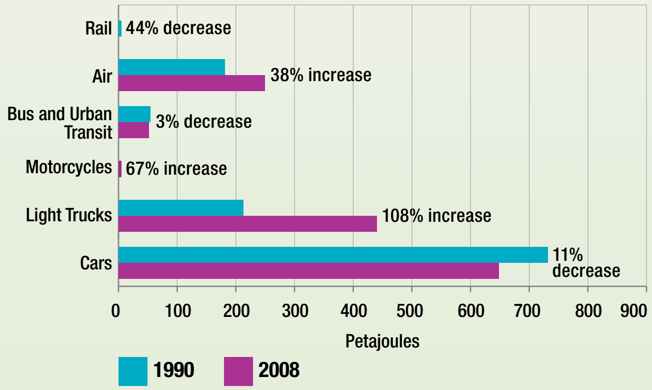
* Aviation fuels include aviation turbo fuel and aviation gasoline.

** Other includes electricity, natural gas, heavy fuel oil and propane.

More Canadians drive minivans and SUVs.

The choices that Canadians make to meet their transportation needs contribute to the growth in energy use. A greater share of Canadians bought light trucks (including minivans and sport utility vehicles [SUVs]), which usually have less favourable fuel consumption ratings than cars. In 2008, 39 percent of all new passenger vehicle sales were light trucks, compared with 26 percent in 1990. This change, characterized by a shift away from the use of cars to the use of light trucks, brought about a large increase in passenger transportation energy use. Between 1990 and 2008, light-truck energy use increased more quickly than any other passenger transportation mode, rising 108 percent (Figure 6.8).

Figure 6.8 — Passenger transportation energy use by mode, 1990 and 2008



Air transport is rising in popularity.

Canadians have steadily been increasing their use of air transportation since 1990, with the number of passengers moved by Canadian carriers rising 56 percent and the average trip length increasing 25 percent during the period between 1990 and 2008.[10] Both of these factors help to explain the large increase of 96 percent in aviation passenger-kilometres that the transportation sector has experienced since 1990. However, in the same period, growth in energy use was significantly less at 38 percent, pointing to the increasing efficiency of the industry. Two key factors have contributed to this improvement in efficiency. First is the growing effort on the part of carriers to match their aircraft size with the size of the market, thereby increasing their overall load factor. The second factor is the implementation of the "Open Skies" agreement between Canada and the United States, which came into effect in 1994–1995. The agreement made it possible to add a number of short routes provided by regional carriers with smaller aircraft.[11]

Passenger transportation energy intensity and efficiency

Energy intensity

Passenger transportation energy intensity is defined as the amount of energy required to move one person over 1 km. Between 1990 and 2008, energy intensity decreased by 17 percent, from 2.4 MJ per Pkm travelled to 2.0 MJ/Pkm. An improvement in vehicle fuel efficiency is the main reason for this change. Average fuel efficiency is measured by litres used per 100 kilometres (L/100km).

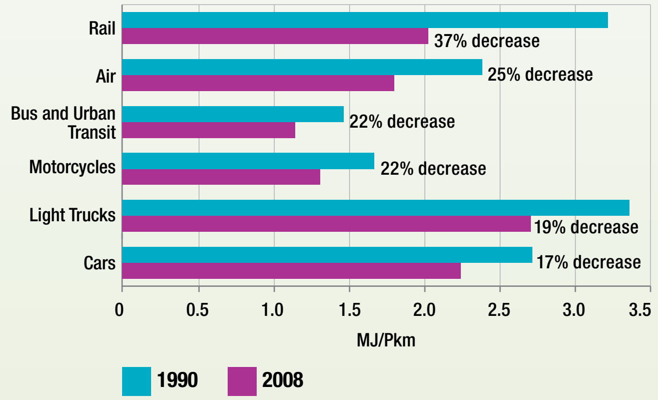
Figure 6.9 shows that the average fuel efficiency improved for all types of transportation for the period 1990–2008. Passenger rail services in Canada achieved the greatest improvement in energy intensity with a decrease of 37 percent, followed by air transportation with 25 percent. In third place are buses and urban transit with a reduction of close to a quarter of the 1990 level, that is 22 percent. Finally, light trucks and cars have registered the least efficient performance as their respective intensity reductions were 19 percent and 17 percent, compared to the 1990 level.

[10] Statistics Canada, *Civil Aviation, Annual Operating and Financial Statistics, Canadian Air Carriers, Levels I to III: 2008*, Ottawa, March 2009 (Cat. 51-004-XIE).

[11] Transport Canada, *Assumptions Report 2007–2011: Final Report*, Ottawa, December 2007.

There were two major contributors to the rise in passenger energy use since 1990. First was the increased popularity of light trucks, which consume more fuel than cars. Second, light trucks have the highest level of energy intensity of the modes of transport studied.

Figure 6.9 — Passenger transportation energy intensity by modes, 1990 and 2008

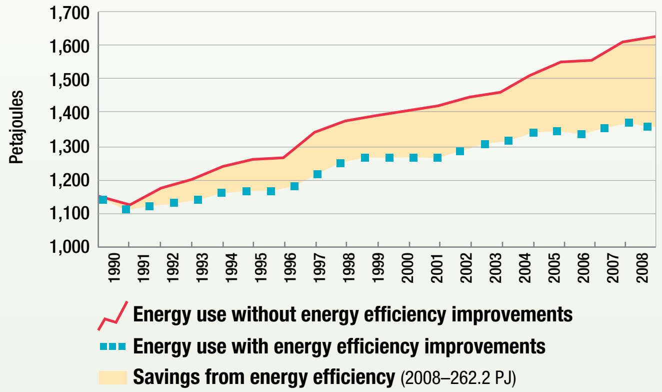


Energy efficiency

Energy efficiency improvements in passenger transportation generated energy savings of 262.2 PJ, or $8.3 billion, in the transportation sector in 2008.

The amount of energy used for passenger travel increased 18 percent, rising from 1,184.5 PJ in 1990 to 1,396.9 PJ in 2008. Also, energy-related GHG emissions increased 15 percent, from 82.3 Mt to 94.9 Mt.[12] As seen in Figure 6.10, without energy efficiency improvements, energy use would have increased 41 percent during the period, instead of the observed 18 percent.

Figure 6.10 — Passenger transportation energy use, with and without energy efficiency improvements, 1990–2008 (petajoules)



* The presented data do not include non-commercial airline aviation.

Figure 6.11 illustrates the influence of various factors on the change in passenger transportation energy use between 1990 and 2008. These effects are the following:

- **Activity effect** — The activity effect (i.e. passenger-kilometres travelled) increased energy use by 39 percent, or 445.0 PJ, with a corresponding 30.2-Mt increase in GHG emissions. This rise in passenger-kilometres (and therefore, activity effect) is mainly due to an increase of 157 percent in the light-truck activity and 96 percent in air transportation.

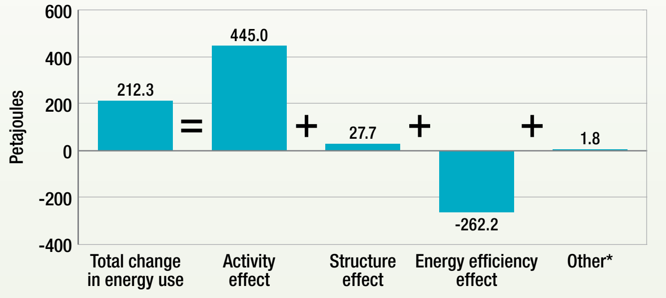
- **Structure effect** — Changes to the mix of transportation modes, or the relative share of passenger-kilometres travelled by air, rail and road, are used to measure changes in structure. Therefore, for example, an overall change in the structure would result in a decrease (increase) in energy use if a relative share of a more (or less) efficient transportation mode increases relative to other modes. The relative shares of passenger-kilometres have seen a strong increase in passenger air

[12] Electricity accounts for only 0.2 percent of total passenger transportation energy use and is used, for the most part, for urban transit.

transportation and light trucks. The overall effect on the structure was positive, given that the popularity of minivans and SUVs increased the activity share of light trucks compared with other modes, contributing to a 27.7-PJ increase in energy consumption and a 1.9-Mt increase in GHG emissions.

- **Energy efficiency effect —** Improvements in the energy efficiency of passenger transportation produced energy savings of 262.2 PJ and helped prevent the release of 17.8 Mt of energy-related GHG emissions. The light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation represented 73 percent of these energy savings.

Figure 6.11 — Impact of activity, structure and energy efficiency on the change in passenger transportation energy use, 1990–2008 (petajoules)



* "Other" refers to non-commercial airline aviation, which is included in the Total change in energy use value depicted above, but is excluded from the factorization analysis.

Energy efficiency: a consumer's choice

The analysis of data from the last two decades shows growing improvements in efficiency for personal vehicles. However, some factors indicate that even greater improvements are possible.

1. Technological advances have not only improved energy efficiency but have also enhanced vehicle performance and power. A greater number of valves per cylinder, installation of electronic control systems and improvement of aerodynamics have contributed to the increase in energy efficiency. These technological advances have also contributed to better acceleration, higher top speeds, greater load capacity and more horsepower, which saw a rise on average by 69 percent between 1990 and 2008. Trade-offs in terms of performance and power could generate even greater efficiency improvements.

2. Toward the end of 1970s, the Government of Canada proposed a number of voluntary targets for the automotive industry in Canada. Between 1978 and 1985, fuel economy standards changed from 13.1 L/100 Km to 8.6 L/100 Km and were not modified between 1985 and 2008. Targets for light trucks were introduced in 1990 and *were later slightly adjusted from 11.8 L/100 Km to 10.5 L/100 Km in 2008. The context of the last 20 years has therefore facilitated the use of research investments and industry development for purposes other than energy efficiency improvement.*

3. Consumer habits have shifted toward purchases of heavier and more fuel-intensive vehicles, such as minivans and SUVs. More consumer choices of energy-efficient vehicles would have produced much more significant improvements in efficiency.

The example of these three factors thus shows that despite economic and environmental considerations, the aspect of consumer's choices can influence energy consumption.

Characteristics of light vehicles	Model year		
	1990	2000	2008
Number of gears	3 gears (30%) 4 gears (47%) 5 gears (23%)	3 gears (4%) 4 gears (78%) 5 gears (18%)	4 gears (46%) 5 gears (38%) 6 gears (15%) more than 6 gears (1%)
Inertia weight (kilograms)	1,450	1,680	1,730
Engine	4 or fewer cylinders (50%) 5 or 6 cylinders (38%) 7 or more cylinders (12%)	4 or fewer cylinders (38%) 5 or 6 cylinders (49%) 7 or more cylinders (13%)	4 or fewer cylinders (48%) 5 or 6 cylinders (40%) 7 or more cylinders (12%)
Fuel injection system	Multipoint Injection, Indirect Injection	Multipoint Injection, Electronic Injection	Electronic Injection
Horsepower	127	171	214*
Consumption targets for vehicles**	8.6 L/100 Km	8.6 L/100 Km	8.6 L/100 Km
Consumption targets for light trucks**	11.8 L/100 Km	11.4 L/100 Km	10.5 L/100 Km
Average consumption for vehicles***	8.2 L/100 Km	7.8 L/100 Km	7.1 L/100 Km
Average consumption for light trucks***	11.3 L/100 Km	11.1 L/100 Km	9.5 L/100 Km

* Data estimations based on: U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2008, September 2008.*

** Corporate Average Fuel Consumption (CAFC) available on the Transport Canada Web site

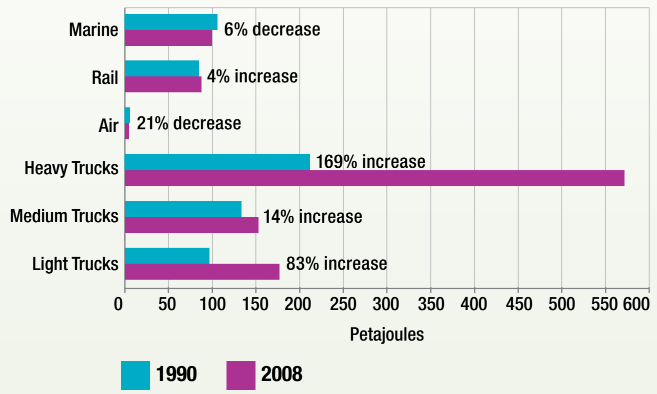
*** Canadian Fleet Averages of fuel consumption available on the Transport Canada Web site

Trends — Freight transportation energy use and GHG emissions

The freight subsector in Canada includes four modes: trucking, air, marine and rail. The trucking mode is divided into three truck types: light, medium and heavy. Energy use for freight transportation is related to tonne-kilometres (Tkm). One tonne-kilometre represents the movement of one tonne of goods across one kilometre.

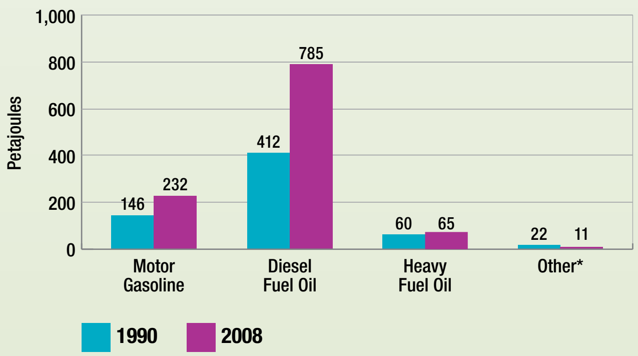
Freight energy use increased 71 percent, from 640.0 PJ in 1990 to 1,094.5 PJ in 2008. As a result, energy-related GHG emissions produced by freight transportation increased 70 percent, from 45.7 Mt in 1990 to 77.5 Mt in 2008. Figure 6.12 illustrates that energy use increased for all modes of freight transportation, except marine and air, where there were declines of 6 percent and 21 percent, respectively. Heavy and light trucks showed the largest increase in energy use, accounting for the majority of energy consumed for freight transportation in 2008.

Figure 6.12 — Freight transportation energy use by mode, 1990 and 2008



The mix of fuels used in the freight subsector remained relatively constant between 1990 and 2008. Diesel fuel continued to be the main source of energy, comprising 72 percent of the fuel consumed for freight transportation (Figure 6.13).

Figure 6.13 — Freight transportation energy use by fuel type, 1990 and 2008

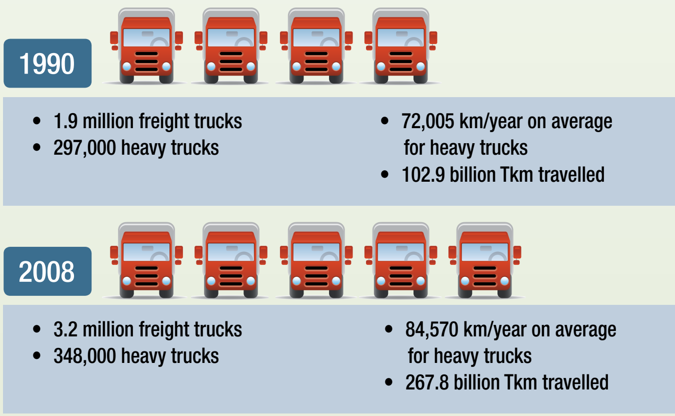


* "Other" includes aviation turbo fuel, aviation gasoline, natural gas and propane.

Just-in-time delivery pushes the demand for heavy-truck transportation.

The move toward just-in-time inventory for many companies has had a major impact on the freight subsector. Just-in-time inventory limits the use of warehouse space for inventory and instead relies on orders arriving at the company just as they are required for production. By using transportation vehicles as virtual warehouses, companies require an efficient and on-time transportation system, such needs usually being met by the use of heavy trucks. As a result, heavy truck use for freight transportation has been increasingly significant over the period. Between 1990 and 2008, the number of heavy trucks increased 17 percent, and the average distance travelled increased 17 percent, to reach 84,570 km per year. However, heavy trucks are not only travelling longer distances but also carrying more freight as the number of trailers they pull increases. These factors are having a major impact on the tonne-kilometres and energy use that heavy trucks are contributing to the freight subsector.

Figure 6.14 — Freight transportation energy indicators, 1990 and 2008



Rail remains the main mode for moving goods in Canada.

For many commodities, such as coal and grain, trucks are not an efficient means of transportation. Instead, rail and marine are still heavily relied upon. As a result, they make up the largest portions of the freight sector's activity. Rail ranks first in terms of tonne-kilometres in transported goods, with 344.9 billion Tkm in 2008, or 39 percent more than in 1990. In second position, marine transportation was used for 241.2 Tkm in 2008, an increase of 27 percent relative to 1990. However, with respect to the increase in freight transportation, the use of heavy trucks surpassed all other modes with a 185 percent growth since 1990. Analyses of transportation modes show a convergence of shares of heavy trucks and marine transportation markets.

Figure 6.15 — Freight transportation energy use versus activity by mode, 1990 and 2008

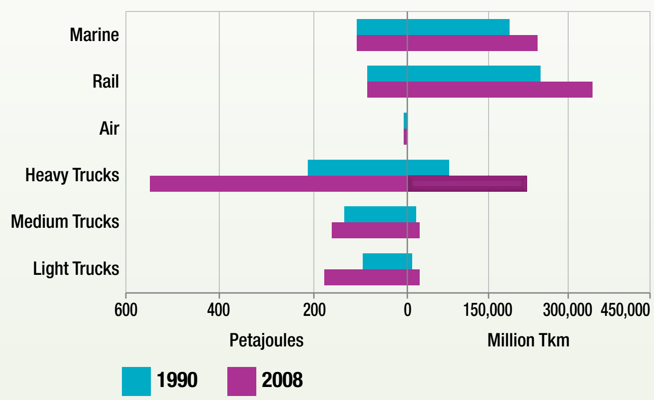
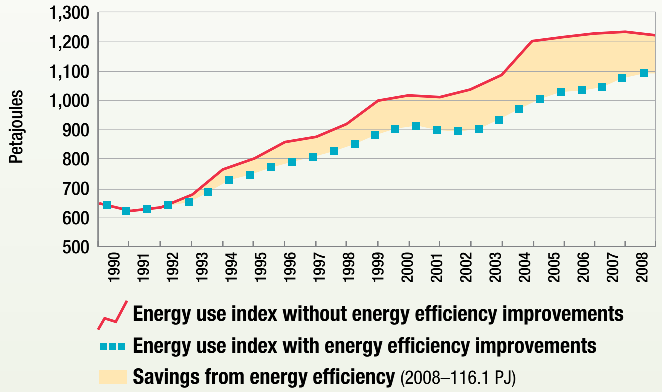


Figure 6.16 — Freight transportation energy use, with and without energy efficiency improvements, 1990–2008 (petajoules)



Since 1990, all modes of freight transportation have become more efficient in terms of energy use relative to tonne-kilometres moved. Figure 6.15 shows that the relative efficiency of rail and marine is greater than that of trucks at moving goods. These two modes of transportation have the highest levels of activity and a relatively low energy use. However, over the period, trucks increased in efficiency because their on-road average fuel consumption improved, from 42.5 L/100 km in 1990 to 35.3 L/100 km in 2008.

Freight transportation energy efficiency

Energy efficiency improvements in freight transportation resulted in energy savings of 116.1 PJ, or $3.7 billion, in the transportation sector in 2008.

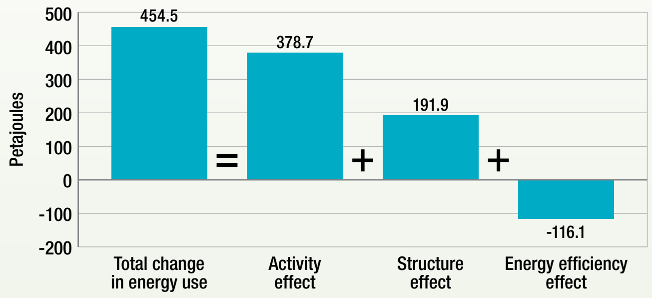
Between 1990 and 2008, energy use by freight transportation increased 71 percent, from 640.0 PJ to 1,094.5 PJ. Without energy efficiency improvements, energy use would have increased 89 percent, or 18 percent more than observed in 2008 (Figure 6.16).

Figure 6.17 illustrates the influence that various factors had on the change in freight transportation energy use between 1990 and 2008. These effects are the following:

- **Activity effect** — The activity effect (i.e. tonne-kilometres moved) increased energy use 59 percent, or 378.7 PJ, and caused a corresponding 26.8-Mt increase in GHG emissions. This increase in the number of tonne-kilometres was mainly due to an increase of 185 percent in heavy-trucks activity and an increase of 53 percent in medium-trucks activity.
- **Structure effect** — Changes to the mix of transportation modes, or the relative share of tonne-kilometres travelled by air, marine, rail and road, are used to measure changes in structure. Therefore, for example, an overall change in the structure would result in a decrease (increase) in energy use if a relative share of a more (or less) efficient transportation mode increases relative to other modes. The shift between modes was the increase in the share of freight moved by heavy trucks relative to other modes. The overall effect on the structure was positive, given the increase in Canada-USA trade and the just-in-time delivery demanded by clients, thus contributing to a more intensive use of truck transportation. Therefore, the analyses show an increase of 191.9 PJ in energy use and 13.6 Mt more in GHG emissions due to the structure effect.

- **Energy efficiency effect —** Improvements in the energy efficiency of freight transportation saved 116.1 PJ of energy and 8.2 Mt of GHG emissions. Improvements in freight trucks (light, medium and heavy trucks) were a large contributor, representing 51 percent of the savings.

Figure 6.17 — Impact of activity, structure and energy efficiency on the change in freight transportation energy use, 1990–2008 (petajoules)



Appendices

Appendix A: Reconciliation of Data

Figure A.1 Reconciliation of data with Canada's *Report on Energy Supply and Demand in Canada* — 2008 (petajoules)

	RESD Data	Residential Wood	Commercial & Public Admin. Diesel	Commercial & Public Admin. Aviation Fuels	Commercial & Public Admin. Motor Gasoline	Pipeline Fuels	Wood Waste & Pulping Liquor	Waste Fuels Used in Cement Industry	Re-allocation of Producer Consumption by Refineries and Mining Industries	Data Presented in This Handbook
Sector										
Residential	1,360	105								1,465
Commercial/ Institutional	1,531		(214)	(41)	(70)					1,206
Industrial	2,312						458	5	463	3,238
Transportation	2,430		214	41	70	(161)				2,594
Agriculture	217									217
Final Demand	**7,850**	**105**	**0**	**0**	**0**	**(161)**	**458**	**5**	**463**	**8,720**
Non-Energy	1,013									1,013
Producer Consumption	1,285					161			(463)	983
Net Supply	**10,148**	**105**	**0**	**0**	**0**	**0**	**458**	**5**	**0**	**10,716**
Fuel Conversion										
Electricity, Steam & Coal/Coke Input Fuels[1]	4,161									4,161
Electricity, Steam & Coal/Coke Production[2]	(2,366)									(2,366)
Total Primary	**11,943**	**105**	**0**	**0**	**0**	**0**	**458**	**5**	**0**	**12,510**

[1] "Electricity, Steam & Coal/Coke Input Fuels" represents the amount of input energy from source fuels (coal, uranium, etc.) that is transformed to electricity, steam, coke and coke gas.

[2] "Electricity, Steam & Coal/Coke Production" represents the amount of electricity, steam, coke and coke gas produced. The difference between these items is referred to as conversion losses.

Notes on sources of energy use data for five end-use sectors:

Residential: Base data taken from RESD (Table 2-1) Residential plus residential wood use (estimated from Natural Resources Canada's Residential End-Use Model).

Commercial/Institutional: Base data taken from RESD (Table 2-1) Public administration and Commercial and other institutional less (Tables 4-1) Public administration and Commercial and other institutional motor gasoline, diesel, aviation gasoline and aviation turbo fuel columns.

Industrial: Base data taken from RESD (Table 2-1) Total industrial plus (Table 10) solid wood waste and spent pulping liquor less (Table 8) wood waste and spent pulping liquor used for electricity generation multiplied by a conversion factor, plus (Table 4-1) Producer consumption for refining and mining industries of still gas, diesel, heavy fuel oil, light fuel oil, kerosene, petroleum coke and refinery LPG columns, plus (Canadian Industrial Energy End-Use Data and Analysis Centre) waste fuels from the cement industry.

Transportation: Base data taken from RESD (Table 2-1) Total transportation less Pipelines plus (Table 4-1) Public administration and Commercial and other institutional motor gasoline, diesel, aviation gasoline and aviation turbo fuel columns.

Agriculture: Base data taken from RESD (Table 2-1) Agriculture.

Appendix B: Glossary of Terms

Activity: This term characterizes major drivers of energy use in a sector (e.g. floor space area in the commercial/institutional sector).

AECO-C hub: A hub is a market centre where several pipelines interconnect and where many buyers and sellers trade gas, thereby creating a liquid pricing point. The AECO-C hub is the main pricing point for Alberta natural gas and represents the major pricing point for Canadian gas. Prices are determined through the spot market, which includes all transactions for sales of 30 days or less, but it typically refers to a 30-day sale.

Agriculture: The agriculture sector includes all types of farms, including livestock, field crops, grain and oilseed farms, as well as activities related to hunting and trapping. Energy used in this sector is for farm production and includes energy use by establishments engaged in agricultural activities and in providing services to agriculture. Agriculture energy use is included in total secondary energy use for Canada.

Apartment: This type of dwelling includes dwelling units in apartment blocks or apartment hotels; units in duplexes or triplexes where the division between dwelling units is horizontal; suites in structurally converted houses; living quarters located above or in the rear of stores, restaurants, garages or other business premises; caretakers' quarters in schools, churches, warehouses, etc.; and private quarters for employees in hospitals or other types of institutions.

Appliance: This term is for energy-consuming equipment used in the home for purposes other than air conditioning, centralized water heating and lighting. Appliances include cooking appliances (gas stoves and ovens, electric stoves and ovens and microwave ovens) as well as refrigerators, freezers, clothes washers and dishwashers. Other appliances include devices such as televisions, video cassette recorders, digital video disc players, radios, computers and set-top boxes.

Auxiliary equipment: With the exception of auxiliary motors (see Auxiliary motors), auxiliary equipment includes stand-alone equipment powered directly from an electrical outlet, such as computers, photocopiers, refrigerators and desktop lamps. It also includes equipment that can be powered by natural gas, propane or other fuels, such as clothes dryers and cooking appliances.

Auxiliary motors: This term refers to devices used to transform electric power into mechanical energy to provide a service, such as pumps, ventilators, compressors and conveyors.

Annual fuel utilization efficiency (AFUE): The AFUE refers to the amount of energy supplied to a natural gas or oil furnace compared with the amount of energy delivered to the home in the form of heat. For example, a furnace that has a 90 percent AFUE will lose 10 percent of the energy it is supplied (conversion loss) and will deliver 90 percent of the energy supplied in the form of heat to the dwelling.

Biomass: 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 that consists of primarily 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 it is burned in a boiler or produce electricity through thermal generation.

Bitumen: Bitumen is a dense type of petroleum that is often mixed with sand, clay and water in its natural state. Because it is too thick to flow, it is not usually recoverable at commercial rates through a well (see Oil sands, Unconventional crude oil).

Capacity utilization rate: The rate of capacity use is a measure of the intensity with which industries use their production capacity. The rate is the ratio of an industry's actual output to its estimated potential output.

Appendix B: Glossary of Terms

Carbon dioxide (CO_2): This compound of carbon and oxygen is formed when 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 (see Greenhouse gas).

Compact fluorescent lamp (CFL), also known as compact fluorescent light bulb: A compact fluorescent bulb is a smaller version of a fluorescent lamp. These bulbs use 67 percent to 75 percent less energy but provide comparable lighting to that which is supplied by an incandescent bulb.

Commercial/institutional sector: 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 10 activity types based on the North American Industry Classification System. 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.

Conventional crude oil: This is a liquid form of petroleum that can be economically produced through a well by using normal production practices and without further processing or dilution.

Cooling degree-day (CDD): The cooling degree-day is a measure of how hot a location was over a period, relative to a base temperature. In this publication, the base temperature is 18°C and the period 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 is the sum of the daily cooling degree-days for the days in that period.

Cooling degree-day index: This index is a measure of how relatively hot (or cold) a summer was compared with the cooling degree-day (CDD) average. When the CDD index is above (below) 1, the observed temperature is warmer (colder) than normal. The CDD normal represents a weighted average of the 1951 to 1980 CDDs observed in a number of weather stations across Canada.

Dwelling: A dwelling is a structurally separate set of living premises with a private entrance from outside the building or from a common hallway or stairway inside. A private dwelling is one in which one person, a family or other small group of individuals may reside, such as a single house or apartment.

Electricity conversion loss: This term refers to the energy lost during the conversion from primary energy (petroleum, natural gas, coal, hydro, uranium and biomass) to electrical energy. Losses occur during generation, transmission and distribution of electricity and include plant and unaccounted for uses.

End-use: An end-use is any specific activity that requires energy (e.g. lighting, space heating, water heating and manufacturing processes).

Energy efficiency: This term refers to how effectively energy is being used for a particular purpose. For example, providing a similar (or better) level of service with less energy consumption on a per unit basis is considered an improvement in energy efficiency.

Energy intensity: Energy intensity is the amount of energy use per unit of activity. Examples of activity measures in this publication are households, floor space, passenger-kilometres, tonne-kilometres, physical units of production and constant dollar value of gross domestic product (also see Activity).

Energy source: This term refers to any substance that supplies heat or power (e.g. petroleum, natural gas, coal, renewable energy and electricity).

Factorization method: This statistical method — based on the Log-Mean Divisia Index I (LMDI I) approach — is used in this publication to separate changes in energy use into five factors: activity, structure, weather, service level, and energy efficiency.

Freight transportation: This subsector of the transportation sector includes the energy used by transportation modes that transport freight and whose activity is measured in tonne-kilometres. These modes include trucking, rail, marine and air.

Floor space (area): Floor space is 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.

Gigajoule (GJ): One gigajoule equals 1×10^9 joules. (see Petajoule).

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 because 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). The most abundant greenhouse gas is CO_2, accounting for approximately 70 percent of total GHG emissions (see Carbon dioxide, Methane).

Greenhouse gas intensity: This intensity is the amount of greenhouse gases emitted per unit of energy used.

Gross domestic product (GDP): This measure is 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 2002 dollars.

Gross output (GO): The GO is the total value of goods and services produced by an industry. It is the sum of the industry's shipments plus the change in value due to labour and capital investment. GO figures are reported in constant 2002 dollars.

Heating degree-day (HDD): The HDD is a measure of how cold a location was over a period, relative to a base temperature. In this publication, the base temperature is 18°C and the period is one year. If the daily average temperature is below the base temperature, the number of HDDs for that day is the difference between the two temperatures. However, if the daily average temperature is equal to or higher than the base temperature, the number of HDDs for that day is zero. The number of HDDs for a longer period is the sum of the daily HDDs for the days in that period.

Heating degree-day index: This index is a measure of how relatively cold (or hot) a winter was when compared with the heating degree-day (HDD) average. When the HDD index is above (below) 1, the observed temperature is colder (warmer) than normal. The HDD normal represents a weighted average of the 1951 to 1980 HDDs observed in a number of weather stations across Canada.

Heavy truck: A heavy truck has a gross vehicle weight that is more than, or equal to, 14 970 kilograms (33 001 pounds). The gross vehicle weight is the weight of the empty vehicle plus the maximum anticipated load weight.

High efficiency heating system: This classification indicates the efficiency of natural gas and oil furnaces. The high efficiency classification refers to a heating system that has average annual fuel utilization efficiency (AFUE) of 90 percent or higher.

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

Housing stock: Housing stock is the number of physical dwellings, as opposed to the number of households, which refers to the number of occupied dwellings. Therefore, housing stock includes both occupied and unoccupied dwellings.

Appendix B: Glossary of Terms

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

Joule (J): A joule is the international unit of measure for energy — the energy produced by the power of one watt flowing for a second. There are 3.6 million joules in one kilowatt hour (see Kilowatt hour).

Just-in-time inventory: This inventory system limits the required warehouse space by having orders arrive at the company only as they are required.

Kilowatt hour (kWh): This measurement is equivalent to 1000 watt hours. A kilowatt hour is 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-duty vehicle (LDV): This segment of passenger transportation vehicles includes small cars, large cars, motorcycles and light trucks.

Light truck: A light truck has a gross vehicle weight of up to 3,855 kg (8,500 lb). 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.

Lighting: The use of energy to light the interior and exterior of a dwelling.

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.

Medium efficiency heating system: This classification indicates the efficiency of natural gas and oil furnaces. The medium efficiency classification refers to a heating system with an average annual fuel utilization efficiency (AFUE) between 78 and 89 percent.

Medium truck: A medium truck has a gross vehicle weight ranging from 3,856 to 14,969 kg (8,501 to 33,000 lb). The gross vehicle weight is the weight of the empty vehicle plus the maximum anticipated load weight.

Megajoule (MJ): One megajoule equals 1×10^6 joules (see Joule).

Methane (CH_4): Methane is a very potent greenhouse gas, as the release of one tonne of methane has the same GHG impact as 21 t of carbon dioxide. It has an energy content of 20.3 MJ/m^3 (see Greenhouse gas).

Minimum energy performance standards: These standards are established to ensure a minimum standard for appliances across Canada and ensure environmental concerns are met through reduced energy consumption and therefore reduced emissions.

Mobile home: A moveable dwelling designed and constructed to be transported by road on its own chassis to a site and placed on a temporary foundation (such as blocks, posts or a prepared pad). If required, it can be moved to a new location.

Multifactor productivity: This is the ratio of output to unit of combined inputs (capital services and labour services).

Normal efficiency heating system: This classification indicates the efficiency of natural gas and oil furnaces. The normal efficiency classification refers to a heating system with an average annual fuel utilization efficiency (AFUE) of less than 78 percent.

North American Industry Classification System (NAICS): This classification system 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), was developed by the statistical agencies of Canada, Mexico and the United States.

Occupied dwelling: An occupied dwelling acts as a residence for a household, where the number of households will equal the number of occupied dwellings. Occupied dwellings may be occupied on a full-time or part-time basis.

Off-road transportation: Off-road transportation is a subsector of the transportation sector, which includes the energy used by off-road vehicles. These vehicles include items such as lawnmowers, snowmobiles and ATVs. Due to limitations in available data, this subsector is not analysed in detail.

Oil sands: The oil sands are a deposit of sand and other rock material saturated with bitumen, a type of crude oil (see Bitumen, Unconventional crude oil).

Passenger-kilometre (Pkm): This is an activity measure in the passenger transportation subsector that describes the transportation of one passenger across a distance of one kilometre.

Passenger transportation: This subsector of the transportation sector includes the energy used by transportation modes that transport passengers and whose activity is measured in passenger-kilometres. These modes include light-duty vehicles, buses and urban transit, passenger rail and passenger aviation.

Petajoule (PJ): One petajoule equals 1 x 10^{15} joules (see Joule).

Pulping liquor: This substance consists primarily of lignin, 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.

Residential sector: 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.

Sector: A sector is 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: This term characterizes the increased penetration of auxiliary equipment in commercial/institutional buildings and the increased penetration of appliances and space cooling units in residential dwellings.

Single attached (dwelling): Each half of a semi-detached (double) house and each section of a row or terrace are defined as single attached dwellings. A single dwelling attached to a non-residential structure also belongs to this category.

Single detached (dwelling): This type of dwelling is commonly called a single house (i.e. a house containing one dwelling unit and completely separated on all sides from any other building or structure).

Space cooling: This term refers to the conditioning of room air for human comfort by a refrigeration unit (e.g. air conditioner or heat pump) or by the circulation of chilled water through a central- or district-cooling system.

Space heating: This term refers to the use of mechanical equipment to heat all or part of a building and includes the principal space heating system and any supplementary equipment.

Standard Industrial Classification (SIC): This classification system 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 compared to another is considered a structural change; in the electricity generation sector, a relative increase in production from one fuel process compared to another is considered a structural change.

Synthetic crude oil (SCO): This term refers to a mixture of hydrocarbons, similar to light crude oil, derived by upgrading bitumen from oil sands or conventional heavy crude oil.

Terajoule (TJ): One terajoule equals 1×10^{12} joules (see Joule).

Appendix B: Glossary of Terms

Thermal envelope: Described as the shell of a dwelling, the thermal envelope protects the dwelling from the elements. The envelope consists of the basement walls and floor, the above-grade walls, the roof and the windows and doors. To maintain the indoor environment, the envelope must control the flow of heat, air and moisture between the inside and the outside of the dwelling.

Tonne-kilometre (Tkm): This term is an activity measure in the freight transportation subsector describing the transportation of one tonne across a distance of one kilometre.

Transportation sector: The transportation sector in Canada includes all modes of transportation required for the movement of passengers or freight. These modes include road, air, rail and marine transport. The transportation sector is divided into three subsectors: passenger, freight and off-road; however, only the passenger and freight subsectors are analysed in detail.

Unconventional crude oil: This term is for crude oil that is not classified as conventional crude oil (e.g. bitumen) (see Bitumen, Oil sands).

Upstream mining: The companies that explore for, develop and produce Canada's petroleum resources are known as the upstream sector of the petroleum industry.

Vintage: This term means the year of origin or age of a unit of capital stock (e.g. a building or a car).

Waste fuel: This name is applied to any number of energy sources other than conventional fuels used in the cement industry. It includes materials such as tires, municipal waste and landfill off-gases.

Water heater: This term refers to an automatically controlled vessel designed for heating water and storing heated water.

Water heating: This term refers to 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 watt is a unit of power equal to one joule of energy per second. For example, a 40-watt light bulb uses 40 watts of electricity (see Kilowatt hour).

Wood waste: This term refers to a fuel that consists of bark, shavings, sawdust, low-grade lumber and lumber rejects from the operation of pulp mills, sawmills and plywood mills.

Appendix C: List of Abbreviations

\$2002	constant 2002 dollars
bbl.	barrel
ACM	Annual Census of Mines
CAFC	company average fuel consumption
CANSIM	Canadian Socio-Economic Information Management System
CBEEDAC	Canadian Building Energy End-Use Data and Analysis Centre
CEUM	commercial/institutional end-use model
CFL	compact fluorescent lamp, also known as compact fluorescent light bulb
CIEEDAC	Canadian Industrial End-Use Energy Data and Analysis Centre
CREEDAC	Canadian Residential Energy End-Use Data and Analysis Centre
CVIOC	Canadian Vehicles in Operation Census
CVS	Canadian Vehicle Survey
DVD	digital video disc or digital versatile disc
EC	Environment Canada
EER	energy efficiency ratio
GDP	gross domestic product
GHG	greenhouse gas
GJ	gigajoule = 1×10^9 joules
GO	gross output
GWh	gigawatt hour = 1×10^9 Wh
HFE	Household Facilities and Equipment survey
ICE	Industrial Consumption of Energy survey
IEUM	industrial end-use model
km	kilometre
kW	kilowatt
kWh	kilowatt hour = 1×10^3 Wh
L	litre
LDV	light-duty vehicle
LPG	liquefied petroleum gases
m^2	square metre
m^3	cubic metre
MJ	megajoule = 1×10^6 joules
Mt of CO_2e (Mt)	megatonne of carbon dioxide equivalent = 1×10^6 tonnes
NAICS	North American Industry Classification System
n.e.c.	not elsewhere classified
NGL	natural gas liquids
NRCan	Natural Resources Canada
OEE	Office of Energy Efficiency
PBS	Passenger Bus and Urban Transit Statistics
PJ	petajoule = 1×10^{15} joules
Pkm	passenger-kilometre
RESD	*Report on Energy Supply and Demand in Canada*
REUM	residential end-use model
SEER	seasonal energy efficiency ratio
SIC	standard industrial classification
SHEU	Survey of Household Energy Use
SHS	Survey of Household Spending
SC	Statistics Canada
TEUM	transportation end-use model
TIP	Trucking Industry Profile
TJ	terajoule = 1×10^{12} joules
Tkm	tonne-kilometre
UEC	unit energy consumption
VCR	videocassette recorder
VFEIS	Vehicle Fuel Economy Information System
W	watt
Wh	watt-hour

Notes