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Energy Efficiency Trends in Canada
1990 to 2007
September 2009

Canada

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Preface

This twelfth 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 Resource Canada's (NRCan's) Office of Energy Efficiency (OEE). This database can be viewed at oee.nrcan.gc.ca/tables07.

This report covers the five sectors analysed by the OEE, which are the residential, commercial/institutional, industrial, transportation and agriculture sectors. The 2007 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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Chapter 1 Introduction

Canadians spent $166 billion on energy in 2007.

Energy accounts for a large segment of spending by households, businesses and industries alike. In 2007, Canadians spent about $166 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 12 percent of the country's gross domestic product (GDP).

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 2007, this report also analyses the energy intensity and efficiency trends between 1990 and 2007. Such monitoring aids the OEE in promoting energy efficiency in all aspects of Canadian life. It contributes toward the goal of improving our natural environment through knowledge and understanding.

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 1015 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).

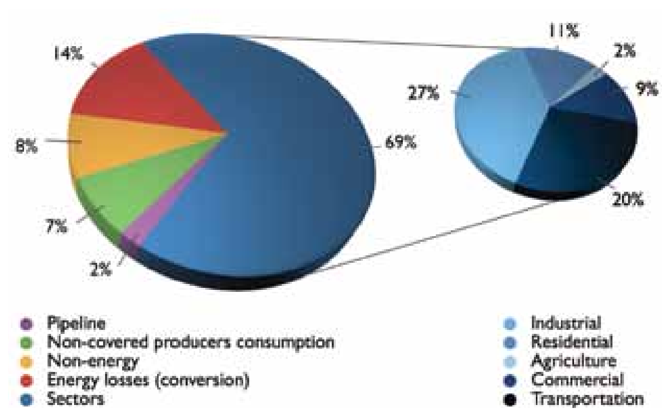
It also includes the energy used to bring energy supplies to the consumer (e.g. pipeline). Further, it entails the energy used to feed industrial production processes (e.g. the natural gas used by the chemical industries). In 2007, the total amount of primary energy consumed was estimated at 12,786 PJ (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 69 percent of the primary energy use in 2007, or 8,870.5 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."

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

Figure 1.1 Primary and secondary energy use by sector, 2007 (percent)



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

GHG emissions

This report also analyses energy-related GHG emissions, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_20). CO_2 represents more than 98 percent of Canada's energy-related GHG emissions.

Total Canadian GHG emissions are estimated to have been 746.7 megatonnes (Mt) in 2007; of this, 67 percent (or 501.6 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, 1990–2007 – 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.

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.

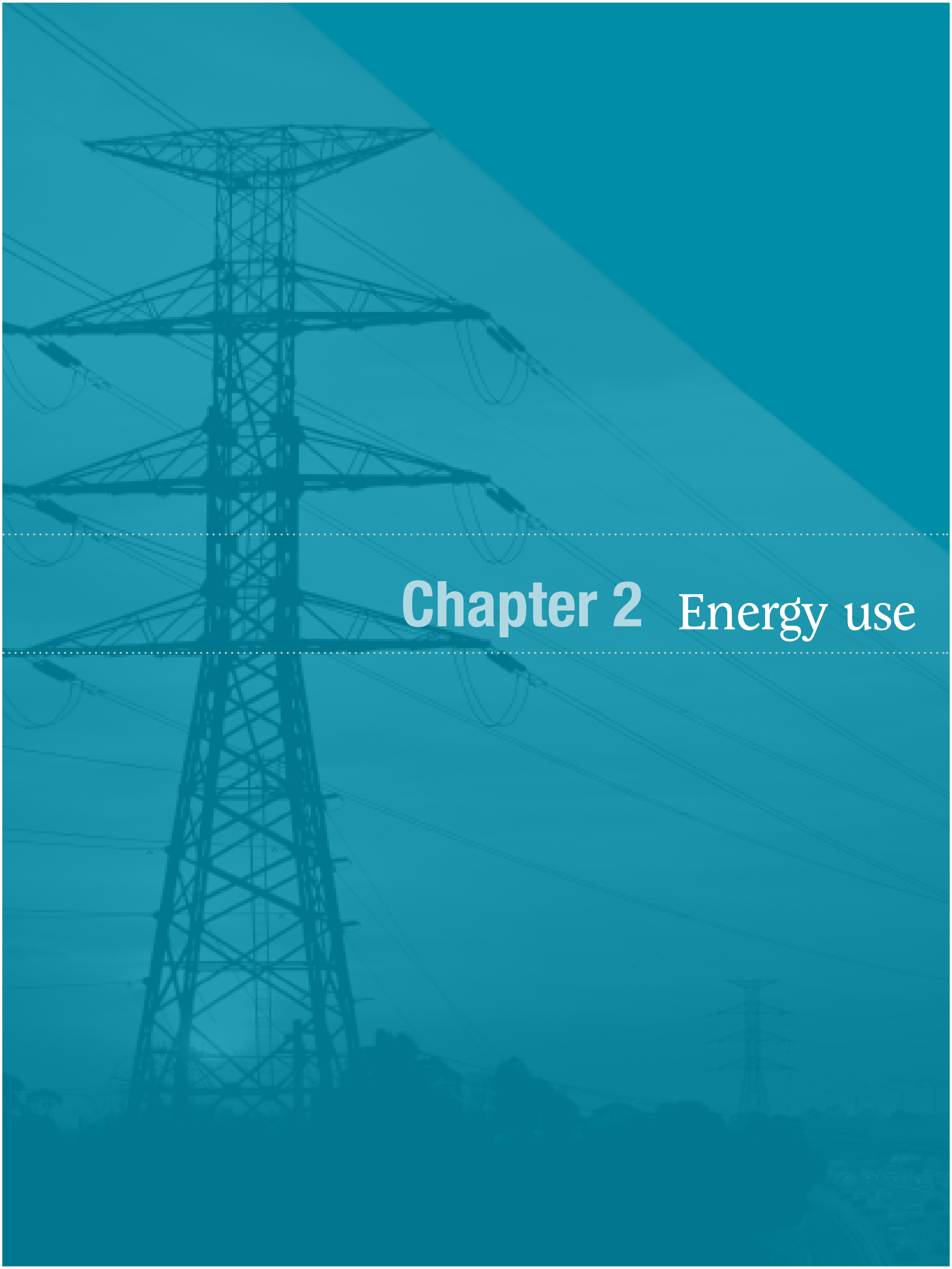
The methodology of this factorization – the Log-Mean Divisia Index I (LMDI I) methodology – is an internationally recognized factorization analysis technique. It decomposes changes in energy use into the various drivers in each sector so that energy efficiency can be assessed.[3]

In this report

This report describes secondary energy use in Canada, overall, and also at a sectoral level. For each sector, the status in 2007 of energy use and GHG emissions is described, followed by the trends in energy use and GHG emissions from 1990 to 2007. 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.

Due to rounding, the numbers in the figures may not add up or calculate to their reported totals or growth rates.

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



Chapter 2 Energy use

Overview – Energy use and GHG emissions

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

Energy is used in all five sectors of the economy: residential, commercial, industrial, transportation and agriculture. In 2007, these sectors used a total of 8,870.5 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 501.6 Mt in 2007.

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

Figures 2.1 and 2.2 show the distribution of secondary energy use and GHG emissions, by sectors. Emissions from the transportation and agriculture sectors exceeded their share of energy consumption because these sectors tended to use forms of energy that were more GHG intensive.

Figure 2.1 Secondary energy use by sector, 2007 (percent)

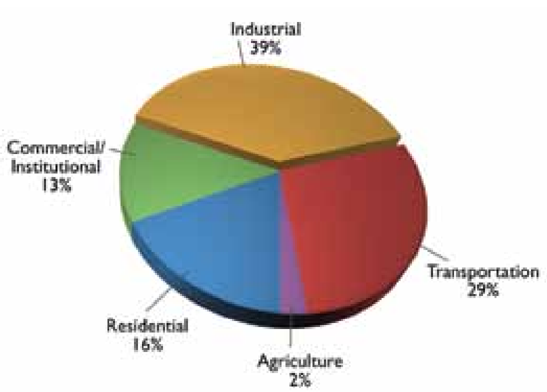
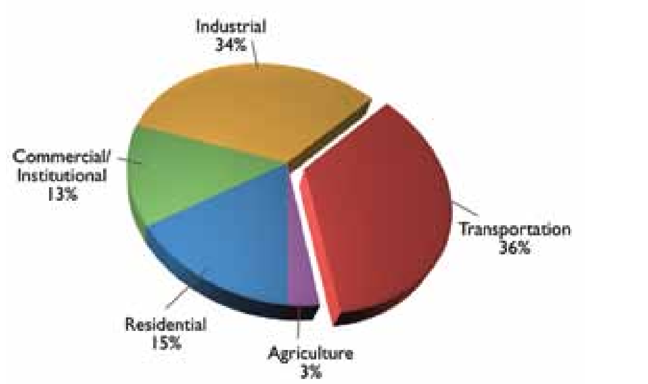


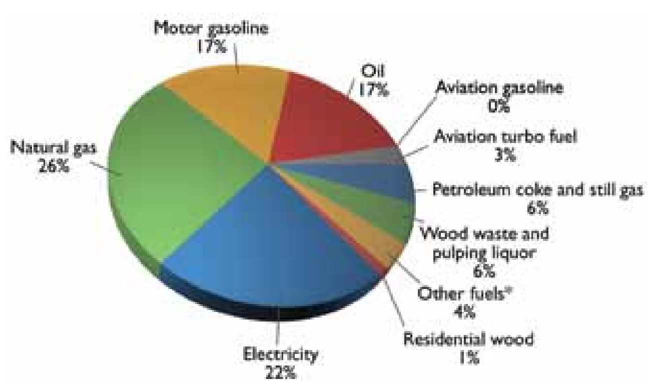
Figure 2.2 GHGs by sector, 2007 (percent)



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

In 2007, natural gas and electricity accounted for almost half the energy used in Canada (Figure 2.3). This was followed by motor gasoline and other oil products (diesel fuel oil, light fuel oil, kerosene and heavy fuel oil), which represented approximately 33 percent of energy usage. Natural gas and electricity are used in all sectors of the economy while motor gasoline is mainly used in the transportation and agricultural sectors.

Figure 2.3 Secondary energy use by fuel, 2007 (percent)



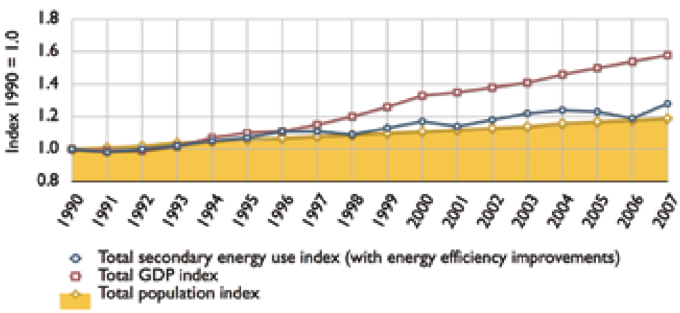
* Other fuels include coal, coke, coke oven gas, liquefied petroleum gas and gas plant natural gas liquids, and waste fuels from the cement industry.

Trends – Energy use and GHG emissions

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

Between 1990 and 2007, energy use in Canada increased by 28 percent, from 6,936.3 PJ to 8,870.5 PJ (Figure 2.4). At the same time, the Canadian population grew 19 percent (approximately 1 percent per year), and GDP increased 58 percent (more than 3 percent per year). More generally, energy use per unit of GDP declined, while energy use on a per capita basis increased.

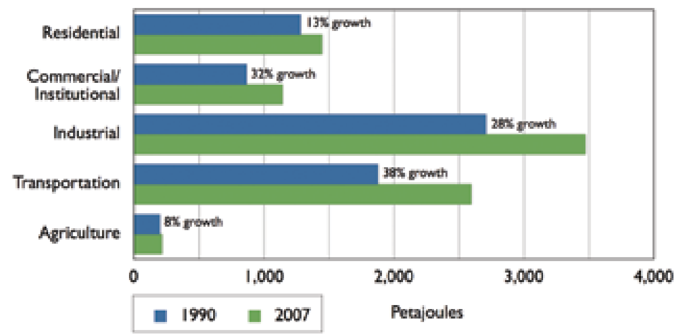
Figure 2.4 Total secondary energy use, Canadian population and GDP, 1990–2007



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

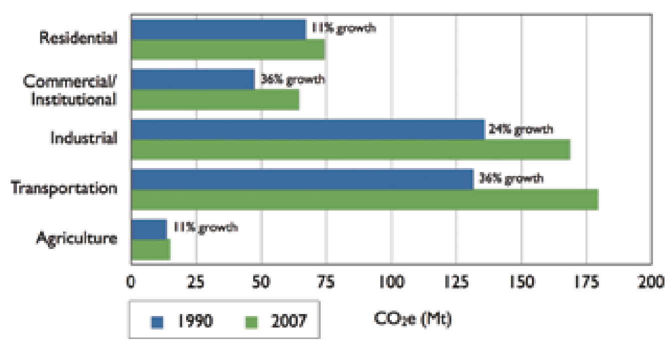
The industrial sector uses the most energy in our economy, consuming 3471.6 PJ of energy in 2007. But growth in energy use in the transportation sector has outpaced all sectors. Over 1990–2007, this sector registered a 38 percent increase in energy use (Figure 2.5), driven mainly by a 70 percent increase in freight energy use.

Figure 2.5 Total secondary energy use and growth by sector, 1990 and 2007



Growth in energy use was reflected in growth of GHG emissions. Consequently, the transportation sector experienced the highest growth in emissions at 36.4 percent followed closely by the commercial/institutional sector at 36.1 percent (Figure 2.6).

Figure 2.6 Total GHG emission and growth by sector, 1990 and 2007



The growth in GHG emissions in the transportation sector allowed it to outpace all other sectors in producing the most GHG emissions in our economy. This is the result even with electricity-related emissions included in the industrial sector. Several reasons may explain this, specifically the trend to move more freight by road (trucks), increasing fossil fuel use.

Energy intensity and efficiency

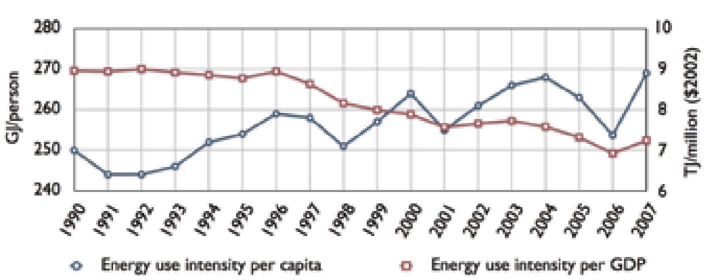
Canada improved its energy efficiency between 1990 and 2007. The following section discusses two indicators of energy efficiency: energy intensity and an energy efficiency measure using factorization.

Energy intensity

Canada's energy intensity improved 19 percent between 1990 and 2007. Despite this, per capita energy use increased 7 percent.

Energy intensity, when defined as the amount of energy required per unit of activity (GDP), improved 19 percent between 1990 and 2007 (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 2007 had produced the same level of GDP that it did in 1990, it would have used less energy.

Figure 2.7 Total secondary energy use intensity per capita and unit of GDP, 1990–2007



Conversely, the amount of energy required per capita, which is the energy intensity for each individual, increased 7 percent between 1990 and 2007 (Figure 2.7). This upward trend in part reflects the increasing use of electronic goods, increasing ownership of personal vehicles and increasing number of goods transported. 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.

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 from the underlying data identify areas that can continue to improve energy efficiency.

Energy efficiency

Energy efficiency improved 16 percent since 1990. These improvements reduced energy use by approximately 1,089.7 PJ, decreased GHG emissions by 63 Mt and saved Canadians $22.8 billion in 2007.

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 levels 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 floor space cooled. 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 44 percent between 1990 and 2007, instead of 28 percent. These energy savings of 1,089.7 PJ are equivalent to removing about 16 million cars and passenger light trucks from the road.

Figure 2.8 Secondary energy use, with and without energy efficiency improvements, 1990–2007

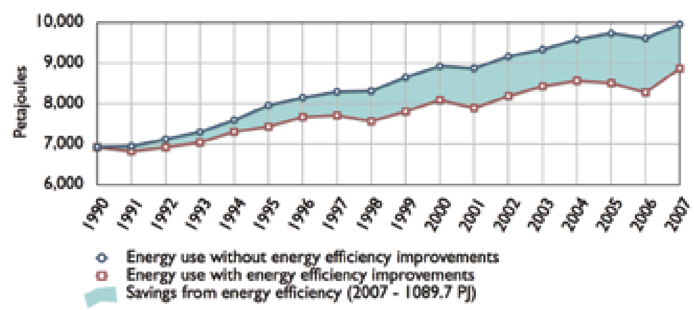
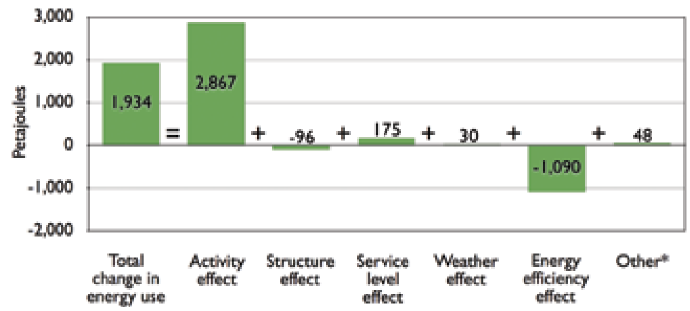


Figure 2.9 illustrates the relative impact of each effect on energy use over the 1990–2007 period for the economy as a whole. The following is a summary of and rationale for the results:

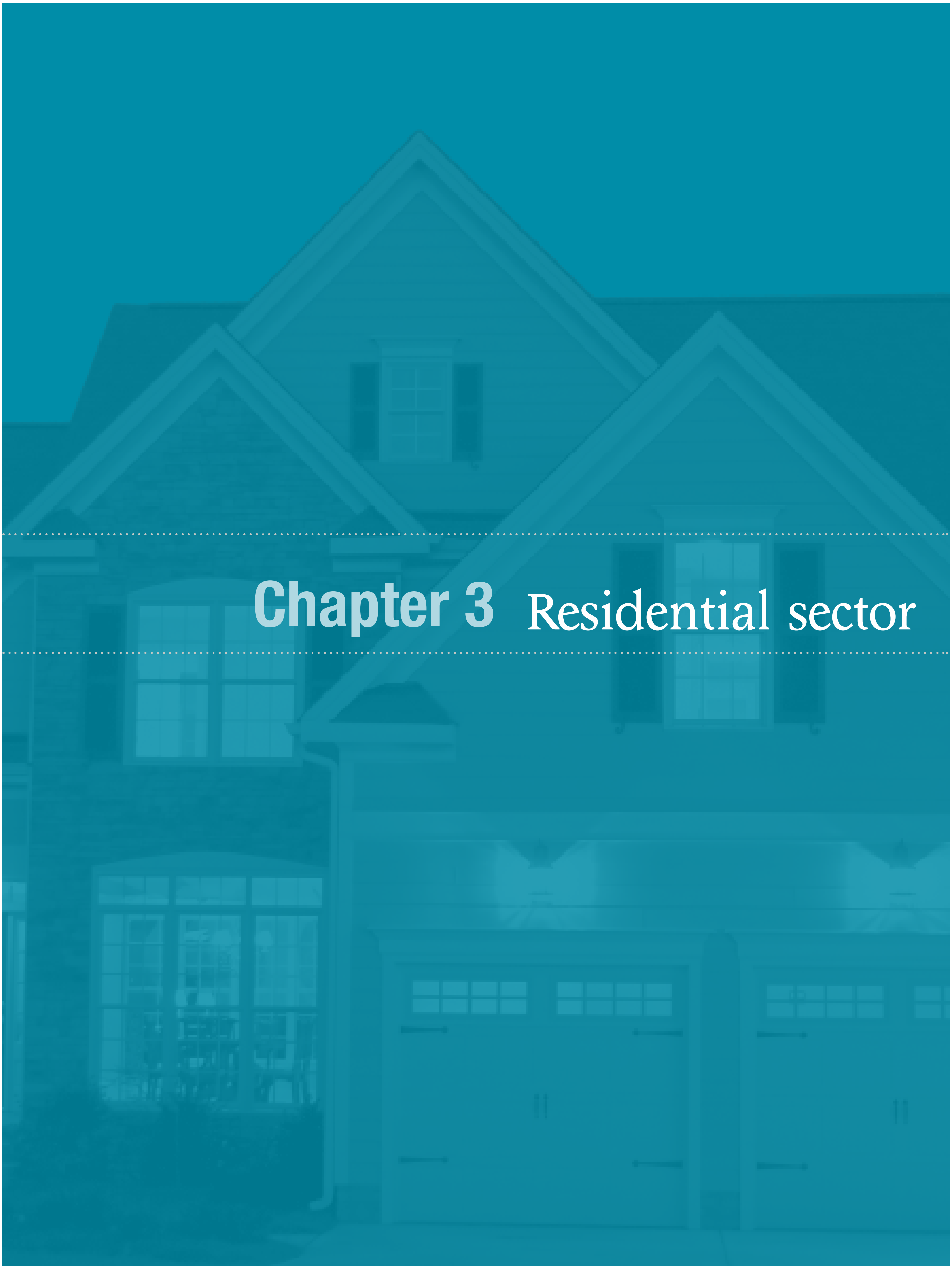
- **activity effect** – The GDP of Canada grew 58 percent between 1990 and 2007. This activity effect is estimated to have increased energy use by 41 percent, or 2,866.6 PJ, with a corresponding 162 Mt increase in GHG-related emissions.
- **structure effect** – Over the 1990–2007 period, a shift in production toward industries that are less energy intensive resulted in a decrease of 95.8 PJ and an 5.4 Mt decrease in GHG emissions.
- **weather effect** – In 2007, winter temperatures were similar to those of 1990 but the summer was warmer. The result was an overall increase in energy demand for temperature control of 30.2 PJ and a 1.7 Mt increase in GHG-related emissions.
- **service level effect** – From 1990 to 2007, changes in service level (e.g. increased use of computers, printers and photocopiers in the commercial/institutional sector) raised energy use by 174.7 PJ, and increased GHG-related emissions by 9.9 Mt.
- **energy efficiency effect** – As noted above, improvements in energy efficiency saved 1,089.7 PJ of energy and 63 Mt of GHG-related emissions from 1990 to 2007.

Figure 2.9 Impact of activity, structure, service level, weather and energy efficiency effects on the change in energy use, 1990–2007



* 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.

We can apply this analysis to the residential, commercial/institutional, industrial and transportation sectors.



Chapter 3 Residential sector

Overview – Residential energy use and GHG emissions

In Canada in 2007, 81 percent of all residential energy use was for space and water heating.

In 2007, Canadians spent $28.4 billion on household energy needs. Total household energy use was 16 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). The energy used was 1,447.2 PJ and 74.3 Mt of GHGs were emitted by the residential sector.

Figure 3.1 Energy use by sector, 2007 (percent)

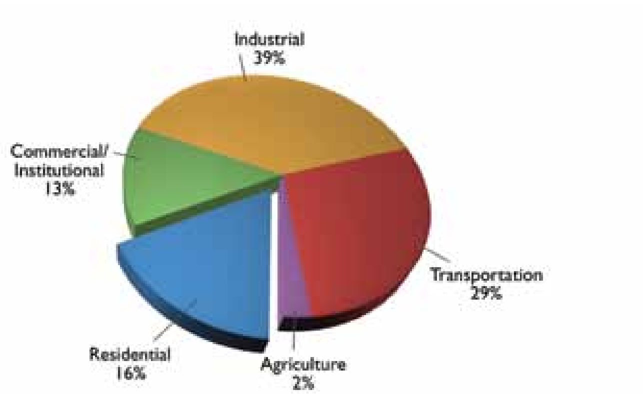
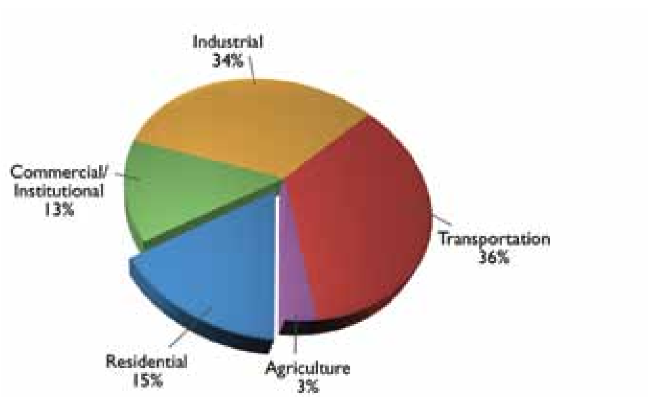
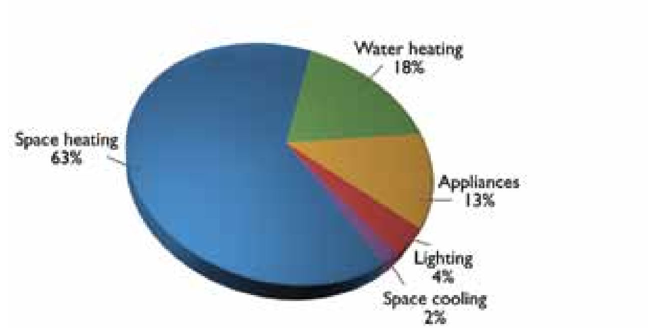


Figure 3.2 GHG emissions by sector, 2007 (percent)



Natural gas and electricity together accounted for 86 percent of all residential energy use in 2007. Wood, heating oil and propane were the other 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 81 percent of Canada's residential energy use, followed by appliances, lighting and air conditioning.

Figure 3.3 Distribution of residential energy use by end-use, 2007 (percent)



Trends – Residential energy use and GHG emissions

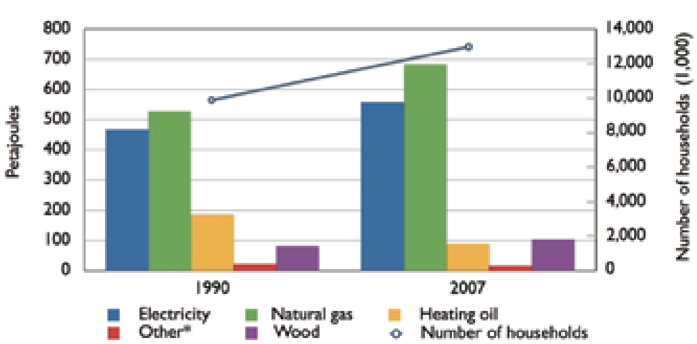
Population growth and fewer people per household led to a 31 percent rise in the number of households, which contributed to a 13 percent increase in residential energy use from 1990 to 2007.

Between 1990 and 2007, residential energy use increased 13 percent or 164.9 PJ, from 1,282.3 PJ to 1,447.2 PJ. The associated GHG emissions grew 11 percent, from 67.1 Mt to 74.3 Mt. During the period, the population grew 19 percent (5.3 million people) and the number of households increased 31 percent (3.1 million).

> The 3.1 million households added in Canada since 1990 represented approximately the total number of households in Quebec, Nova Scotia and New Brunswick in 1990 or the total number of households in British Columbia and Alberta in 2007.

The mix of energy used in the residential sector changed slightly over the period. Specifically, natural gas and electricity became even more dominant while heating oil use declined (Figure 3.4). 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 2007



* Other includes coal and propane.

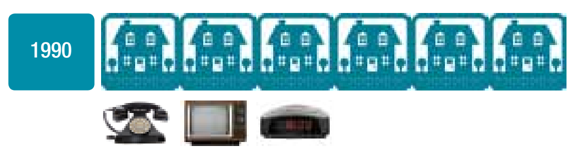
Canadians have bigger homes with fewer people living in them.

The choices Canadians made with respect to their living space also contributed to an increase in energy use. Average living space in 2007 was 10 percent greater than that in 1990. Specifically, average living space in 1990 was 116 square metres (m^2), compared to 128 m^2 of living space in 2007 (Figure 3.5).

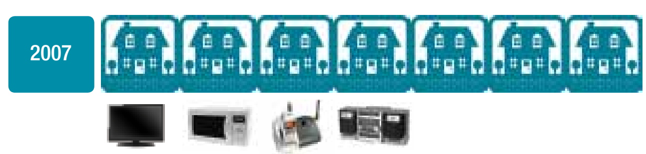
Canada has an aging population that tends to remain in their homes longer, in many cases long after their children have moved out. A falling birth rate and more young people living in single person households have contributed to a reduction in individuals per household from 2.8 in 1990 to 2.5 in 2007. 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, such as computers, televisions and microwaves. 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 2007



- 2.8 people per house
- 116 m^2 of living space
- 9.9 million households
- 15 appliances
- 23 percent of occupied floor space cooled



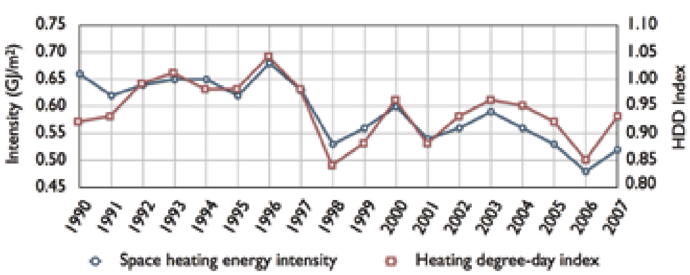
- 2.5 people per house
- 128 m^2 of living space
- 13.0 million households
- 21 appliances
- 43 percent of occupied floor space cooled

Trends – Residential space heating energy use

Despite a 21 percent decline in space heating energy intensity, total space heating energy use increased 14 percent between 1990 and 2007.

The amount of energy used by the residential sector to heat each square metre of living space decreased 21 percent between 1990 and 2007. Although influenced by weather variations, the 2007 heating degree-days were only marginally higher than 1990 which confirms the decrease in space heating intensity from 0.66 gigajoules per square metre (GJ/m^2) to 0.52 GJ/m^2 (Figure 3.6) was mainly driven by energy efficiency gains.

Figure 3.6 Space heating energy intensity and heating degree-day index, 1990–2007



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 2007, medium and high efficiency oil and gas systems increased their share of the oil and gas market from 8 percent to 81 percent.

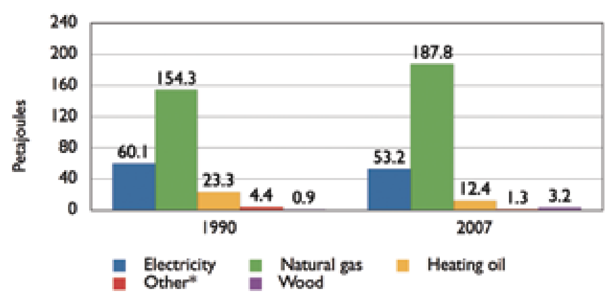
While the amount of energy used to heat each square metre of living space in a Canadian home decreased, this was not enough to compensate for the fact that the number of households increased 31 percent. Additionally, the average Canadian home was larger in 2007 than it was in 1990. Consequently, the energy required to heat all the dwellings in Canada increased 14 percent from 794.4 PJ in 1990 to 908.1 PJ in 2007.

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 19 percent decrease in the energy used per household for heating water (from 24.6 GJ per household in 1990 to 19.9 GJ per household in 2007).

Figure 3.7 Water heating energy use by fuel type, 1990 and 2007



* Other includes coal and propane.

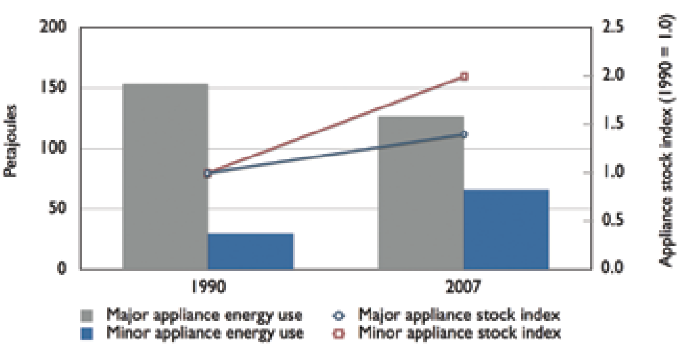
Although there was a decrease in per household energy used to heat water, the total number of households grew more quickly than energy efficiency improvements from new equipment. The result was an overall increase of 6 percent in residential water heating energy use, from 243.0 PJ to 257.9 PJ.

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 2007 increased 44 percent (Figure 3.8). However, the total amount of energy that households used to power major appliances decreased 18 percent over the same period. In fact, the average unit energy use of all major household appliances decreased noticeably from 1990 to 2007.

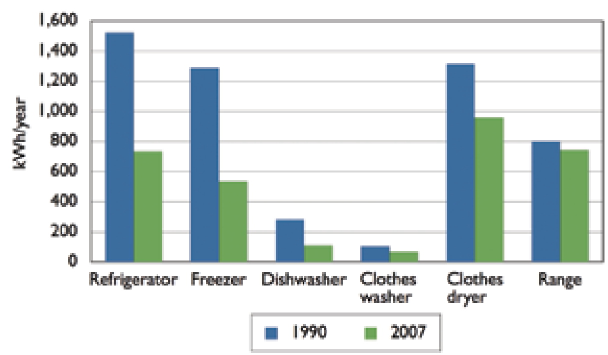
Figure 3.8 Residential energy use and appliance stock index by appliance type, 1990 and 2007



The largest percentage decrease was in the unit energy use of dishwashers (Figure 3.9), which in 2007 used 68 percent less energy than in 1990 (from 273 kilowatt hours [kWh] per year to 87 kWh per year).[4] A new fridge in 1990 used an average of 956 kWh per year versus 483 kWh per year in 2007, a decrease of 49 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 2007. This increase of 36.5 PJ is equivalent to the energy required to provide lighting to all the homes in Ontario, Quebec and Nova Scotia in 2007.

Figure 3.9 Unit energy consumption of major electric appliance stock, 1990 and 2007



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 (+124 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 2007 they were present in more than three out of four households in Canada.

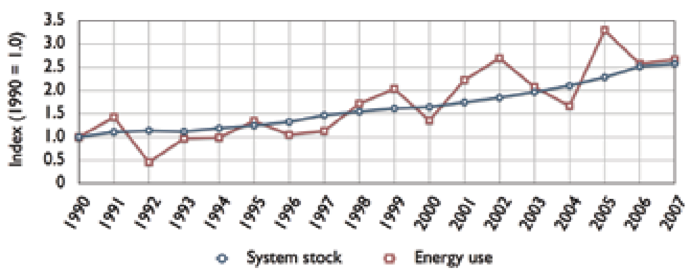
[4] Excludes hot water requirements.

Trends – Space cooling energy use

More Canadians lived in air-conditioned homes.

The amount of occupied floor space with air conditioners rose to 708 million square metres (million m^2) in 2007, from 267 million m^2 in 1990. The percentage of floor space cooled rose from 23 percent in 1990 to 43 percent in 2007. As a result, the energy required to cool Canadian homes rose 167 percent (Figure 3.10), from 10.5 PJ to 27.9 PJ over the same period.

Figure 3.10 Space cooling stock and energy use, 1990–2007



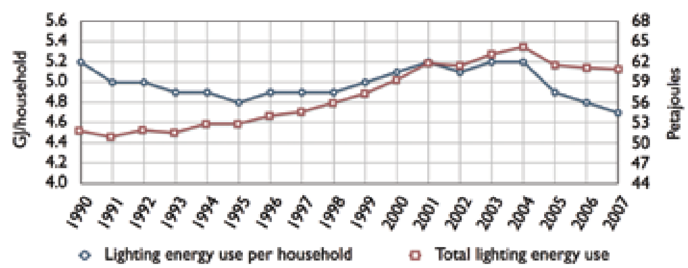
The increase in energy used for space cooling would have been more pronounced if not for efficiency improvements associated with room and central air conditioners. Compared to 1990, the stock of room and central air conditioners in 2007 were 36 and 22 percent more efficient, respectively.

Trends – Lighting energy use

The market share of energy-efficient lighting alternatives increased significantly between 1990 and 2007.

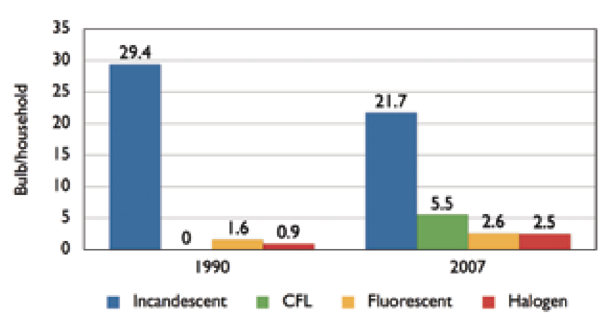
Despite a drop in lighting energy use per household, the energy required to light all the households in Canada increased 18 percent, from 51.7 PJ to 60.8 PJ (Figure 3.11). This was entirely due to the 31 percent increase in the number of households, as the energy required to light each household in Canada decreased 10 percent, from 5.2 GJ to 4.7 GJ. Lighting energy use reached a peak of 64.1 PJ in 2004, before declining to 60.8 PJ in 2007.

Figure 3.11 Lighting energy use per household and total lighting energy use, 1990–2007



Some of the decrease in lighting energy use 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 they represented over 17 percent of light bulbs used in 2007.

Figure 3.12 Number of light bulb per household by bulb type, 1990 and 2007



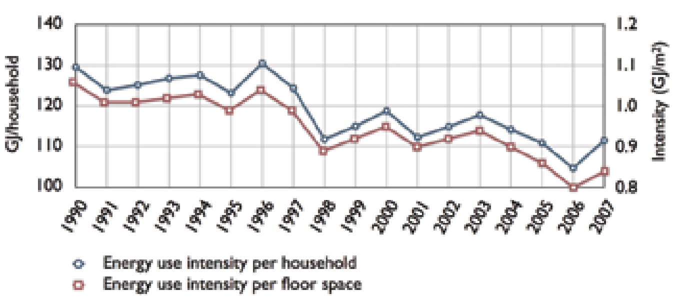
Residential energy intensity and efficiency

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 111.5 GJ in 2007 (Figure 3.13). This occurred despite the average household operating more appliances, becoming larger, and increasing its use of space cooling. Energy intensity per square metre decreased 21 percent from 1.06 GJ to 0.84 GJ.

Figure 3.13 Residential energy intensity per household and floor space, 1990–2007



Energy efficiency

Energy efficiency improvements resulted in energy savings of $7.4 billion in the residential sector in 2007.

Energy efficiency improvements in the residential sector have resulted in significant savings between 1990 and 2007. 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 and lighting.

Energy efficiency in the residential sector improved 29 percent from 1990 to 2007, allowing Canadians to save 378.2 PJ of energy (Figure 3.14) and $7.4 billion in energy costs in 2007.

Figure 3.14 Residential energy use, with and without energy efficiency improvements, 1990–2007

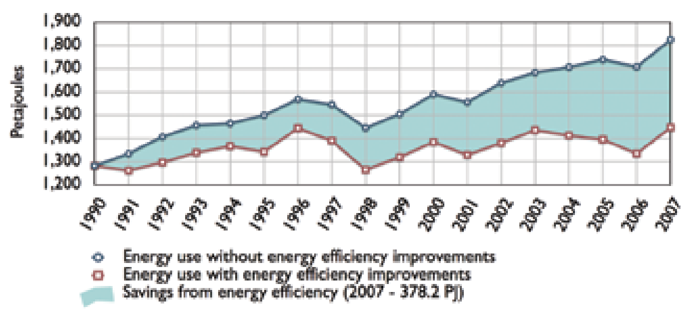


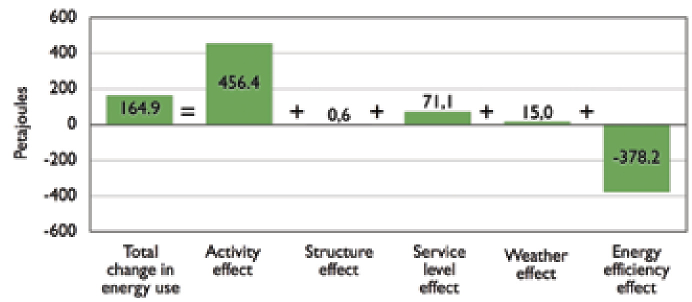
Figure 3.15 illustrates the influence that various factors had on the change in residential energy use between 1990 and 2007. These effects are the

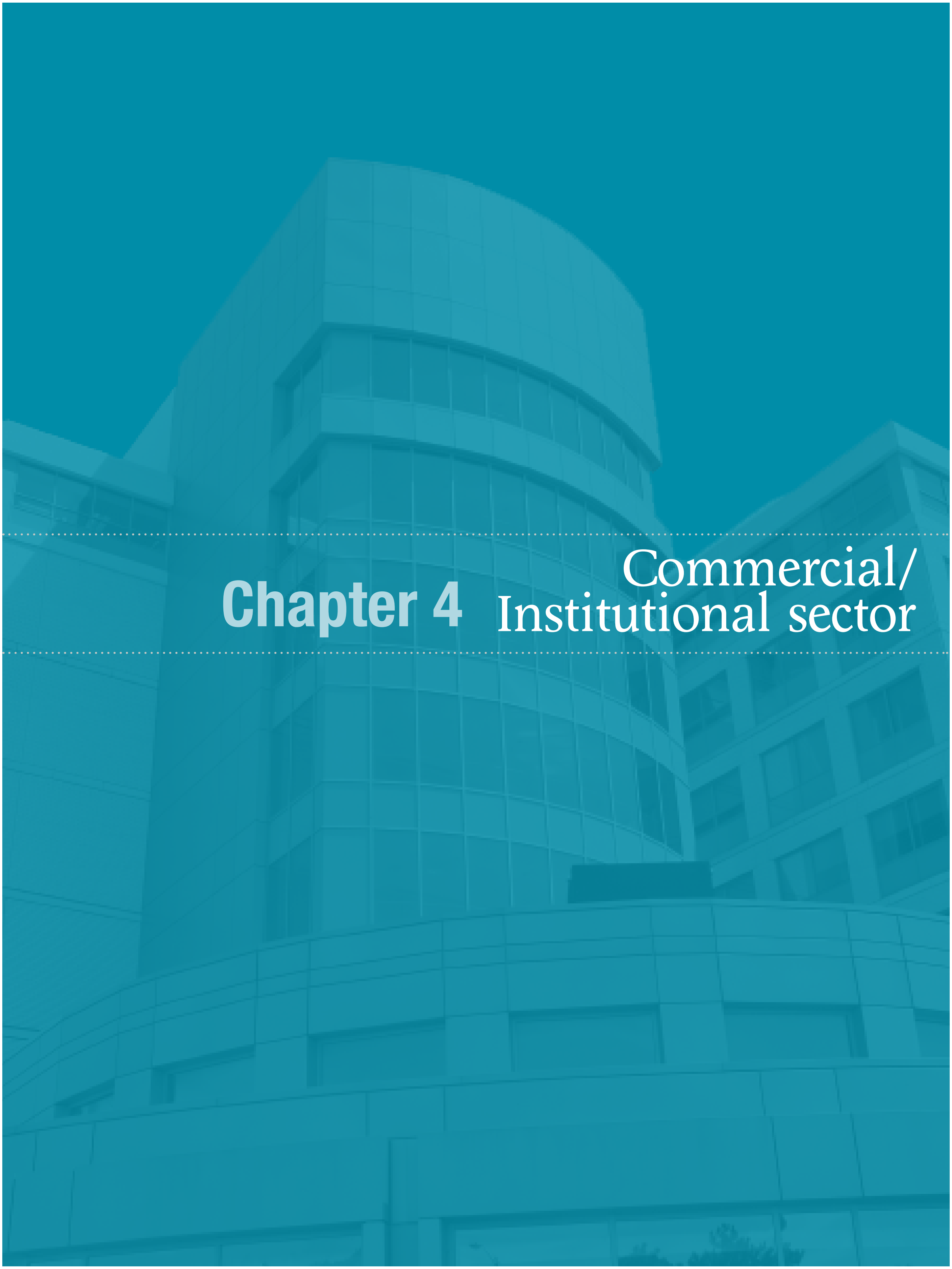
- **activity effect** – As measured by combining a mix of households and floor space, energy use increased 36 percent (456.4 PJ). Growth in activity was driven by a 44 percent increase in floor area and by a rise of 31 percent in the number of households.

These energy efficiency savings translate into an average savings of $572 per Canadian household in 2007.

- **structure effect** – The increase in the relative share of households by dwelling type resulted in the sector using an additional 0.6 PJ of energy.
- **service level effect** – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 71.1 PJ of the increase in energy.
- **weather effect** – In 2007, winter temperatures were similar to those of 1990 but the summer was warmer. The net result was an overall increase in energy demand for temperature control of 15.0 PJ.
- **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 378.2 PJ of energy.

Figure 3.15 Impact of activity, structure, service level, weather and energy efficiency on the change in residential energy use, 1990–2007





Chapter 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 2007, commercial business owners and institutions spent $24 billion on energy to provide services to Canadians. This represents approximately 3 percent of the value of GDP related to this sector. In 2007, this sector was responsible for 13 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, 2007 (percent)

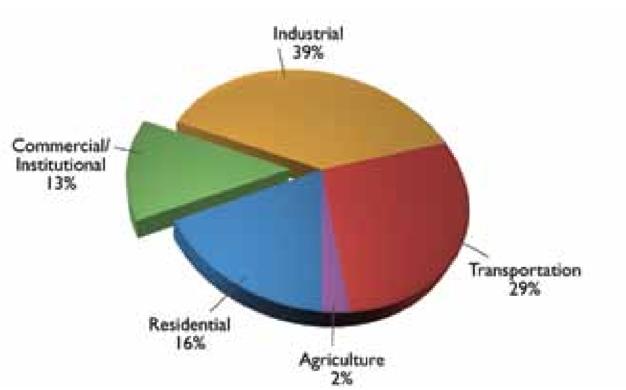
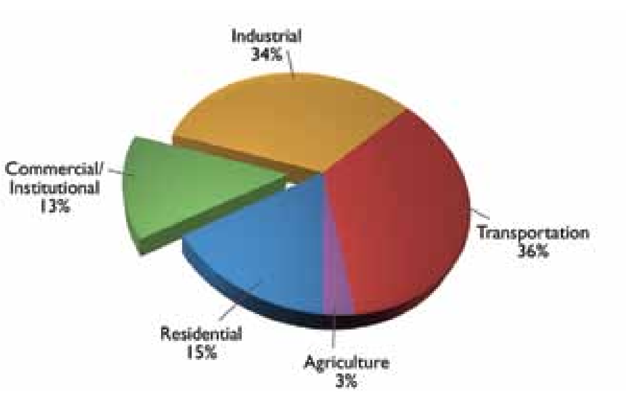
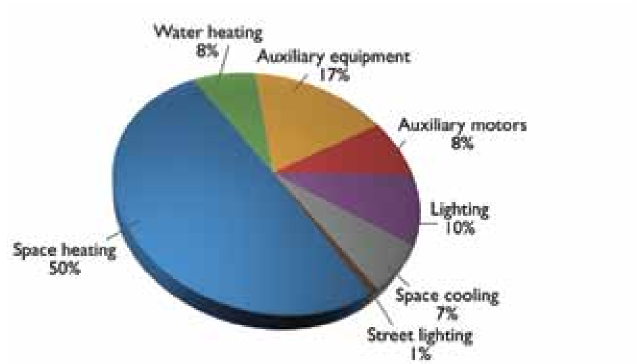


Figure 4.2 Total GHG emissions by sector, 2007 (percent)



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 in the sector with half of the total energy used for this purpose (Figure 4.3).

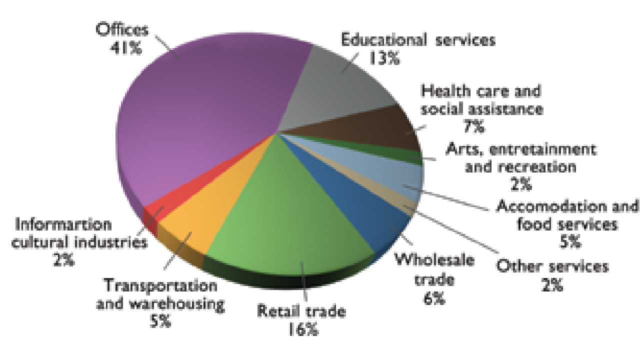
Figure 4.3 Commercial/Institutional energy use by end-use, 2007 (percent)



Included in the commercial/institutional sector are activities related to trade, finance, real estate, public administration, education and commercial services. These activities have been grouped into 10 subsectors (see Figure 4.4 for a complete listing of activities).

Together, offices, retail trade and educational services account for 70 percent of the total Canadian commercial/ institutional floor space. In 2007, the floor space associated with commercial/institutional activities was estimated at 682.2 million m^2.

Figure 4.4 Commercial/Institutional floor space by activity type, 2007 (percent)



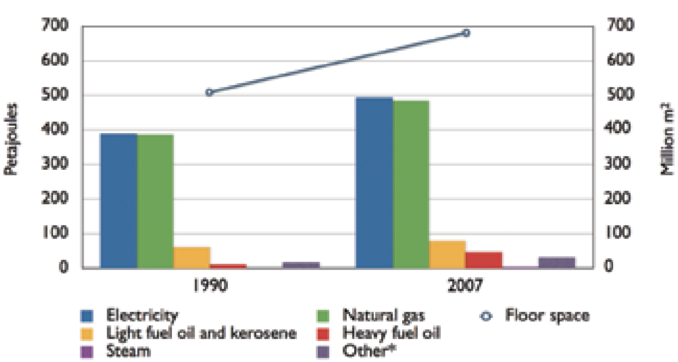
[5] Among the sectors presented in this document, the commercial/institutional sector has the most significant data limitations.

Trends – Commercial/ Institutional energy use and GHG emissions

Between 1990 and 2007, the commercial/institutional sector was the second fastest growing sector with respect to energy use (transportation was first), and one of the fastest growing sectors, equivalent to total transportation, with respect to GHG emissions.

From 1990 to 2007, total commercial/institutional energy use increased 32 percent, from 867 PJ to 1,142 PJ, including street lighting. At the same time, GDP for the commercial/ institutional sector grew 68 percent and floor space grew 34 percent.

Figure 4.5 Commercial/Institutional energy use by fuel type and floor space, 1990 and 2007



* Other includes coal and propane.

The GHG emissions associated with the sector's energy use increased 36 percent over the same period. The increase in the use of more GHG-intensive fuels, such as heavy oil and light fuel oil, explains why GHG emissions grew at a faster pace than energy use.

Natural gas and electricity are the main energy sources for the commercial/institutional sector accounting for 86 percent of total energy use (Figure 4.5). A rapid growth in the use of heavy fuel oil (177 percent), light fuel oil and kerosene (68 percent) is observed since 1999.

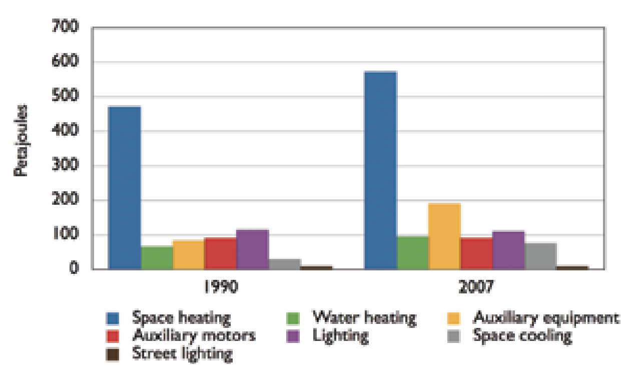
The reason for these petroleum product increases is still unknown and may be due, in part, to secondary distribution. Fuel marketers included in the commercial/institutional sector buy petroleum products from refineries and then resell the fuel to other sectors (e.g. industrial, transportation). As a result, these fuel types can be inappropriately attributed to the commercial/institutional sector. NRCan is working with Statistics Canada (SC) to determine the possible reasons for these anomalies in order to improve the quality of the commercial/institutional data.

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

As shown in Figure 4.6, of the seven end-uses, space heating and cooling, water heating and auxiliary equipment 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.

Space heating continues to be the primary end-use in the sector. Energy use for space heating increased 21 percent between 1990 and 2007. 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).

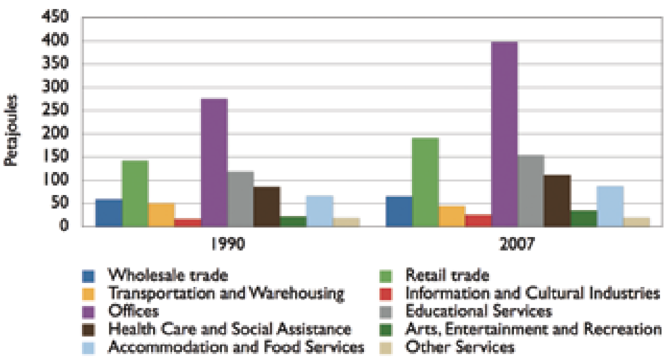
Figure 4.6 Commercial/Institutional energy use by end-use, 1990 and 2007



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 2007 (35 percent). Retail trade (17 percent) and education services (14 percent) were the next largest users. Offices also had the largest increase in energy consumption, using 122.4 PJ more energy in 2007 than in 1990, followed by retail trade (48.2 PJ increase).

Figure 4.7 Commercial/Institutional energy use by activity type, 1990 and 2007



Thirteen million people worked in Canada's commercial/institutional sector in 2007.[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 34 percent from 1990 and the number of employees in this sector increased 38 percent.

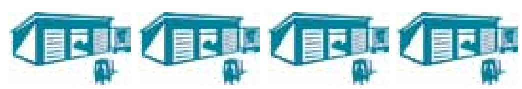
While some gains in energy efficiency were made in terms of overall energy per floor space, this was offset by an increase in energy requirements for auxiliary equipment. Not only was there an overall increase in computerization of the work environment in the commercial/institutional sector during this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

Figure 4.8 Commercial/Institutional energy indicators, 1990 and 2007

1990

- Floor space: 509.9 million m^2
- Employees: 9 million
- GDP: $472 billion ($2002)

2007



- Floor space: 682.2 million m^2
- Employees: 13 million
- GDP: $793 billion ($2002)

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

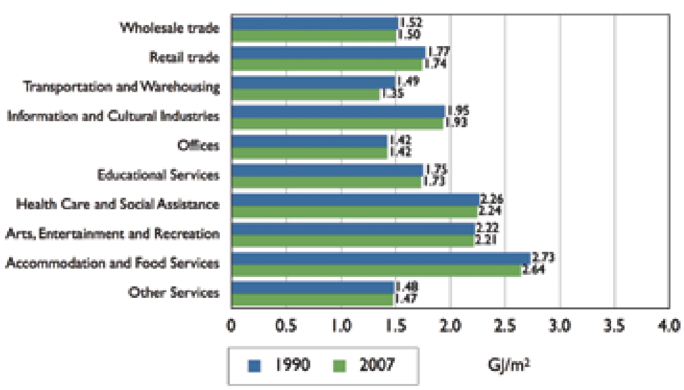
Commercial/Institutional energy intensity and efficiency

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).

Figure 4.9 Commercial/Institutional energy intensity by activity type, 1990 and 2007



As shown in Figure 4.9, Accommodation and Food Services consumed 2.64 GJ/m^2 in 2007, followed by Health Care and Social Assistance and the Art, Entertainment and Recreation, which consumed, respectively, 2.24 GJ/m^2 and 2.21 GJ/m^2. They are the most energy-intensive activity types despite a slight decrease of their energy intensity. This may be attributable to the energy-demanding nature of their activities (restaurants, laundry) and services (extensive hours of operation), as well as the use of numerous pieces of electronic equipment that have high energy requirements (such as medical scanners)

The commercial/institutional sector as a whole experienced only a slight decrease in terms of energy consumed per unit of floor space (GJ/m^2). However, the sector improved its energy intensity by 22 percent when measured against economic activity (PJ/GDP).

Energy efficiency

Energy efficiency improvements in Canada resulted in an energy savings of $2.9 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 138.7 PJ energy savings for this sector between 1990 and 2007 (Figure 4.10).

Figure 4.10 Commercial/Institutional energy use, with and without energy efficiency improvements, 1990–2007

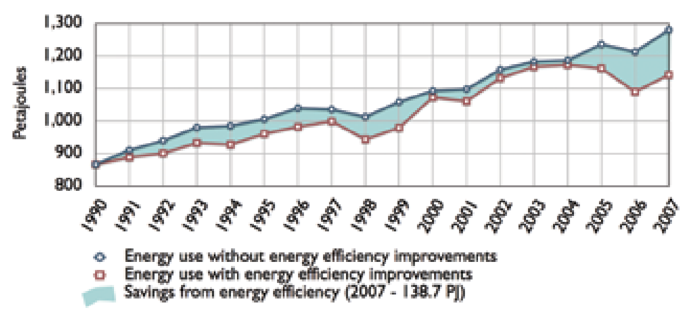
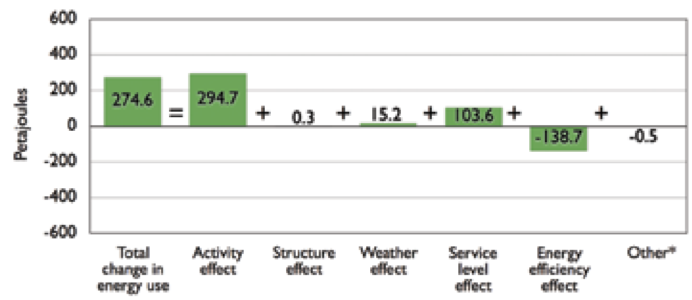


Figure 4.11 illustrates the influence that various factors had on the change in commercial/institutional sector energy use between 1990 and 2007. These effects are the

- **activity effect** – An increase in floor space increased energy use 34 percent (294.7 PJ) and led to an increase of 16.7 Mt in GHG-related 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-related emissions.
- **weather effect** – The winter of 2007 was similar to the winter of 1990, but the summer was warmer. The net result was a 15.2 PJ increase in energy demand in the commercial/institutional sector, mainly for space conditioning which had the effect of increasing GHG-related emissions by 0.9 Mt.
- **service level effect** – An increase in space cooling and in the service level of auxiliary equipment, which is the penetration rates of office equipment, (e.g. computers, fax machines and photocopiers), led to a 103.6 PJ increase in energy use and a 5.9 Mt increase in GHG-related emissions.
- **energy efficiency effect** – Improvements in the energy efficiency of the commercial/institutional sector saved 138.7 PJ of energy and 7.8 Mt of related emissions.

Figure 4.11 Impact of activity, structure, weather, service level and energy efficiency on the change in commercial/institutional energy use, 1990–2007



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

Chapter 5 Industrial sector

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 2007 alone, these industries spent $39.9 billion for energy. Total energy use by industry accounted for 39 percent of the total energy use (Figure 5.1) and 34 percent of end-use GHG emissions (Figure 5.2).

Figure 5.1 Energy use by sector, 2007 (percent)

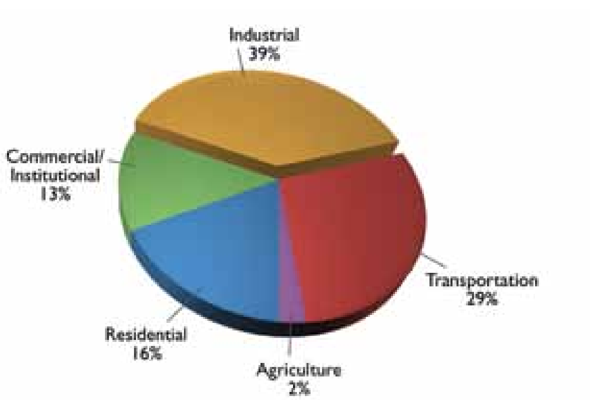
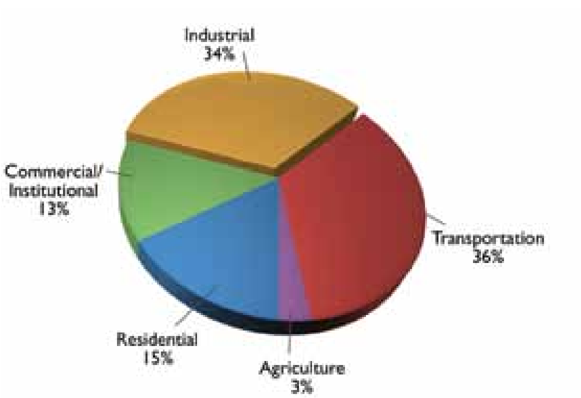


Figure 5.2 GHG emissions by sector, 2007 (percent)



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

In 2007, the industrial sector's share of GDP accounted for 27 percent of the Canadian total (excluding agriculture). The main contributor to industrial GDP was the other manufacturing industry, which includes activities such as food and beverage, textile, computer and electronic industries. Construction and mining were the only two other industries that contributed more than 10 percent to the industrial sector's GDP (Figure 5.4).

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 3 percent of economic activity (Figure 5.4) but 19 percent of industrial energy use (Figure 5.3). In contrast, an industry such as construction is responsible for 22 percent of the economic activity (Figure 5.4) but only 2 percent of industrial energy use (Figure 5.3).

Figure 5.3 Distribution of energy use by industry, 2007 (percent)

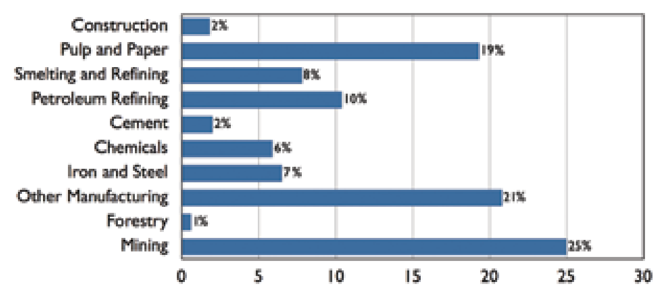
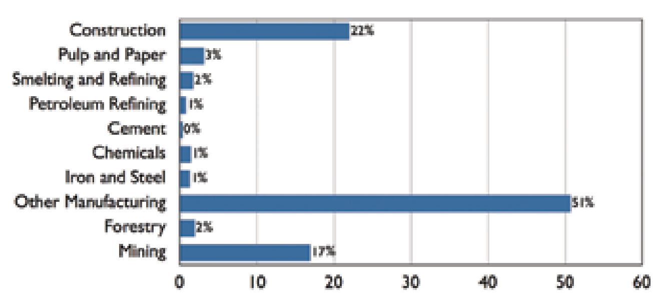


Figure 5.4 Distribution of activity by industry, 2007 (percent)



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 type 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 2007, 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 fuel types used the most.

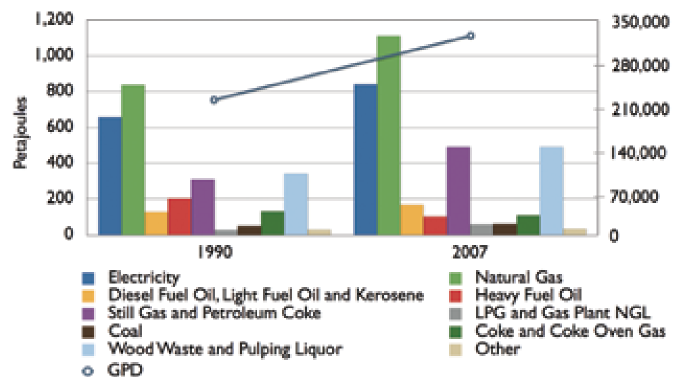
The type of energy used varies greatly, depending on the industries in which it is used. Although electricity is used across the entire sector, the pulp and paper and the smelting and refining industries require the most electricity. Combined, these two industries account for more than 49 percent of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

Wood waste and pulping liquor are used primarily in the pulp and paper industry because they are recycled materials produced only 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 2007, industrial energy use increased 28 percent, from 2,710 PJ to 3,472 PJ. The associated end-use GHGs increased 24 percent, from 136 Mt to 169 Mt. GDP increased 47 percent, from $221 billion ($2002) in 1990 to $324 billion ($2002) in 2007 (Figure 5.5).

Figure 5.5 Industrial energy use by fuel type and GDP, 1990 and 2007



In most cases, fuel shares remained relatively constant between 1990 and 2007 because fuel consumption increased for most fuel types during this period. The exceptions were heavy fuel oil (HFO), which experienced a 48 percent decrease, and coke and coke oven gas, which decreased 16 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.

Forestry, mining, smelting and refining, other manufacturing, and cement have all experienced large growth in energy use since 1990. However, forestry and cement consume proportionately less energy than the other three sectors (mining, smelting and refining, and other manufacturing). The trends for these three main contributors to energy demand in the industrial sector are now described in greater detail. Given the relative size of the pulp and paper subsector, further details on that sector are also provided.

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.[7]

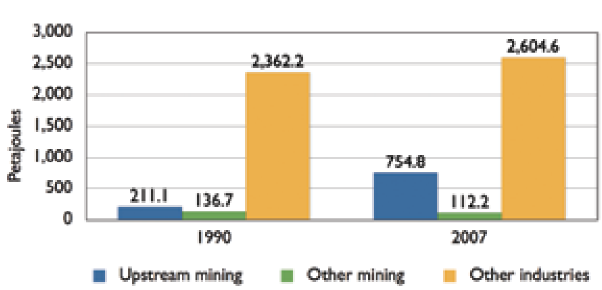
Since 1990, the mining industry's energy consumption grew 149 percent, and its associated end-use emissions grew 130 percent. The GDP of the mining industry increased 41 percent over the 1990–2007 period, from $38.9 billion ($2002) to $54.8 billion ($2002), compared with a 47 percent increase for the entire industrial sector.

Upstream mining was the biggest contributor to GDP, representing $48 billion ($2002) of Canada's GDP in 2007. However, 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 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 191,000 m^3/day by 2007. This rise is the principal factor explaining the increase of 258 percent in the energy used by the upstream mining industry since 1990 (Figure 5.6).

Figure 5.6 Industrial energy use by selected industry, 1990 and 2007



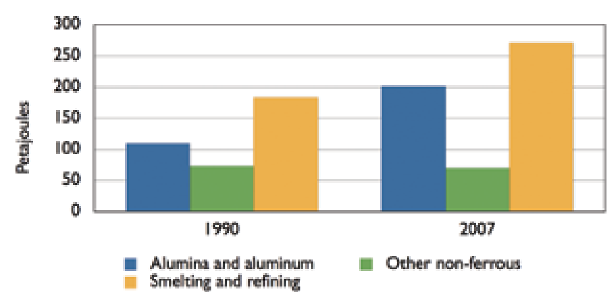
[7] NAICS code 21, excluding 213118, 213119 and part of 212326.

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 demand was mainly driven by economic growth, as the GDP increased from $2.8 billion ($2002) in 1990 to $5.4 billion ($2002) in 2007 – a 93 percent increase. During the same period, associated GHG emissions increased 48 percent.

Figure 5.7 Smelting and refining energy use by selected industry, 1990 and 2007



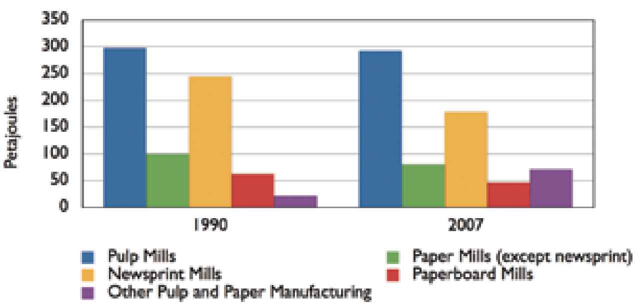
The primary production of alumina and aluminum was responsible for most of the 48 percent growth in energy use in this subsector since 1990 (Figure 5.7). This increase is consistent with the growth in the production of aluminum, which grew 96 percent between 1990 and 2007.

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. The pulp and paper industry is the main user of biomass as a source of energy.

Pulp and paper production decreased its energy use by 8 percent since 1990, for a 19 percent share of sectoral energy used. The largest decline came from the newsprint mill industry, with a 27 percent decrease since 1990 (Figure 5.8). GHG emissions decreased 28 percent since 1990 for the sector as a whole.

Figure 5.8 Energy consumption by subsector of the pulp and paper industry, 1990 and 2007



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 PJ to 722 PJ between 1990 and 2007. GHG emissions increased from 28 Mt to 32 Mt over the same period, while GDP increased from \$102 billion (\$2002) to 164 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

This industry represented 7 percent of the other manufacturing subsector's energy use, with 54.0 PJ. Its average annual increase was 1.3 percent.

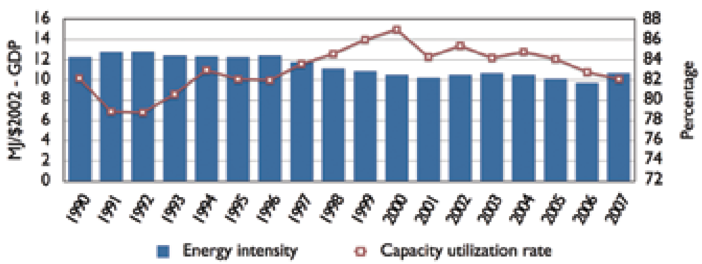
Detailed energy use data are taken from the *Industrial Consumption of Energy* survey for 1990 and from 1995 onward. Data for 1991–1994 are from the Canadian Industrial End-Use Energy Data and Analysis Centre's (CIEEDAC) report *Energy Intensity Indicators for Canadian Industry 1990–2007*. Previously, all detailed energy use data came from the CIEEDAC report. This means that detailed industry categories will not compare exactly with 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 rate of 0.7 percent per year, from 12.3 megajoules (MJ) per 2002 dollar of GDP in 1990 to 10.7 MJ per $2002 of GDP in 2007 (Figure 5.9).

Figure 5.9 Capacity utilization and energy intensity per year

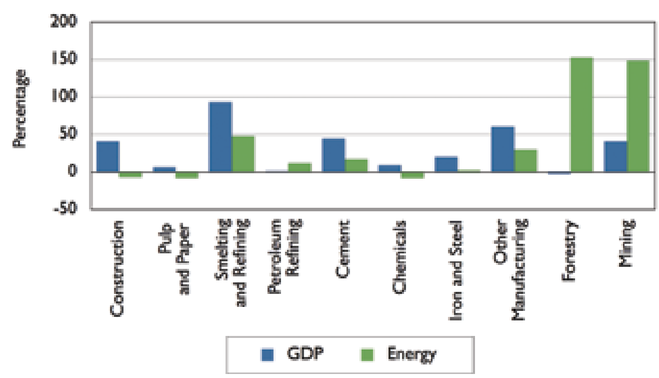


Energy efficiency improvements in the form of more efficient capital and management practices are important factors. Another key variable linked to energy intensity is the capacity utilization rate. This rate is calculated by dividing the actual production level for an establishment (measured in dollars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

At the aggregate industry level, 7 of the 10 industries reduced their energy intensity[8] from 1990 to 2007. Three industries experienced an increase: mining, petroleum refining and forestry. The biggest increase in energy intensity was 159 percent in forestry. Figure 5.10 illustrates that energy use in forestry increased 153 percent, while GDP fell 3 percent. Forestry energy use was driven up by an increased consumption of diesel fuel oil (partially used for hauling). In the mining sector, the move toward unconventional crude oil production contributed to the increase in energy intensity.

Gains in energy efficiency and a shift toward less energy-intensive activities were contributing factors in the subsectors that decreased their energy. In 2007, the share of industries that used more than 6 MJ per dollar of GDP represented 25 percent of total industrial GDP. This number is down from 28 percent in 1990.

Figure 5.10 Change in GDP and energy use, 1990–2007



[8] MJ/($2002) of GDP

Energy efficiency

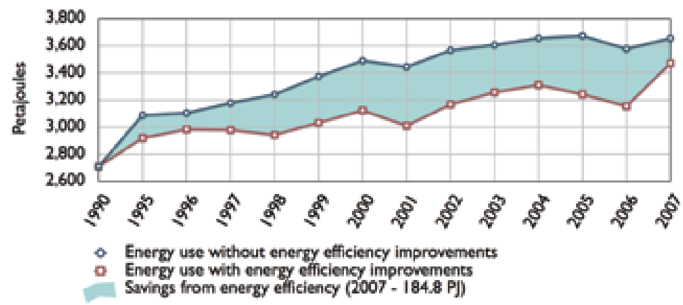
As demonstrated earlier, changes in upstream mining have had a significant influence on industrial sector energy consumption and intensity. From 1990 to 2007, the upstream mining share of industrial energy use grew from 8 percent to 22 percent. This reflects not only growth in production but also a shift from conventional to the significantly more energy-intensive unconventional oil production.

Although energy efficiency gains were achieved in unconventional oil production, the available data are not sufficient to quantify these gains. This lack of data has dampened the energy efficiency effect for the industrial sector as a whole.

To provide a better assessment of energy efficiency gains from the rest of the industrial sector, the factorisation analysis was produced and is presented here with and without the upstream mining sector.

Netting out the upstream mining, energy efficiency in the industrial sector improved 7 percent since 1990. In 2007 alone, Canadian industry saved 184.8 PJ because of energy efficiency (Figure 5.11), which corresponds to $2.1 billion in avoided energy costs. The improvement in energy efficiency was largely the result of reduction in energy intensity.

Figure 5.11 Industrial energy use, with and without energy efficiency improvements, 1990–2007



Netting out the upstream mining, Canadian industries improved energy efficiency by 23 percent, which represents 617.7 PJ of savings (Figure 5.12) and corresponds to $7 billion in avoided energy costs.

Figure 5.12 Industrial energy use, with and without energy efficiency improvements (without upstream mining), 1990–2007

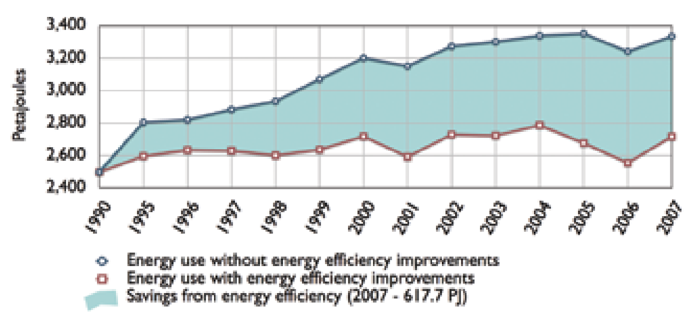


Figure 5.13 illustrates the influence that various factors had on the change in industrial energy use (including upstream mining) between 1990 and 2007. These effects are the

- **activity effect** – The mix of GDP, GO and production units (activity measures) increased the energy use 75 percent, or 1,261.7 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 315.3 PJ. Note that industries consuming more than 6 MJ per dollar of GDP (e.g. pulp and paper, petroleum refining, upstream mining) represented 28 percent of industrial GDP in 1990. They accounted for 25 percent in 2007.
- **energy efficiency effect** – Improvements in the energy efficiency of the industrial sector avoided 184.8 PJ of energy use.

Figure 5.13 Impact of activity, structure and energy efficiency on the change in industrial energy use, 1990–2007

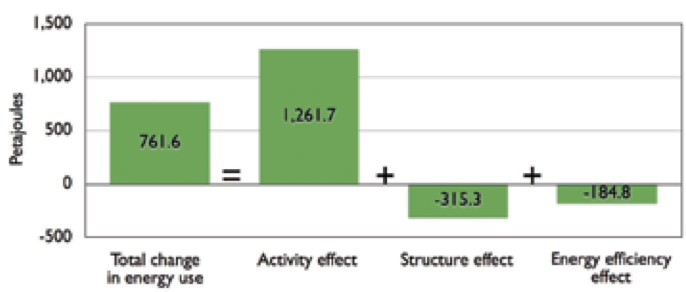
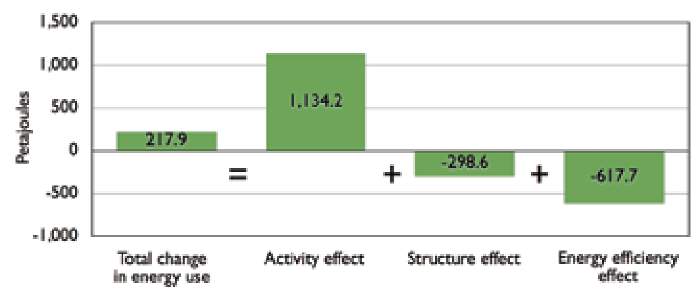
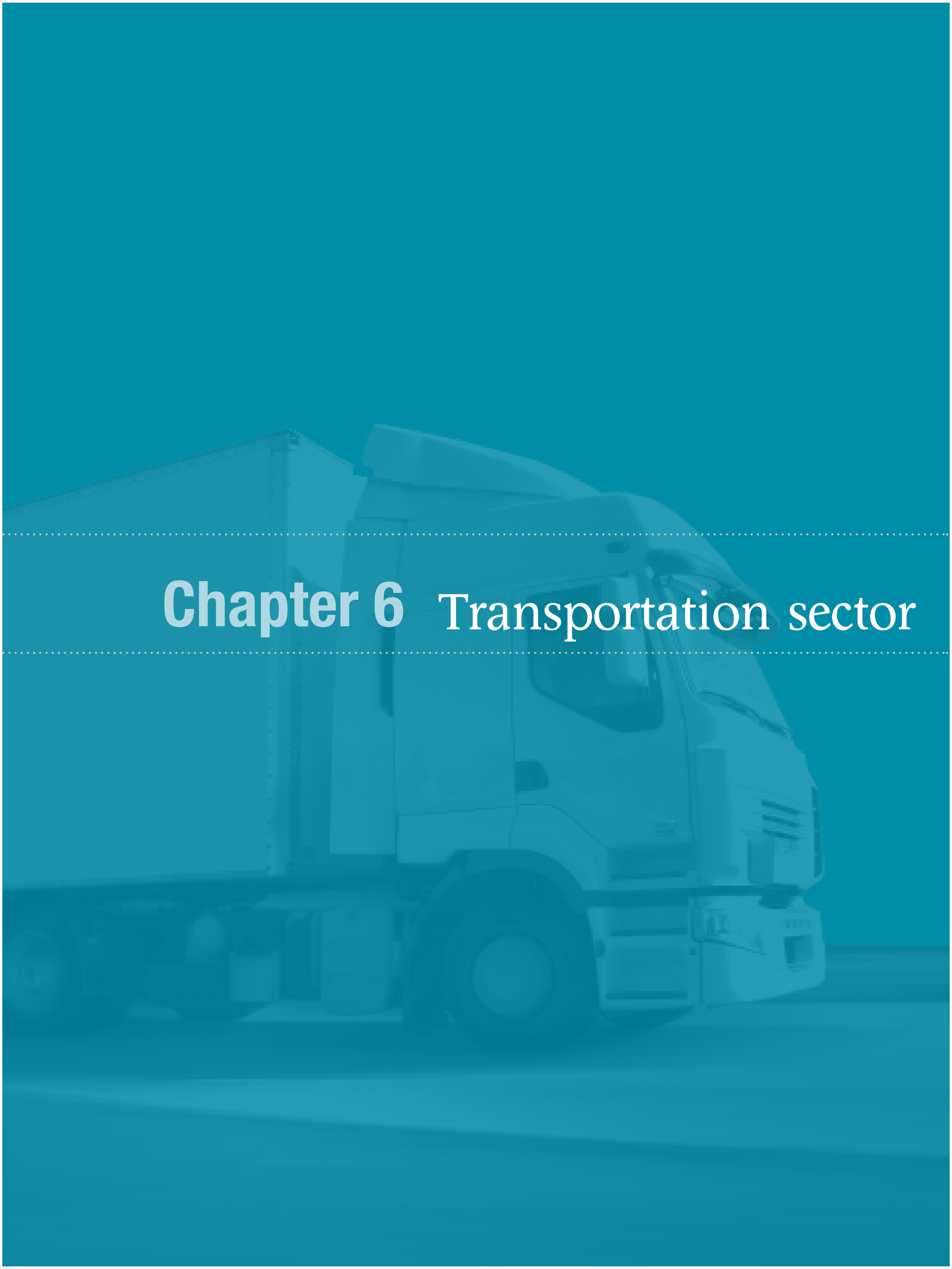


Figure 5.14 presents impact of activity, structure and energy efficiency on the change in industrial energy use without upstream mining.

- **activity effect** – The mix of GDP, GO and production units (activity measures) increased energy use by 1,134.2 PJ.
- **structure effect** – The structural changes in the industrial sector helped the sector to reduce its energy use by 298.6 PJ.
- **energy efficiency effect** – Improvements in the energy efficiency of the industrial sector avoided 617.7 PJ of energy use.

Figure 5.14 Impact of activity, structure and energy efficiency on the change in industrial energy use (without upstream mining), 1990–2007





Chapter 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 2007.

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 these two groups.

Environment Canada recently undertook a review of the emissions factors for refined petroleum products. As a result of this review, GHG emissions were revised downward throughout the series.

In 2007, Canadians (people and companies) spent $69.0 billion on transportation energy, the most of any sector in Canada and 73 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 (29 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, 2007

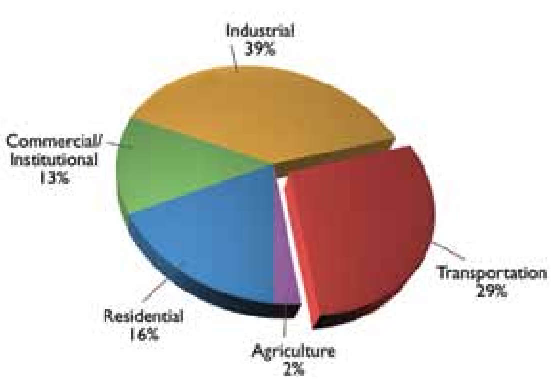
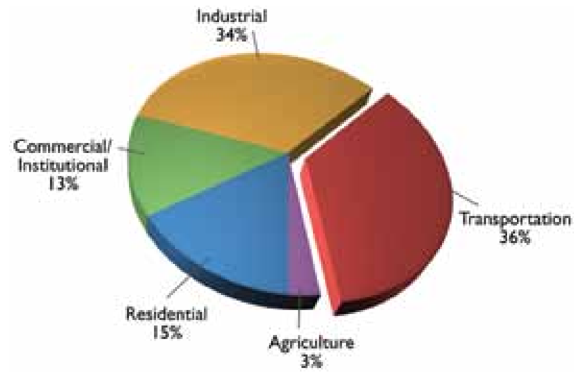


Figure 6.2 GHG emissions by sector, 2007



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 such items as snowmobiles and lawnmowers. Off-road transportation is not analyzed in this report because few data are available for these vehicles, and the energy consumption is relatively small.

Figure 6.3 Energy use by subsector, 2007

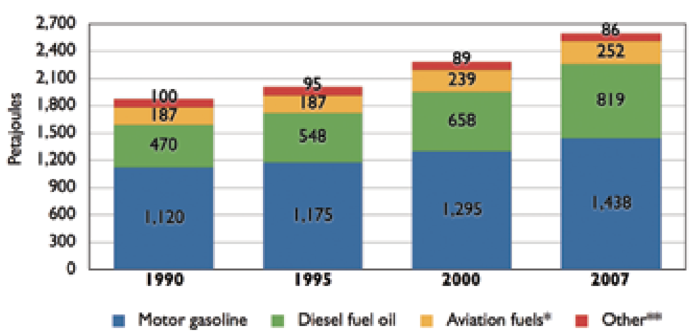
Trends – Transportation energy use and GHG emissions

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

Between 1990 and 2007, total transportation energy use increased 38 percent, from 1,877.9 PJ to 2,595.2 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 62 percent of the change in total transportation energy use. Heavy trucks, which have moved an increasing share of goods but are more energy-intensive than other modes, explain 76 percent of this increase in freight energy use.

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 a 74 percent increase in the demand for diesel fuel.

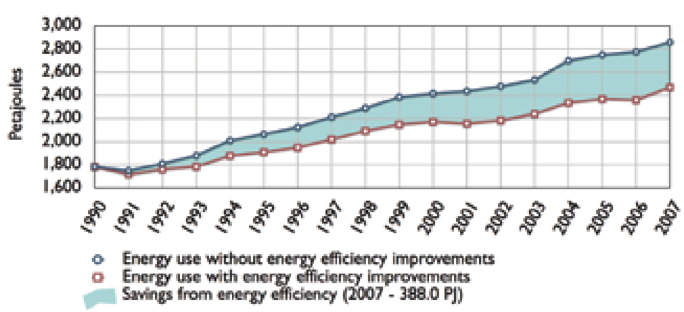
Motor gasoline and diesel fuel oil, as seen in Figure 6.4, are the main fuels used in the transportation sector, accounting for 87 percent of the energy. In order of amount used, aviation turbo fuel, heavy fuel oil, propane, aviation gasoline, electricity and natural gas are also reported. Diesel fuel oil experienced a 74 percent increase in use since 1990, as a result of the large rise in freight activity. However, total diesel use is still less than motor gasoline use. Aviation gasoline, propane and electricity are the only transportation fuels whose consumption decreased over the period.

Transportation energy efficiency

Energy efficiency improvements in transportation resulted in energy savings of 388.0 PJ, or $10.3 billion, for Canada in 2007.

Between 1990 and 2007, energy efficiency in the transportation sector improved 22 percent, leading to savings of $10.3 billion, or 388.0 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. Small savings at the individual vehicle level in these modes can have a large impact on the total because these two types of vehicles comprise the majority of transportation use.

Figure 6.5 Transportation energy use, with and without energy efficiency improvements, 1990–2007



Trends – Passenger transportation energy use and GHG emissions

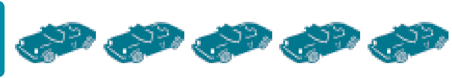
Light-duty vehicles (small cars, large cars, light trucks and motorcycles) represent the main type of transport used by Canadians for passenger transportation. Air, bus and rail modes are also used, but to a lesser extent.

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 often occurs, unless sufficient energy efficiency improvements have taken place to offset the growth in activity.

More vehicles on the road are driving longer distances, on average.

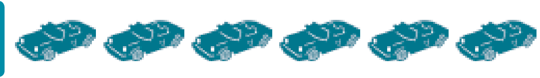
Figure 6.6 Passenger transportation energy indicators, 1990 and 2007

1990



- 14.1 million vehicles
- 19 percent are light trucks
- 17,332 km/year on average
- 376 billion Pkm travelled

2007

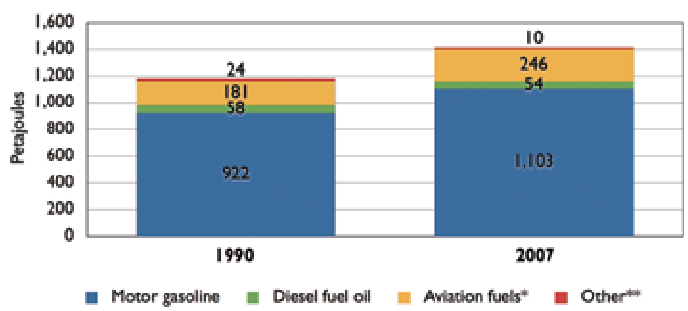


- 16.7 million vehicles
- 32 percent are light trucks
- 19,005 km/year on average
- 513 billion Pkm travelled

Energy use in passenger transportation increased 19 percent, from 1,184.7 PJ to 1,412.5 PJ, between 1990 and 2007. The associated GHG emissions increase was 17 percent, from 82.3 Mt to 96.0 Mt. During the same period, Canada experienced a 26 percent increase in the number of registered drivers,[9] a 19 percent increase in the number of light-duty vehicles registered and a 10 percent increase in the average passenger distance driven; these three factors combined heavily influenced the 42 percent increase in overall passenger-kilometres. However, energy use grew by 19 percent, which was less than half of the growth in passenger-kilometres. The difference in these two values can be attributed to changes in the types of vehicles used for passenger transportation and improvements in energy efficiency.

The mix of fuels for passenger transport has remained relatively constant. Motor gasoline was the main source of energy, representing 78 percent of the fuel mix in 2007, followed by aviation turbo fuel and diesel fuel oil (Figure 6.7).

Figure 6.7 Passenger transportation energy use by fuel type, 1990 and 2007

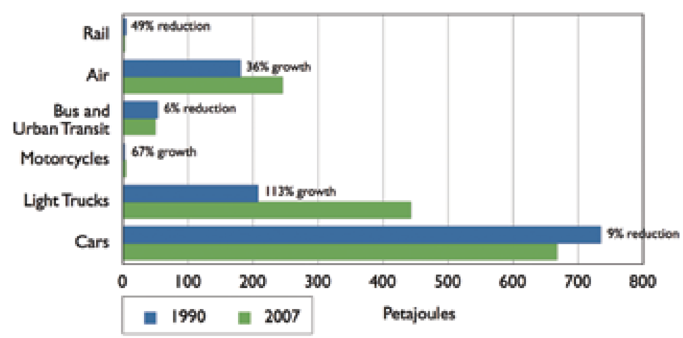


* Aviation fuels include aviation turbo fuel and aviation gasoline.
** Other includes electricity, natural gas, heavy fuel oil and propane.

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 2007, 40 percent of all new passenger vehicle sales were light trucks, compared with 25 percent in 1990. This change in the mix of sales led to a large increase in passenger transportation energy use and a shift in energy use toward light trucks and away from cars. Between 1990 and 2007, light truck energy use increased quicker than any other passenger transportation mode, rising 113 percent (Figure 6.8).

Figure 6.8 Passenger transportation energy use by mode, 1990 and 2007



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 50 percent and the average trip length increasing 27 percent during the period.[10] Both of these factors help to explain the large increase of 89 percent in aviation passenger-kilometres that the transportation sector experienced since 1990. However, in the same period, growth in energy use was significantly less at 36 percent, showcasing the increasing efficiency of the industry. One way this efficiency is attained is through the increasing effort of carriers to match their aircraft size with market size, thereby increasing their overall load factor. The use of smaller regional jets and a turnover in the fleets toward smaller aircraft have aided in this trend.[11]

[9] Transport Canada, *Canadian Motor Vehicle Traffic Collision Statistics: 2006*, Ottawa, December 2007 (Cat. T45-3/2006).
[10] Statistics Canada, *Civil Aviation, Annual Operating and Financial Statistics, Canadian Air Carries, Levels I to III: 2007*, Ottawa, July 2009 (Cat. 51-004-XIE).
[11] Transport Canada, *Assumptions Report 2007–2011: Final Report*, Ottawa, December 2007.

Passenger transportation energy intensity and efficiency

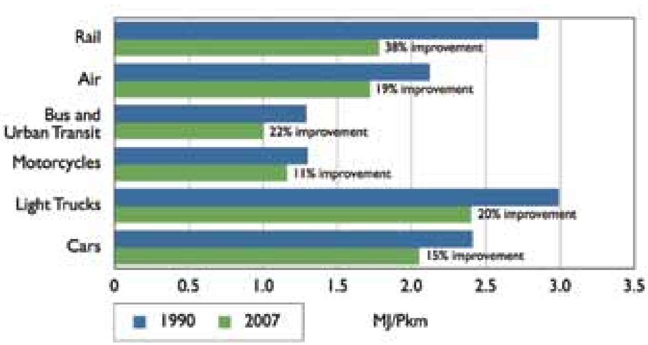
Energy intensity

Passenger transportation energy intensity, defined as the amount of energy required to move one person over 1 km, improved from year to year. Between 1990 and 2007, energy intensity improved 15 percent, from 2.4 megajoules (MJ) per Pkm travelled to 2.0 MJ/Pkm. An improvement in vehicle fuel efficiency is the main reason for this change.

Over the period, the average fuel efficiency improved for all types of on-road vehicles except diesel light trucks. Average fuel efficiency is measured by litres used per 100 kilometres (L/100km).

As expected, light trucks have a higher energy intensity level than passenger cars because they often have a higher rate of fuel consumption (Figure 6.9). This fact, combined with the increased popularity of light trucks, is a major contributor to the rise in passenger energy use since 1990.

Figure 6.9 Passenger transportation energy intensity by modes, 1990 and 2007



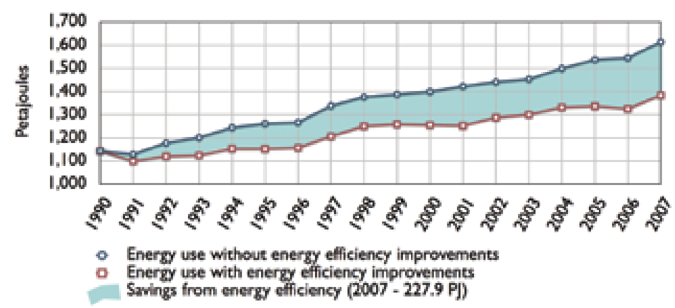
Passenger rail services in Canada have achieved a steady improvement in energy intensity since 1990, as a result of increased fuel efficiency of their operations while at the same time increasing passenger travel. This combination led to a 38 percent improvement in energy intensity over the period (Figure 6.9).

Energy efficiency

Energy efficiency improvements in passenger transportation generated an energy savings of 227.9 PJ, or $6.2 billion, in the transportation sector in 2007.

The amount of energy used for passenger travel increased 19 percent, rising from 1,184.7 PJ in 1990 to 1,412.5 PJ in 2007. Also, energy-related GHG emissions increased 17 percent, from 82.3 Mt to 96.0 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 19 percent.

Figure 6.10 Passenger transportation energy use, with and without energy efficiency improvements, 1990–2007

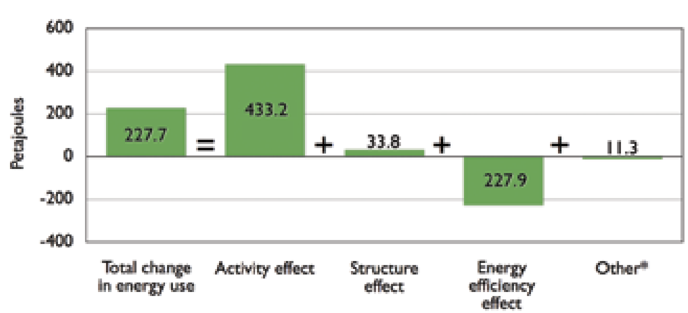


[12] Electricity accounts for only 0.2 percent of total passenger transportation energy use and is used, for the most part, for urban transit.

Figure 6.11 illustrates the influence that various factors had on the change in passenger transportation energy use between 1990 and 2007. These effects are the

- **activity effect** – The activity effect (i.e. passenger-kilometres travelled) increased energy use by 38 percent, or 433.2 PJ, with a corresponding 29.4 Mt increase in GHG emissions. Light truck and air transportation led the growth in passenger-kilometres (and therefore, activity effect), with respective increases of 165 and 89 percent.
- **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. The popularity of minivans and SUVs increased the activity share of light trucks compared with other modes, contributing to a 33.8 PJ increase in energy consumption and a 2.3 Mt increase in GHG emissions.
- **energy efficiency effect** – Improvements in the energy efficiency of passenger transportation saved 227.9 PJ of energy and 15.5 Mt of energy-related GHG emissions. Despite the increasing popularity of larger and heavier light-duty vehicles with greater horsepower, the light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation contributed 172.5 PJ of energy savings.

Figure 6.11 Impact of activity, structure and energy efficiency on the change in passenger transportation energy use, 1990–2007



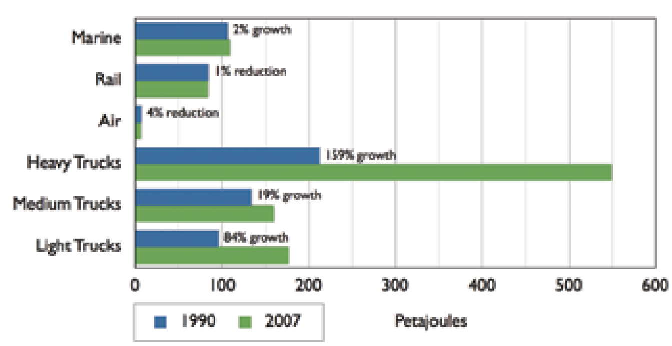
* Other refers to non-commercial airline aviation, which is included in the Total change in energy use value depicted above but is excluded from the factorization analysis.

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.

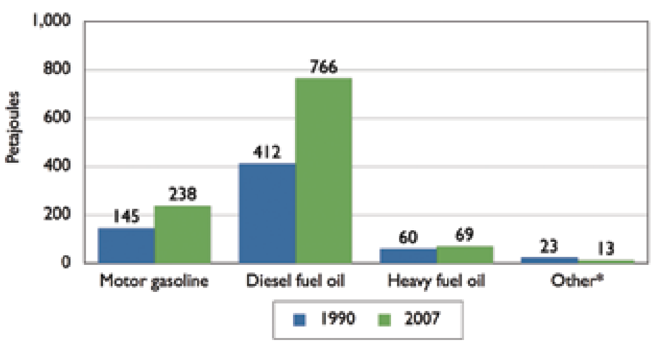
Freight energy use increased 70 percent, from 639.8 PJ in 1990 to 1,085.1 PJ in 2007. As a result, energy-related GHG emissions produced by freight transportation increased 68 percent, from 45.6 Mt in 1990 to 76.8 Mt in 2007. Figure 6.12 illustrates that energy use increased for all modes of freight transportation except air and rail, which experienced declines of 4 percent and 1 percent, respectively. Heavy and light trucks experienced the largest increase in energy use, accounting for the majority of energy consumed for freight transportation in 2007.

Figure 6.12 Freight transportation energy use by mode, 1990 and 2007



The mix of fuels used in the freight subsector remained relatively constant between 1990 and 2007. Diesel fuel oil continued to be the main source of energy, comprising 71 percent of the fuel consumed for freight transportation (Figure 6.13).

Figure 6.13 Freight transportation energy use by fuel type, 1990 and 2007



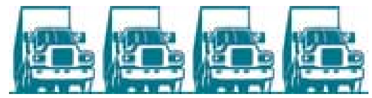
* Other includes aviation turbo fuel, aviation gasoline, natural gas and propane.

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, the companies require an efficient and on-time transportation system that is often met by the means of heavy trucks. As a result, heavy truck use for freight transportation has been increasingly significant. Between 1990 and 2007, the number of heavy trucks increased 17 percent, and the average distance travelled increased 29 percent, to reach 92,660 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.

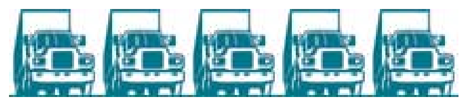
Figure 6.14 Freight transportation energy indicators, 1990 and 2007

1990



- 2.0 million freight trucks
- 297,000 heavy trucks
- 72,005 km/year on average for heavy trucks
- 102.8 billion truck Tkm traveled

2007

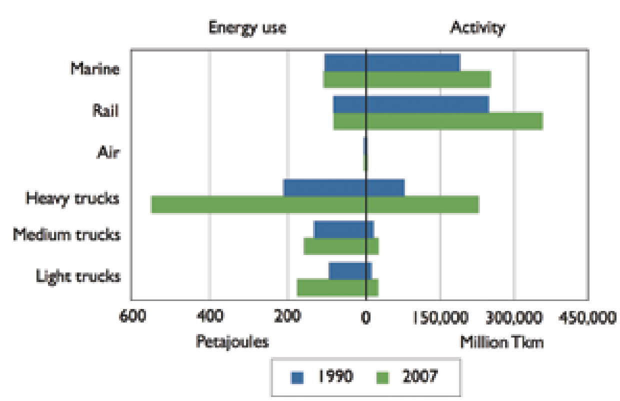


- 2.8 million freight trucks
- 347,000 heavy trucks
- 92,660 km/year on average for heavy trucks
- 275.9 billion truck Tkm traveled

Rail remains the main mode to move 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 for transport. As a result, they make up the largest portions of the freight sector's activity, the same as they did in 1990. Rail moves the largest amount of freight in terms of tonne-kilometres, at 357.4 billion Tkm. This amount is 44 percent higher than in 1990. Growth in marine tonne-kilometres has been significant since 2001, rising 26 percent, and is now 33 percent higher than in 1990. However, both of these increases are overshadowed by the 194 percent growth in tonne-kilometres of heavy trucks.

Figure 6.15 Freight transportation energy use versus activity by mode, 1990 and 2007



Since 1990, all modes of freight transportation became 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. However, over the period, trucks increased in efficiency because their on-road average fuel consumption improved.

Freight transportation energy efficiency

Energy efficiency improvements in freight transportation resulted in energy savings of 160.1 PJ, or $4.1 billion, in the transportation sector in 2007.

Between 1990 and 2007, energy use by freight transportation increased 70 percent, from 639.8 PJ to 1,085.1 PJ. Without energy efficiency improvements, energy use would have increased 95 percent, or 15 percent more than what was observed in 2007 (Figure 6.16).

Figure 6.16 Freight transportation energy use, with and without energy efficiency improvements, 1990–2007

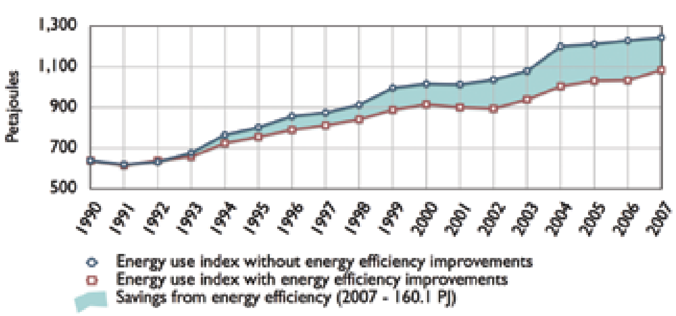
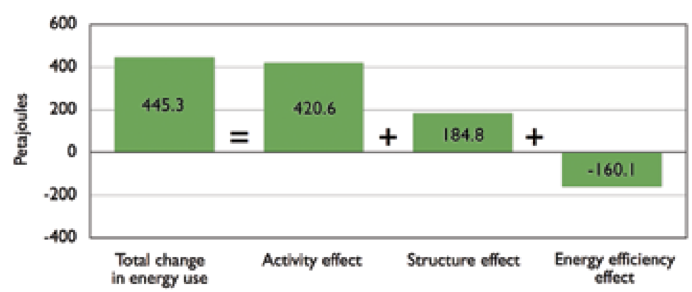


Figure 6.17 illustrates the influence that various factors had on the change in freight transportation energy use between 1990 and 2007. These effects are the

- **activity effect** – The activity effect (i.e. tonne-kilometres moved) increased energy use 66 percent, or 420.6 PJ, and caused a corresponding 29.8 Mt increase in GHG emissions. This increase was influenced by greater international trade and the deregulation of the trucking and rail industries.
- **structure effect** – Changes in the structure of freight transportation (shifts in activity between modes) stemmed from growth in international trade and customer requirements for just-in-time delivery. The shift between modes was the increase in the share of freight moved by heavy trucks relative to other modes. Because trucks are more energy-intensive per tonne-kilometre than other modes, the sector used an additional 184.8 PJ of energy and emitted 13.1 Mt more GHG emissions.
- **energy efficiency effect** – Improvements in the energy efficiency of freight transportation saved 160.1 PJ of energy and 11.3 Mt of GHG emissions. Improvements in freight trucks were a large contributor, saving 101.1 PJ.

Figure 6.17 Impact of activity, structure and energy efficiency on the change in freight transportation energy use, 1990–2007



Appendices

Appendix A Reconciliation of data

Figure A.1 Reconciliation of data with Canada's *Report on Energy Supply-Demand in Canada* (RESD) – 2007 (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 The Energy Efficiency Trends in Canada 1990–2007
Sector										
Residential	1,344	103								1,447
Commercial/ Institutional	1,451		(207)	(28)	(74)					1,142
Industrial	2,466						492	5	509	3,472
Transportation	2,490		207	28	74	(204)				2,595
Agriculture	215									215
Final Demand	**7,966**	**103**	**0**	**0**	**0**	**(204)**	**492**	**5**	**509**	**8,871**
Non-Energy	1,049									1,049
Producer Consumption	1,348					204			(509)	1,042
Net Supply	**10,362**	**103**	**0**	**0**	**0**	**0**	**492**	**5**	**0**	**10,962**
Fuel Conversion										
Electricity, Steam & Coal/Coke Input Fuels [1]	4,068									4,068
Electricity, Steam & Coal/Coke Production [2]	(2,244)									(2,244)
Total Primary	**12,186**	**103**	**0**	**0**	**0**	**0**	**492**	**5**	**0**	**12,786**

[1] Electricity, steam and coal/coke input fuels represents the amount of input energy from source fuels (coal, uranium, etc.) that are transformed to electricity, steam, coke and coke gas.

[2] Electricity, steam and 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 (Table 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.

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

AECO-Chub: 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.

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 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. Gross output 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 heating degree-days 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 heating degree-days for that day is zero. The number of heating degree-days for a longer period is the sum of the daily heating degree-days 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 (kg) (33 001 pounds [lb]). 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.

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).

Large car: A large car has a gross vehicle weight of 1,182 kg (2,601 lb) or more. The gross vehicle weight is the weight of the empty vehicle plus the maximum anticipated load weight.

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.

Model year: An annual period in which a national automotive industry organizes its operations and within which new models are announced. For example, if the model year is 2005, it begins September 1, 2004, and ends August 31, 2005.

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).

Small car: A small car has a gross vehicle weight of up to 1181 kg (2600 lb). The gross vehicle weight is the weight of the empty vehicle plus the maximum anticipated load weight.

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).

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.

$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-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