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Preface

This 16th edition of *Energy Efficiency Trends in Canada* delivers on Canada's commitment to provide a comprehensive summary of secondary energy use and related greenhouse gas (GHG) emissions in Canada. It also tracks trends in energy efficiency. This year's edition is produced electronically and in paper format.

For more secondary energy use statistics, see the comprehensive energy use database. The database includes most of the historical energy use and GHG emissions data used by Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE). This database can be viewed at oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/databases.cfm?attr=0.

This report covers the four sectors analysed by the OEE, which are the residential, commercial/institutional, industrial and transportation sectors. The 2010 period is the most recent year for which data are available.

The reader should be aware that this edition of the *Energy Efficiency Trends in Canada* is based on the revised *Report on Energy Supply and Demand* (RESD), 1995–2010, which represents a re-setting of the energy balances for Canada. The RESD data were released September 14, 2012, on CANSIM and include revisions for all sectors because of the incorporation of the full Industrial Consumption of Energy (ICE) survey and the Survey of Secondary Distributors of Refined Petroleum Products. Previously, the industrial estimates were based on a representative sample of enterprises in the ICE survey by sector. The revised RESD now incorporates all enterprises in the survey to present a more complete and accurate view. The revised RESD data also incorporate results from the Survey of Secondary Distributors of Refined Petroleum Products. This change caused a re-allocation of energy use to end-users of refined petroleum products and away from the commercial sector.

This report reflects these revisions over time, and every effort has been made to preserve historical trends. However, use caution when comparing this data set and analysis to the previous versions because the level of energy use may have changed, and growth rates may have been revised.

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

This report was prepared by Naïma Behidj, Monique Brugger, Rosita Kwan, Stéphane Leblanc, Yantao Liu, Michael Warbanski and Fumiko Yamada, who are staff of the Demand Policy and Analysis Division of the OEE. John Appleby was responsible for the report, with Laura Oleson providing overall direction

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Introduction

Chapter 1

1 Introduction

Canadians spent $163 billion on energy in 2010.

Energy accounts for a large segment of spending by households, businesses and industries alike. In 2010, Canadians spent about $163 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 11 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 2010, this report also analyses the energy intensity and efficiency trends between 1990 and 2010. Such monitoring aids the OEE in promoting energy efficiency in all aspects of Canadian life. It contributes toward the goal of making Canada a world leader in environmental responsibility in the development and use of natural resources.

Measurement of energy

To compare sources of energy, all energy consumption data presented in this report are expressed in joules. One joule is equivalent to the work required to produce one watt of power continuously for one second. One petajoule (PJ), or 10^{15} joules, is equivalent to the energy required by more than 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).

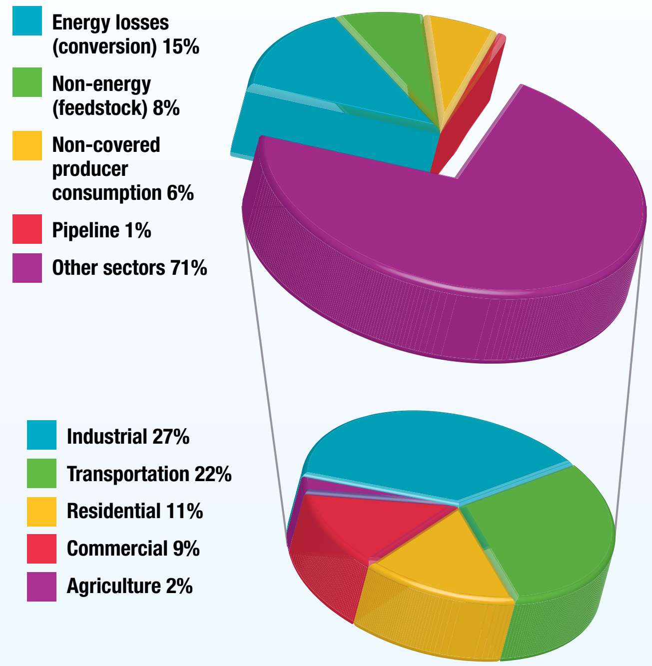
It also includes the energy used to bring energy supplies to the consumer (e.g. pipeline). Further, it entails the energy used to feed industrial production processes (e.g. the natural gas used as feedstock by the chemical industries). In 2010, the total amount of primary energy consumed was estimated at 11,959.6 PJ (see Appendix A, "Reconciliation of data," for more details).

Secondary energy use[1] (Figure 1.1) is the energy used by final consumers in various sectors of the economy. This includes, for example, the energy used by vehicles in the transportation sector. Secondary energy use also encompasses energy required to heat and cool homes or businesses in the residential and commercial/institutional sectors. In addition, it comprises energy required to run machinery in the industrial and agricultural sectors. Secondary energy use accounted for almost 71 percent of the primary energy use in 2010, or 8,479.1 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 users of electricity. This mapping of GHG emissions to appropriate electricity consumers is discussed in more detail in the section GHG emissions.

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

Figure 1.1 – Primary and secondary energy use by sector, 2010



All subsequent references to "energy" in this report refer to secondary energy.

GHG emissions

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

Total Canadian GHG emissions are estimated to have been 692 megatonnes (Mt) in 2010; 70 percent of this total (or 484.4 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 point 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, 1990–2010 – 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.

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

1 Introduction

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 2010 of energy use and GHG emissions is described, followed by the trends in energy use and GHG emissions from 1990 to 2010. Finally, the overall and sector analysis provides the results of the factorization analysis and a detailed discussion of the trends in energy efficiency and energy intensity over the sample period.

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

Energy use

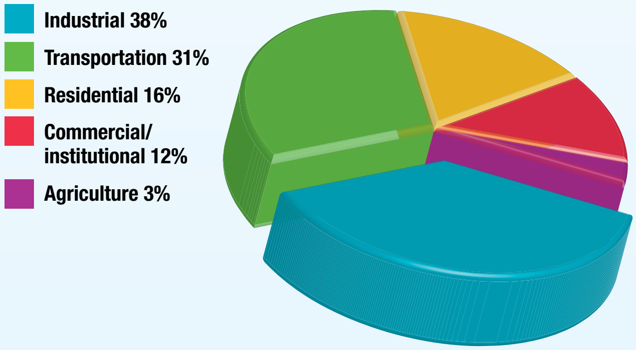
Chapter 2

Overview – Energy use and GHG emissions

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

Energy is used in all five sectors of the economy: residential, commercial, industrial, transportation and agriculture. In 2010, these sectors used a total of 8,479.1 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 484.4 Mt in 2010.

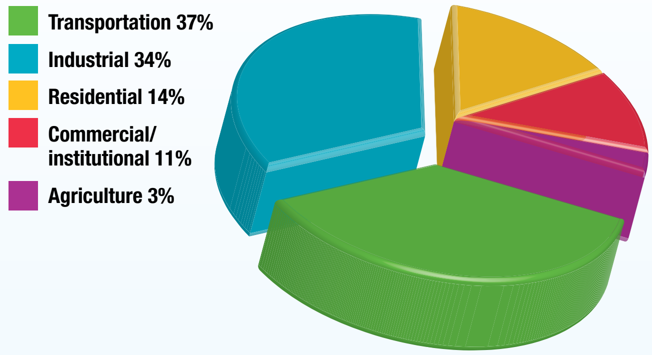
Figure 2.1 – Secondary energy use by sector, 2010



One petajoule is approximately equal to the energy used by more than 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 sector. Energy consumed by the transportation and agriculture sectors is relatively more GHG-intensive than the other sectors.

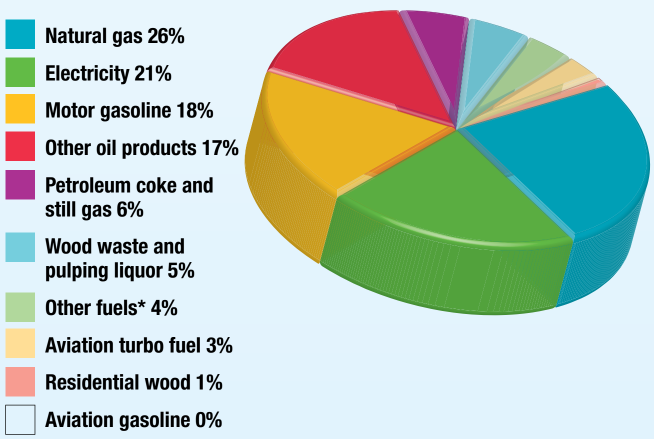
Figure 2.2 – GHG emissions by sector, 2010



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

Natural gas and electricity are used in all sectors of the economy while motor gasoline is mainly used in the transportation and agriculture sectors. In 2010, natural gas and electricity accounted for almost half the energy used in Canada (Figure 2.3). The motor gasoline and other oil products category (diesel fuel oil, light fuel oil, kerosene, and heavy fuel oil) represented approximately 35 percent of energy usage.

Figure 2.3 – Secondary energy use by fuel type, 2010



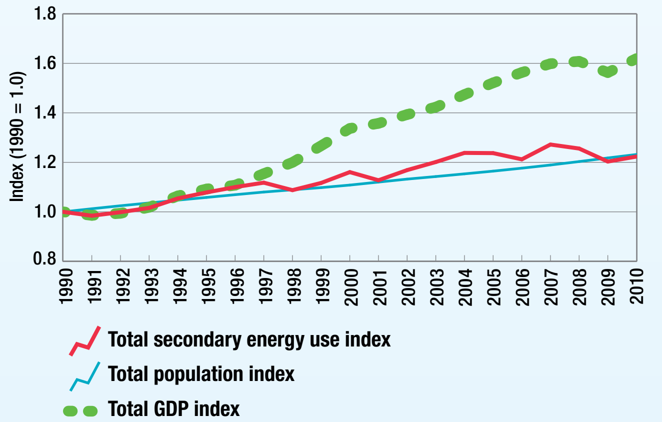
* Other fuels include coal, coke, coke oven gas, liquefied petroleum gas and gas plant natural gas liquids, and waste fuels from the cement industry.

Trends – Energy use and GHG emissions

Energy use grew much more slowly than the economy, and slightly less rapidly than the population.

Between 1990 and 2010, energy use in Canada increased by 22.3 percent, from 6,931.3 PJ to 8,479.1 PJ (Figure 2.4). At the same time, the Canadian population grew 23.2 percent (approximately 1 percent per year) and GDP increased 61.9 percent (about 2 percent per year). More generally, energy use per unit of GDP declined, and energy use on a per capita basis decreased.

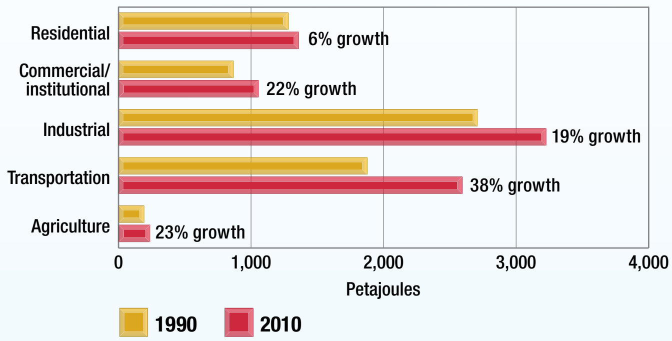
Figure 2.4 – Total secondary energy use, Canadian population and GDP, 1990–2010



Energy use has been growing at the fastest rate in the transportation sector.

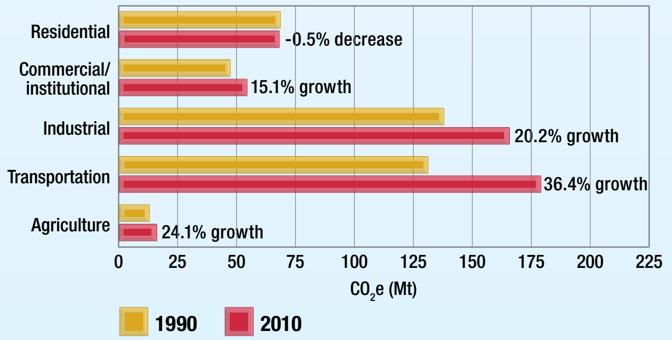
The industrial sector uses the most energy in our economy, consuming 3,227.6 PJ of energy in 2010. However, energy use growth in the transportation sector outpaced all other sectors. Over 1990–2010, transportation energy use grew by 38.2 percent primarily due to a 70.5 percent growth in freight energy use.

Figure 2.5 – Total secondary energy use and growth by sector, 1990 and 2010



Growth in energy use was reflected in growth of GHG emissions. In 2010, Canada's GHG emissions excluding electricity-related emissions increased 25.4 percent compared to 1990, while emissions including those from electricity generation grew 21.5 percent. In 2009 and 2010, demand for electricity dropped compared to 2008 and the mix of electricity generation also changed. In 2010, a decline in electricity generated by coal resulted in fewer GHG emissions. Consequently, total GHG emissions from electricity generation decreased 9.7 percent in 2010 compared to 2008, even though total GHG emissions from 1990 to 2010 experienced an increase of 16.8 percent. The transportation sector experienced the highest growth in emissions at 36.4 percent followed by the agriculture sector at 24.1 percent (Figure 2.6).

Figure 2.6 – Total GHG emissions and growth by sector, 1990 and 2010



The transportation sector accounted for the largest proportion, 37.0 percent, of energy-related emissions (179.2 Mt carbon dioxide equivalent [CO_2e]), followed by the industrial sector, 34.2 percent (165.9 Mt CO_2e), including electricity-related emissions. This difference in the shares of energy and emissions is driven by the dominance of refined petroleum products in the transportation sector providing for a more GHG-intensive energy mix.

Energy intensity and efficiency

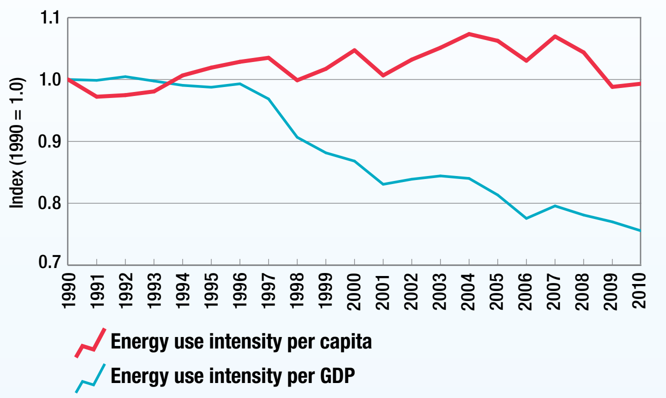
Canada improved its energy efficiency between 1990 and 2010. The following section discusses two indicators of energy efficiency: energy intensity and an energy efficiency measure using factorization.

Energy intensity

Canada's energy intensity improved 24.5 percent between 1990 and 2010 while per capita energy use decreased 0.7 percent.

Energy intensity, when defined as the amount of energy required per unit of activity (GDP), improved 24.5 percent between 1990 and 2010 (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 2010 had produced the same level of GDP that it did in 1990, it would have used much less energy.

Figure 2.7 – Total secondary energy use intensity per capita and unit of GDP index, 1990–2010



Similarly, the amount of energy required per capita, which is the energy intensity for each individual, decreased 0.7 percent between 1990 and 2010 (Figure 2.7). This downward trend reflects the improvement in energy efficiency despite the increasing use of electronic goods, increasing ownership of passenger light trucks and increasing distance and weight of goods transported by heavy trucks.

Energy efficiency

Energy efficiency improved 25.3 percent since 1990. This improvement reduced energy use by approximately 1,680.7 PJ, decreased GHG emissions by 93.3 Mt and saved Canadians $32.4 billion in 2010.

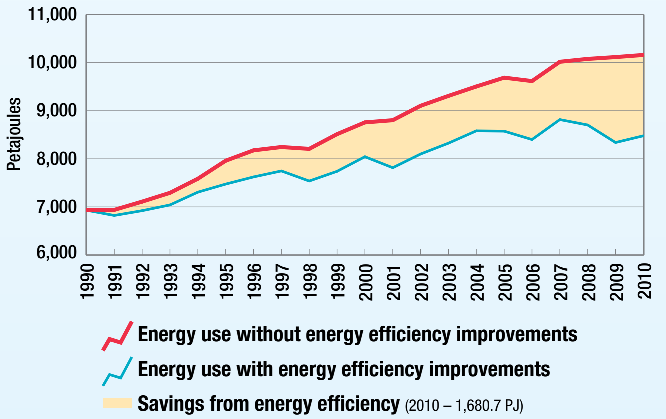
One of the greatest sources of untapped energy is the energy we waste. Isolating and tracking energy efficiency in the Canadian economy is carried out in a conscious effort to publicize this energy resource. This analysis examines all areas of the economy to determine what would have happened had there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

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

- **activity effect –** Activity is defined differently in each sector. For example, in the residential sector, it is defined as the number of households and the floor space of residences. In the industrial sector, it is defined as industrial GDP, gross output (GO) and physical industrial output, such as tonnes of steel.
- **structure effect –** Structure refers to changes in the makeup of each sector. For example, in the industrial sector, a relative increase in activity in one industry over another is considered a structural change.
- **weather effect –** Fluctuations in weather lead to changes in heating and cooling requirements. This is measured in terms of heating and cooling degree-days. This effect is taken into account in the residential and commercial/institutional sectors, where heating and cooling account for a significant share of energy use.
- **service level effect –** Service level refers to the penetration rate of devices and equipment. For example, the term denotes use of auxiliary equipment in commercial/institutional buildings and appliances in homes, or the amount of cooled floor space. Although these devices are becoming more efficient, the addition of more devices would represent an increase in service levels, which has tended to offset these gains in efficiency.
- **capacity utilization rate effect**[4] – Capacity utilization rate refers to the proportion of the installed production capacity that is in use. For more details on capacity utilization rate, see Chapter 5 "Industrial sector."
- **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 46.6 percent between 1990 and 2010 instead of 22.3 percent. These energy savings of 1,680.7 PJ are equivalent to the energy use of about 32 million cars in 2010.

Figure 2.8 – Secondary energy use, with and without energy efficiency improvements, 1990–2010

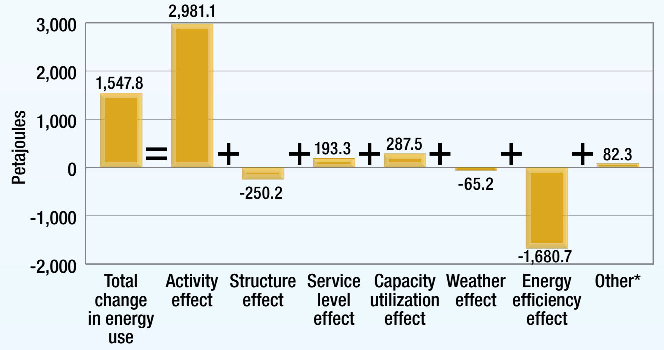


[4] This version of this report continues to include a separate estimate of the impact of changes in capacity utilization with respect to energy use to more accurately reflect changes in the pure energy efficiency effect. The analysis has been conducted back through time, which has the effect of smoothing out the trend in energy efficiency. While detailed analysis is limited to the industrial sector because of data availability, the impact can be seen in the aggregate savings.

Figure 2.9 illustrates the relative impact of each effect on energy use over the 1990–2010 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 61.9 percent between 1990 and 2010. The overall growth in activity effect is estimated to have increased energy use by 43 percent, or 2,981.1 PJ, with a corresponding 167.5-Mt increase in GHG emissions.
- **structure effect** – Over the 1990–2010 period, a shift in production toward industries that are less energy-intensive resulted in a decrease of 250.2 PJ and an 7.8-Mt decrease in GHG emissions.
- **weather effect** – In 2010, the winter was warmer and the summer was hotter than that of 1990. The net result was an overall decrease in energy demand for temperature control of 65.2 PJ and a 3.3-Mt reduction in GHG emissions.
- **service level effect** – From 1990 to 2010, changes in service level (e.g. increased use of computers, printers and photocopiers in the commercial/institutional sector) raised energy use by 193.3 PJ and increased GHG emissions by 9.9 Mt.
- **capacity utilization effect** – The overall decline in the capacity of utilization translated into 287.5 PJ in energy waste and thereby increased GHG emissions by 14.8 Mt.
- **energy efficiency effect** – As noted above, improvements in energy efficiency saved 1,680.7 PJ of energy and avoided 93.3 Mt of GHG emissions from 1990 to 2010.

Figure 2.9 – Summary of factors influencing the change in energy use, 1990–2010



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

Residential sector

Chapter 3

Overview – Residential energy use and GHG emissions

In Canada, 80 percent of all residential energy use was for space and water heating in 2010.

In 2010, Canadians spent $26.3 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 14 percent of all secondary energy use-related GHGs emitted in Canada (Figure 3.2). Specifically, residential energy use was 1,360.7 PJ, emitting 68.4 Mt of GHGs.

Figure 3.1 – Energy use by sector, 2010

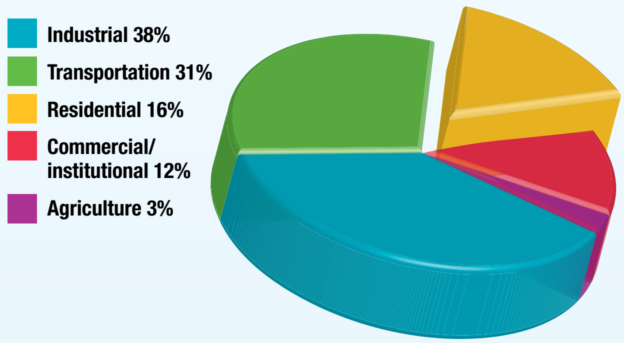
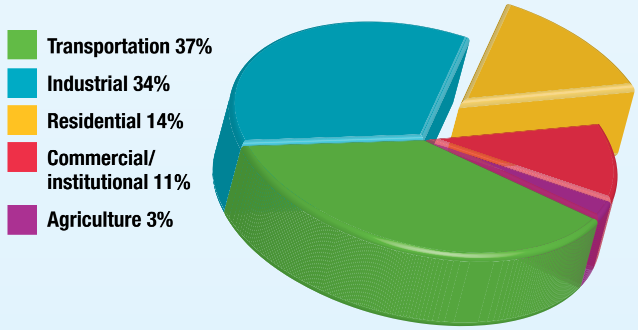
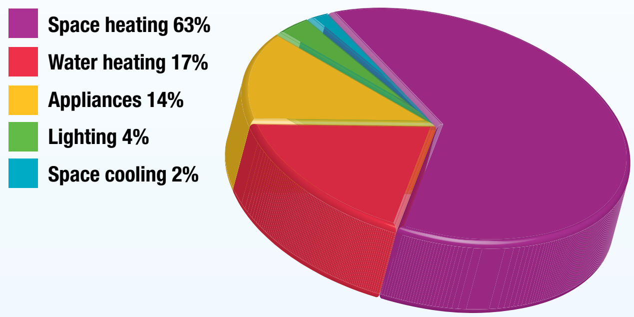


Figure 3.2 – GHG emissions by sector, 2010



Natural gas, electricity, wood, heating oil and propane were the sources of energy being used. As seen in Figure 3.3, given Canada's cold climate, 63 percent of Canada's residential energy use was for space heating in 2010, while water heating accounted for 17 percent. Appliances were also major energy users in Canadian dwellings, followed by lighting and space cooling.

Figure 3.3 – Distribution of residential energy use by end-use, 2010



Trends – Residential energy use and GHG emissions

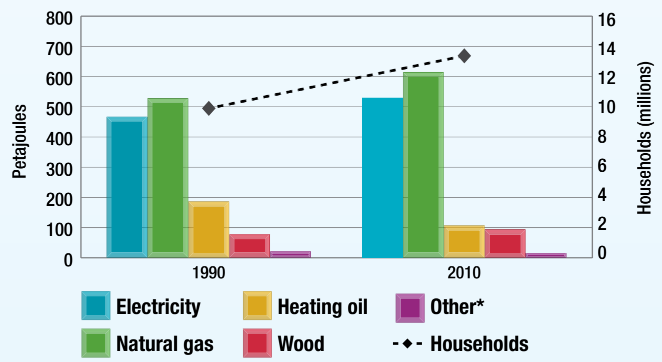
Population growth and fewer people per household led to a 35 percent rise in the number of households, which contributed to a 6 percent increase in residential energy use from 1990 to 2010.

> The 3.5 million households added in Canada since 1990 is more than the total number of households in Quebec.

Between 1990 and 2010, the population grew 23 percent (6.4 million people) and the number of households increased 35 percent (3.5 million). The rise in the number of households, combined with increased average living space and higher penetration rate of appliances, contributed to the increase of 6 percent, or 78.4 PJ, in residential energy use from 1,282.3 PJ to 1,360.7 PJ. As home owners gradually switched to cleaner energy sources, the associated GHG emissions decreased 0.5 percent, from 68.7 Mt to 68.4 Mt during the period.

The mix of energy used in the residential sector changed slightly over the period. Specifically, natural gas and electricity became even more dominant while heating oil use declined (Figure 3.4). Natural gas and electricity together accounted for 84 percent of all residential energy use in 2010, compared to 78 percent in 1990, while heating oil saw its share decrease from 15 percent to 8 percent over the period. The increase in natural gas and electricity share largely reflected increased availability of natural gas and lower natural gas prices relative to oil. It was also in part the result of relatively higher efficiency ratings for gas and electric furnaces.

Figure 3.4 – Residential energy use by fuel type and number of households, 1990 and 2010



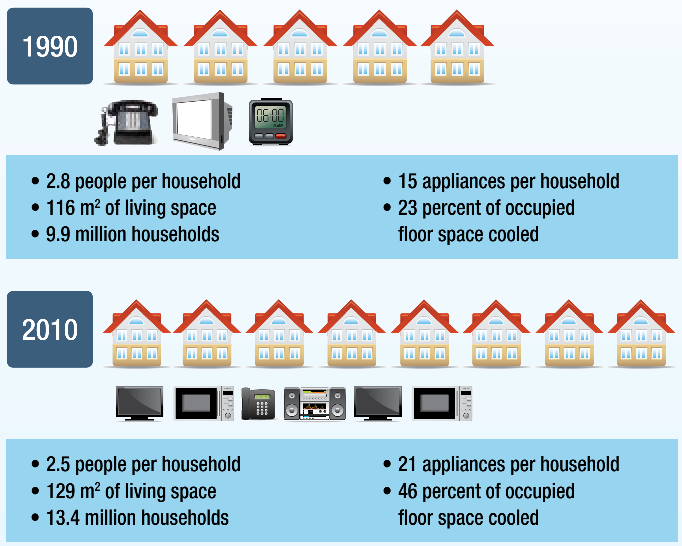
* "Other" includes coal and propane.

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 2010 was 11 percent greater than that in 1990. Specifically, average occupied living space in 1990 was 116 square metres (m^2) compared to 129 m^2 of living space in 2010 (Figure 3.5). At the same time, the number of individuals per household fell to 2.5 in 2010 from 2.8 in 1990. This trend, coupled with population growth, has meant more dwellings built and therefore more energy consumed.

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

Figure 3.5 – Residential energy indicators, 1990 and 2010

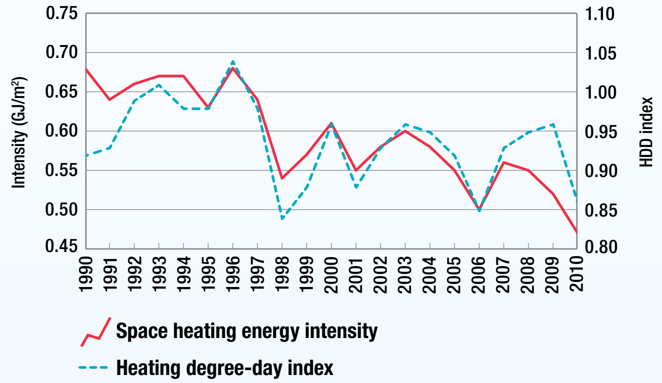


Trends – Residential space heating energy use

Despite a 30.7 percent decline in space heating energy intensity (GJ/m²), total space heating energy use increased 4.3 percent between 1990 and 2010.

The amount of energy used by the residential sector to heat each square metre of living space decreased significantly between 1990 and 2010. The decrease in space heating intensity from 0.68 gigajoules per square metre (GJ/m^2) to 0.47 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, 1990–2010



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 2010, the proportion of medium- and high-efficiency gas furnaces installed in Canadian houses climbed from 9 percent to 91 percent of the gas heating system market. Although there were few medium-efficiency oil heating systems in 1990, almost all oil heating systems were medium-efficiency by 2010.

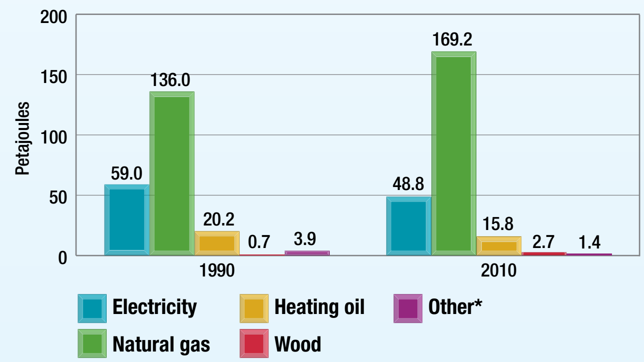
Although space heating intensity decreased 30.7 percent, this was not enough to compensate for the fact that the number of households increased 35 percent. Additionally, the average Canadian home was larger in 2010 than it was in 1990. Consequently, the energy required to heat all the dwellings in Canada increased 4.3 percent from 816.6 PJ in 1990 to 851.5 PJ in 2010, which accounted for approximately 63 percent of all residential energy use.

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 and a decline in household size.

More 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, combined with a decrease in household size, resulted in a 19.9 percent decrease in the energy used per household for heating water (from 22.2 GJ per household in 1990 to 17.8 GJ per household in 2010).

Figure 3.7 – Water heating energy use by fuel type, 1990 and 2010



* "Other" includes coal and propane.

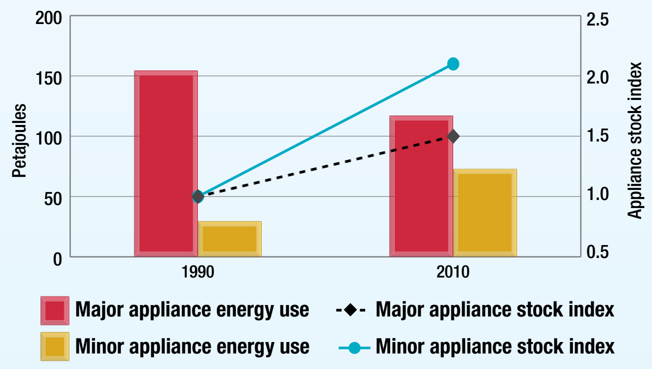
Although there was a decrease in per household energy used to heat water, the total number of households grew more quickly than energy efficiency improvements from new equipment. The result was an overall increase of 8.2 percent in residential water heating energy use, from 219.8 PJ to 237.9 PJ. In 2010, 17 percent of the residential energy demand was used for water heating.

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 2010 increased 48.2 percent (Figure 3.8). However, the total amount of energy that households used to power major appliances decreased 24.2 percent over the same period due to energy efficiency improvements. In fact, the average unit energy use of all major household appliances decreased noticeably from 1990 to 2010.

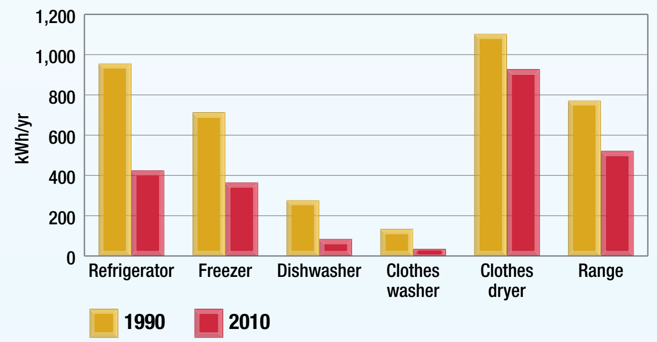
Figure 3.8 – Residential energy use and appliance stock index by appliance type, 1990 and 2010



The largest percentage decrease was in the unit energy use of clothes washers (Figure 3.9), which in 2010 used 74.1 percent less energy than in 1990 (from 134 kilowatt hours per year [kWh/yr] to 35 kWh/yr).[5] A new fridge in 1990 used an average of 956 kWh/yr versus 425 kWh/yr in 2010, a decrease of 55.6 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 2010. This increase of 43.5 PJ was equivalent to the energy required to provide lighting to all the Canadian homes in mid-1980s.

Figure 3.9 – Unit energy consumption for new major electric appliances, 1990 and 2010



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 (+147.6 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 2010 they were present in more than four out of five households in Canada. Furthermore, the rapid penetration of digital televisions, DVDs and digital cable boxes also contributed to the increase.

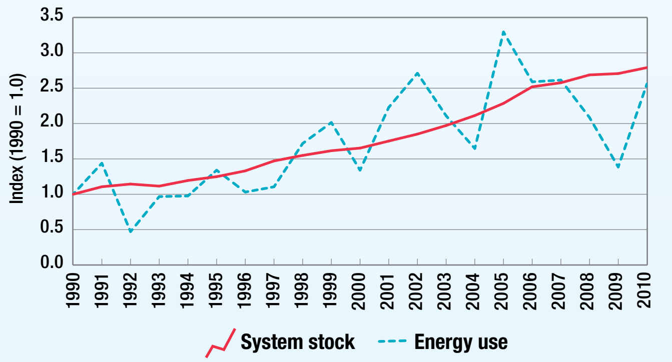
[5] Excludes hot water requirements.

Trends – Space cooling energy use

More Canadians lived in bigger and air-conditioned homes.

The amount of occupied floor space with air conditioners rose to 788 million m^2 in 2010, from 267 million m^2 in 1990. The percentage of occupied floor space cooled rose from 23 percent in 1990 to 46 percent in 2010. Because of that and the fact that the summer in 2010 was much hotter than that in 1990, the energy required to cool Canadian homes rose 155.9 percent (Figure 3.10), from 10.4 PJ to 26.5 PJ over the same period.

Figure 3.10 – Space cooling system stock and energy use, 1990–2010



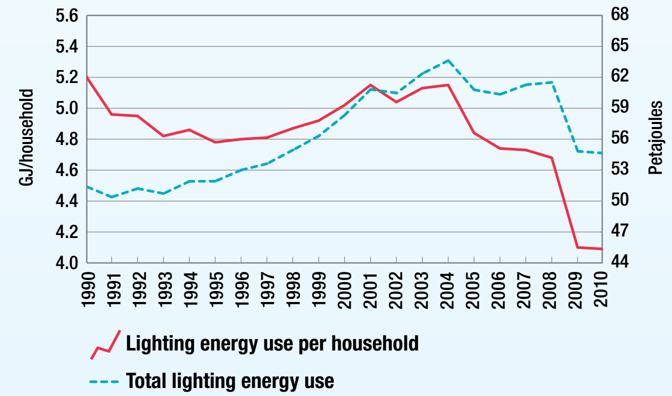
The increase in energy used for space cooling would have been more profound if not for efficiency improvements associated with room and central air conditioners. Compared to 1990, the stock of room and central air conditioners in 2010 were 50 and 28 percent more efficient, respectively.

Trends – Lighting energy use

The market share of energy-efficient lighting alternatives increased significantly between 1990 and 2010.

Despite a drop in lighting energy use per household, the energy required to light all the households in Canada increased 6.2 percent, from 51.6 PJ to 54.8 PJ (Figure 3.11). This was entirely due to the 35 percent increase in the number of households, as the energy required to light each household in Canada decreased 21.4 percent, from 5.2 GJ to 4.1 GJ.

Figure 3.11 – Lighting energy use per household and total lighting energy use, 1990–2010



Some of the decrease in lighting energy use per household can be associated with the increased use of compact fluorescent lamps (CFLs), also known as compact fluorescent light bulbs (Figure 3.12), which use less energy to produce a certain level of light. The use of CFLs was marginal in the residential lighting market before 2000, but CFLs represented around 27 percent of light bulbs used in 2010.

Figure 3.12 – Number of light bulbs per household by bulb type, 1990 and 2010

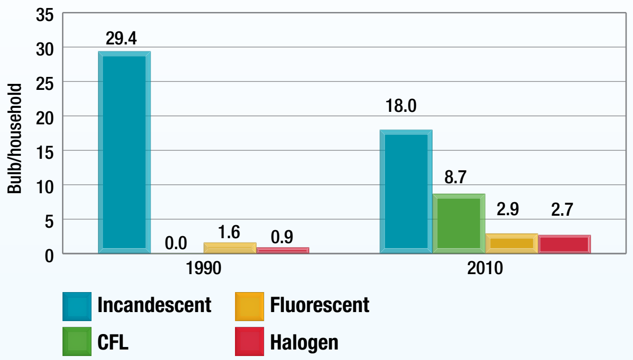
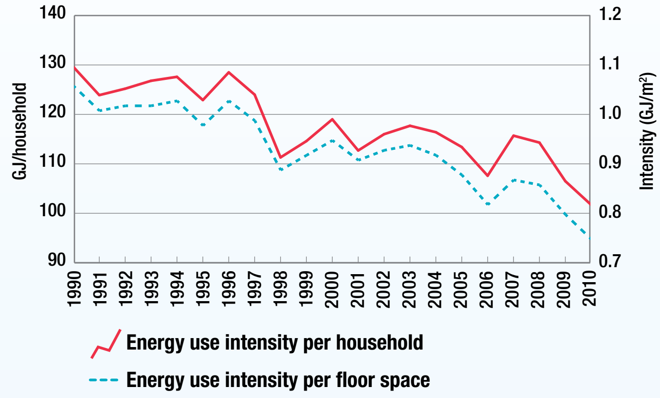


Figure 3.13 – Residential energy intensity per household and floor space, 1990–2010



Residential energy intensity and efficiency

Energy intensity

The average household has reduced its energy use by 21.5 percent since 1990.

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 21.5 percent, from 129.6 GJ per household in 1990 to 101.7 GJ in 2010 (Figure 3.13). This occurred despite the average household operating more appliances, its living space becoming larger and increasing its use of space cooling. Energy use per square metre decreased even more, 29.4 percent, from 1.06 GJ to 0.75 GJ.

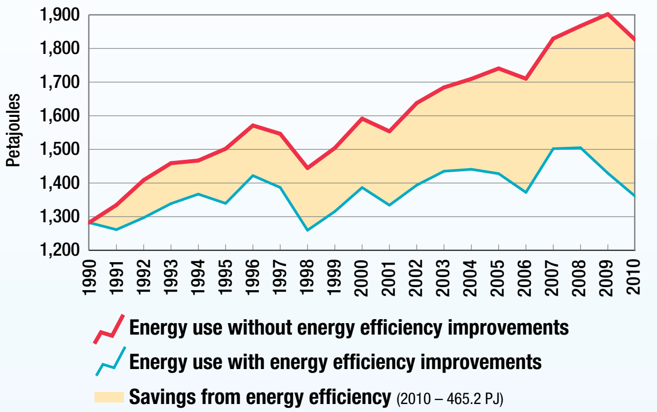
Energy efficiency

Energy efficiency improvements resulted in energy savings of $9.0 billion in the residential sector in 2010.

Energy efficiency improvements in the residential sector have resulted in significant savings between 1990 and 2010. These improvements include changes to the residential thermal envelope (insulation, windows, etc.) and changes to the efficiency of energy-consuming items in the home, such as furnaces, appliances, lighting and air conditioning.

Energy efficiency in the residential sector improved 36 percent from 1990 to 2010, allowing Canadians to save 465.2 PJ of energy (Figure 3.14) and $9.0 billion in energy costs in 2010.

Figure 3.14 – Residential energy use, with and without energy efficiency improvements, 1990–2010

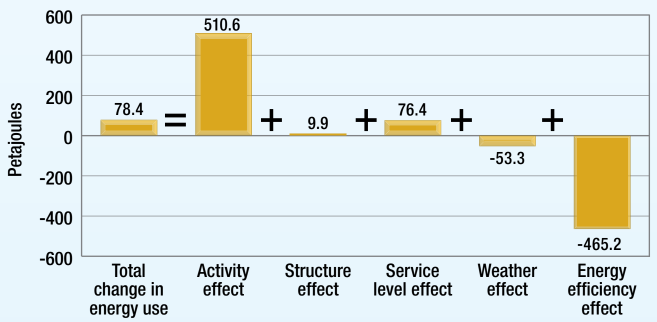


These energy efficiency savings translate into an average savings of $672 per Canadian household in 2010.

Figure 3.15 illustrates the influence that various factors had on the change in residential energy use between 1990 and 2010. These effects are as follows:

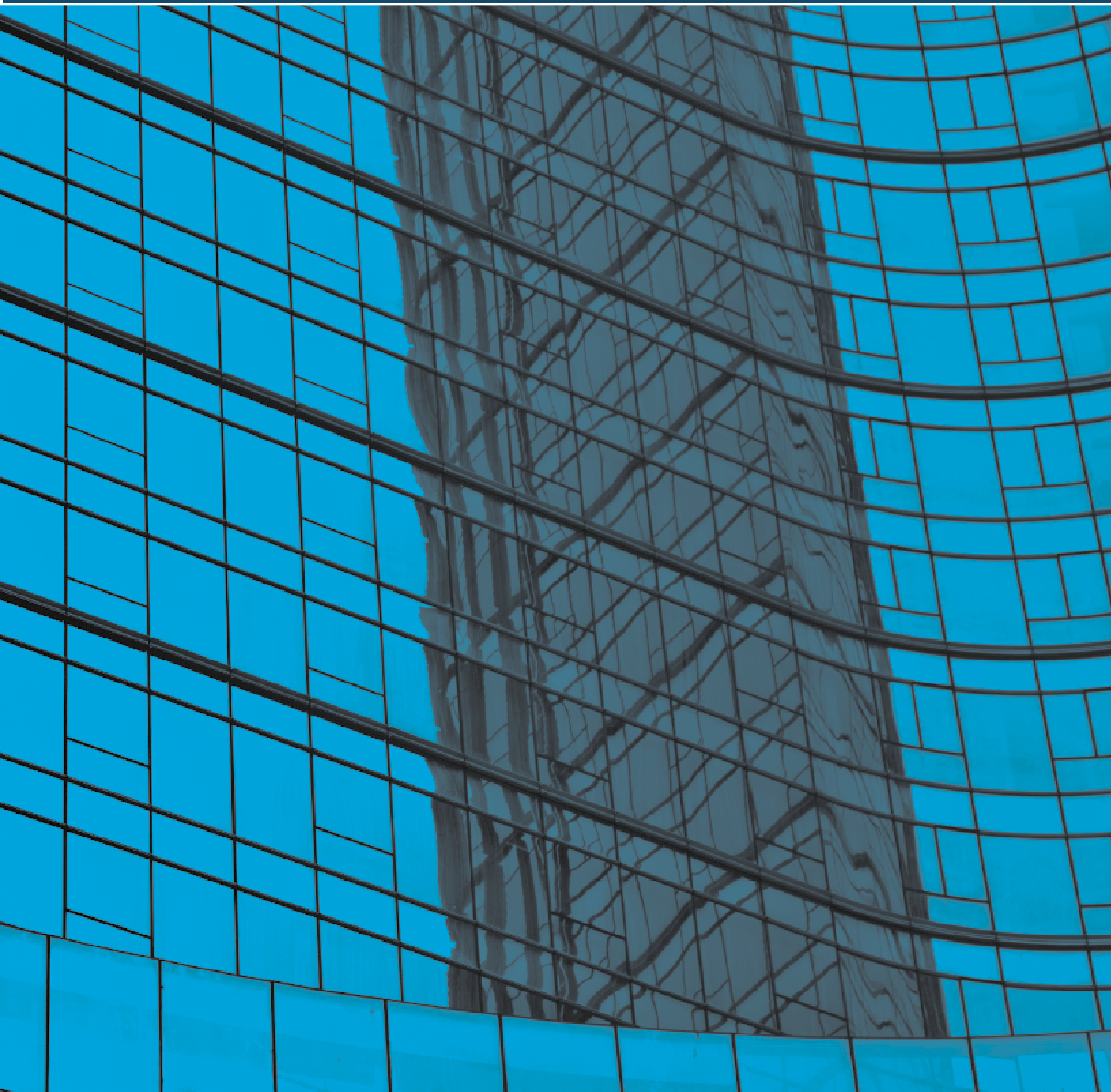
- **activity effect** – As measured by combining a mix of households and floor space, energy use increased 39.8 percent (510.6 PJ), and GHG emissions increased by 25.6 Mt. Growth in activity was driven by a 50.4 percent increase in floor area and by a rise of 35.2 percent in the number of households.
- **structure effect** – The increase in the relative share of single-family houses resulted in the sector using an additional 9.9 PJ of energy and emitting 0.5 Mt more GHGs.
- **weather effect** – In 2010, the winter was warmer and the summer was hotter than in 1990. The net result was an overall decrease in energy demand of 53.3 PJ and a 2.7-Mt reduction in GHGs.
- **service level effect** – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 76.4 PJ of the increase in energy use and a 3.8-Mt increase in GHGs.
- **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 465.2 PJ of energy and 23.4 Mt of GHG emissions.

Figure 3.15 – Impact of activity, structure, weather and energy efficiency on the change in residential energy use, 1990–2010



Commercial/ institutional sector

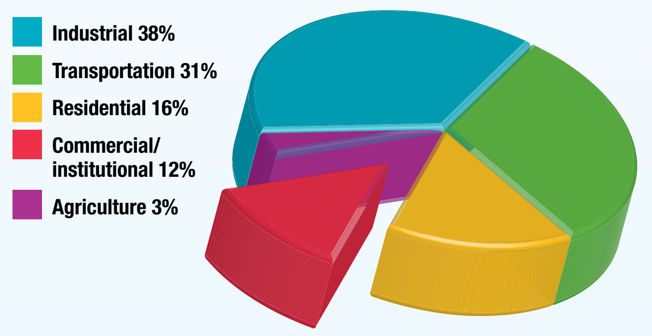
Chapter 4



Overview – Commercial/institutional energy use and GHG emissions

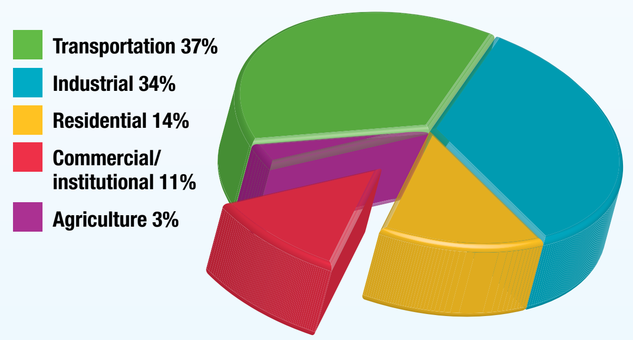
In Canada, floor space for the entire commercial/institutional sector is equivalent to about 40 percent of the total residential floor space.

Figure 4.1 – Secondary energy use by sector, 2010



In 2010, commercial business owners and institutions spent $23 billion on energy to provide services to Canadians. This represents approximately 3 percent of the value of GDP related to this sector. In 2010, this sector was responsible for 12 percent of the total energy use (Figure 4.1) in Canada and produced 11 percent of the associated GHG emissions (Figure 4.2).

Figure 4.2 – GHG emissions by sector, 2010



This edition includes adjustments made to the *Report on Energy Supply and Demand in Canada* (RESD), which is used to produce this report. These adjustments consist of integrating the results of the *Survey of Secondary Distributors of Refined Petroleum Products* (SSDRPP) of 2010 into the RESD.

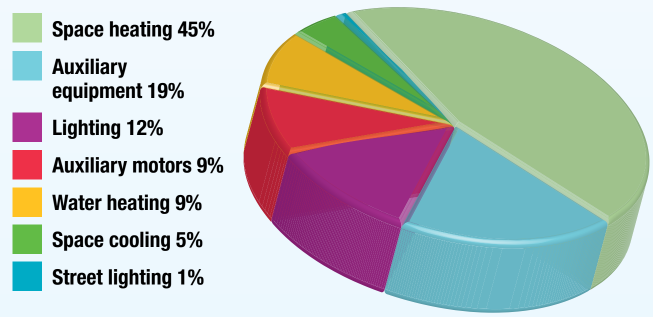
In recent *Energy Efficiency Trends in Canada* publications, the Office of Energy Efficiency (OEE) reported some anomalies in petroleum products data for the commercial and institutional sector. In particular, there was a sharp increase in consumption of these products since 1999. Some heavy fuel oil, light fuel oil and kerosene might have been erroneously attributed to the commercial sector. There was some evidence that fuel marketers (included in the commercial/institutional sector) buy petroleum products from refineries and sell it to other sectors (e.g. industrial and transportation).

To help account for this activity, NRCan and Environment Canada sponsored Statistics Canada to conduct the SSDRPP. Statistics Canada conducted the survey, then used the results to adjust the RESD for petroleum products including revisions to 2000. As a result, a significant decrease in petroleum products, especially heavy fuel oil, has been noticed in the commercial and institutional sector.

Statistics Canada also revised the RESD by integrating the new Industrial Consumption of Energy (ICE) survey back to 1995. However, this particular change has not had a significant impact on the commercial and institutional sector. The changes, originating from the SSDRPP, had the greatest impact on the energy breakdown when compared to the previous edition.

In the commercial/institutional sector,[6] energy is used for different purposes, such as space heating, cooling, lighting and water heating, as well as for operating auxiliary equipment (such as computers) and motors. Space heating accounts for the largest share of energy use, with about 45 percent, followed by auxiliary equipment at 19 percent, which keeps increasing from year to year because of the need for new technologies (Figure 4.3). Street lighting is included in total energy but it is excluded from the factorization analysis because it is not associated with floor space activity.

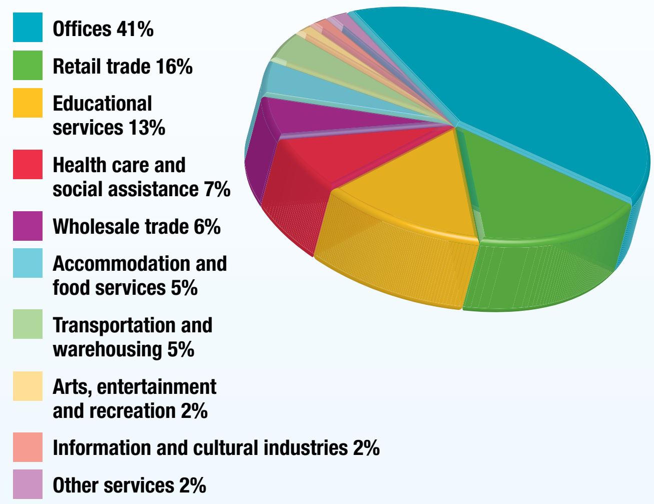
Figure 4.3 – Commercial/institutional energy use by end-use, 2010



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

Offices, retail trade and educational services account for 70 percent of the total Canadian commercial/institutional floor space, which in 2010 was estimated at 717.1 million m^2.

Figure 4.4 – Commercial/institutional floor space by activity type, 2010



Trends – Commercial/institutional energy use and GHG emissions

In 2010, the commercial/institutional sector consumed 22 percent less energy than the residential sector but it grew more than three times faster than this sector between 1990 and 2010.

From 1990 to 2010, total commercial/institutional energy use increased 22 percent, from 867.0 PJ to 1,057.3 PJ, including street lighting. At the same time, GDP for the commercial/institutional sector grew 77 percent and floor space grew 41 percent. The GHG emissions associated with the sector's energy use, including electricity-related emissions, increased 15 percent over the same period.

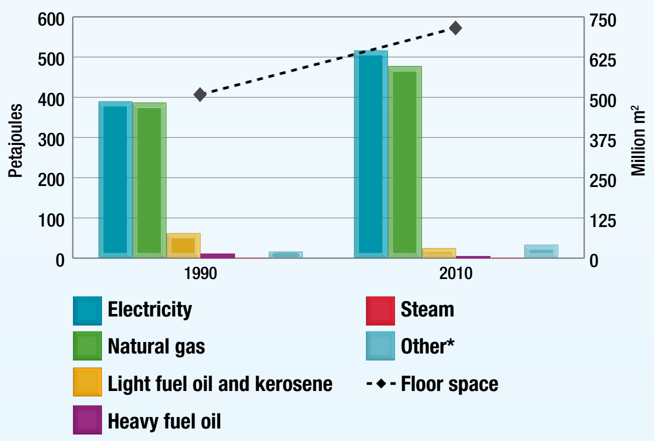
Natural gas and electricity are the main energy sources used for the commercial/institutional sector (Figure 4.5), accounting for about 45 and 49 percent of total energy use of the sector, respectively. Electricity is the primary energy source for lighting, space cooling, auxiliary motors

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

and equipment. Natural gas and the remaining fuels are the primary energy sources for space and water heating. However, natural gas and propane are also used, within a small proportion, to provide energy for auxiliary equipment, such as the propane for stoves and natural gas for space cooling services.

The petroleum products, such as light and heavy fuel oil, combined represented 6 percent of the total energy use in the commercial/institutional sector in 2010.

Figure 4.5 – Commercial/institutional energy use by fuel type and floor space, 1990 and 2010



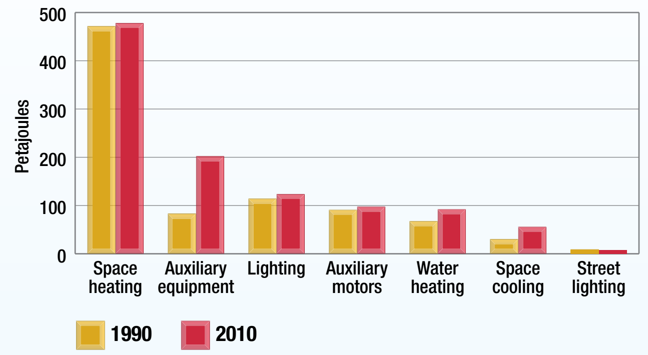
* "Other" includes coal and propane.

The rapid expansion of new technologies increased the use of electronic equipment in all subsectors activities of the commercial and institutional sector in Canada since 1990.

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

Space heating continues to be the primary end-use in the sector while auxiliary equipment use has shown a large increase in energy requirement (143 percent) resulting, in part, from increasing computerization of all work spaces related to commercial and institutional activities (Figure 4.6).

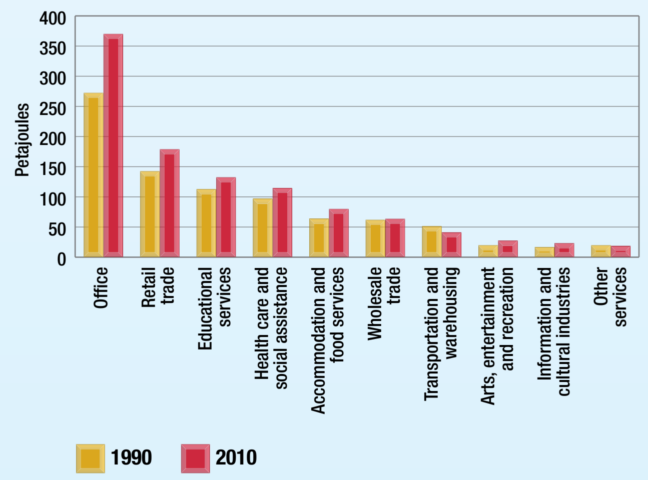
Figure 4.6 – Commercial/institutional energy use by end-use, 1990 and 2010



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 2010 (35 percent). This subsector includes public administration and activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and other offices. Retail trade (17 percent) and educational services (13 percent) were the next largest users. Offices also had the largest increase in energy consumption, using 98 PJ more energy in 2010 than in 1990, followed by retail trade and educational services, which saw increases of 36 and 20 PJ, respectively.

Figure 4.7 – Commercial/institutional energy use by activity type, 1990 and 2010



Thirteen million people worked in Canada's commercial/institutional sector in 2010.[7]

Several indicators can help explain the growth in energy use in the commercial/institutional sector, including the number of employees, floor space and GDP. Figure 4.8 shows that floor space had increased 41 percent since 1990 and the number of employees in this sector had increased 43 percent.

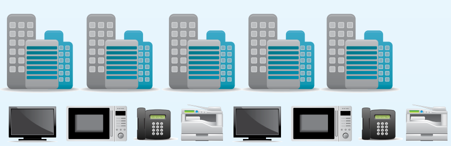
While some gains in energy efficiency were made in terms of overall energy use per floor space, this was offset by an increase in energy requirements for auxiliary equipment. There was not only an overall increase in computerization of the work environment in the commercial/institutional sector during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

Figure 4.8 – Commercial/institutional energy indicators, 1990 and 2010

1990

- Floor space: 509.9 million m^2
- Employees: 9 million
- GDP: $477 billion ($2002)

2010



- Floor space: 717.1 million m^2
- Employees: 13 million
- GDP: $847 billion ($2002)

Commercial/institutional energy intensity and efficiency

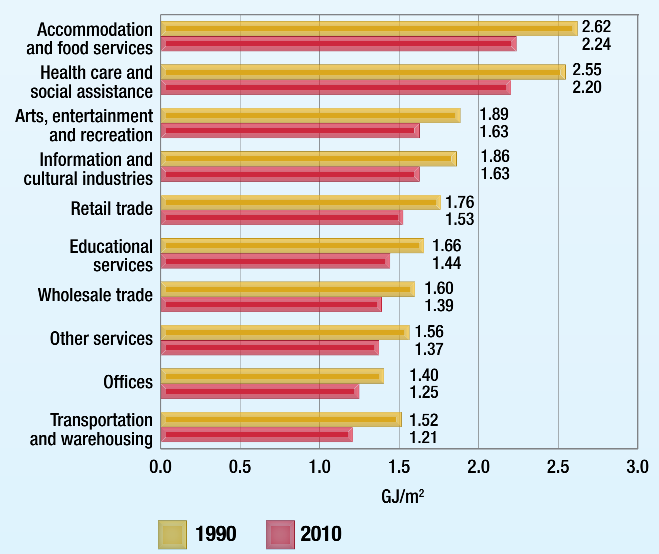
Energy intensity

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).

As shown in Figure 4.9, accommodation and food services consumed 2.24 GJ/m^2 in 2010, followed by health care and social assistance activities, which consumed 2.20 GJ/m^2. They are the most energy-intensive activity types despite a 15 and 13 percent decrease observed in the energy intensity of these respective subsectors. 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 new technologies, which translates into the proliferation of the amount of electronic equipment, such as medical equipment.

Figure 4.9 – Commercial/institutional energy intensity by activity type, 1990 and 2010



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

4 Commercial/institutional sector

The commercial/institutional sector as a whole experienced a 13 percent decrease in energy intensity in terms of energy consumed per unit of floor space (GJ/m^2). However, the sector reduced its energy intensity by 31 percent when measured against economic activity (PJ/GDP).

Energy efficiency

Energy efficiency improvements in Canada have resulted in energy savings of $5.6 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 resulted in a 256.1-PJ energy savings for this sector between 1990 and 2010 (Figure 4.10).

Figure 4.10 – Commercial/institutional energy use, with and without energy efficiency improvements, 1990–2010

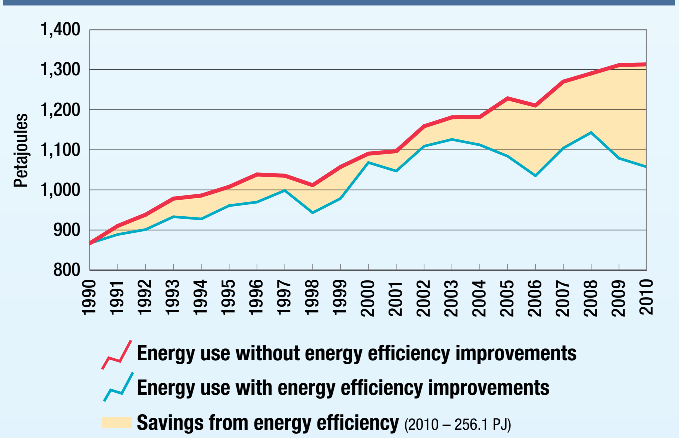
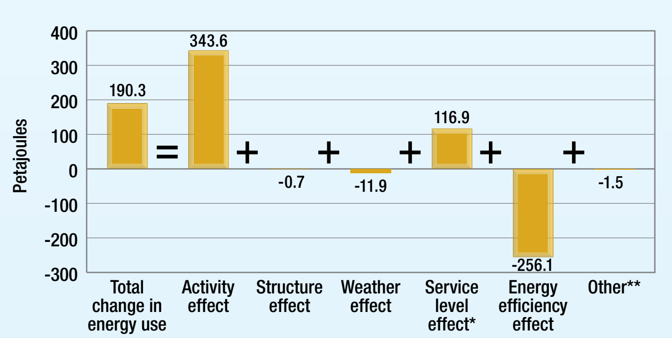


Figure 4.11 illustrates the influence that various factors had on the change in commercial/ institutional sector energy use between 1990 and 2010. These effects are as follows:

- **activity effect –** A 41 percent increase in floor space led to a 343.6-PJ growth in energy use and a 17.8-Mt increase in GHG emissions.
- **structure effect –** The effect of structure changes in the sector (the mix of activity types) was small and thereby had marginal effect on change in GHG emissions.
- **weather effect –** In 2010, the winter was warmer and the summer was hotter than in 1990. The net result was an 11.9-PJ decrease in energy demand in the commercial/institutional sector, which had the effect of decreasing GHG emissions by 0.6 Mt.
- **service level effect –** An increase in the service level of auxiliary equipment, such as the penetration rate of office equipment (e.g. computers, fax machines and photocopiers), led to a 116.9-PJ increase in energy use and a 6.0-Mt increase in GHG emissions.
- **energy efficiency effect –** Improvements in the energy efficiency of the commercial/ institutional sector saved 256.1 PJ of energy and 13.2 Mt of GHG emissions.

Figure 4.11 – Impact of activity, structure, weather, service level and energy efficiency on the change in commercial/ institutional energy use, 1990–2010

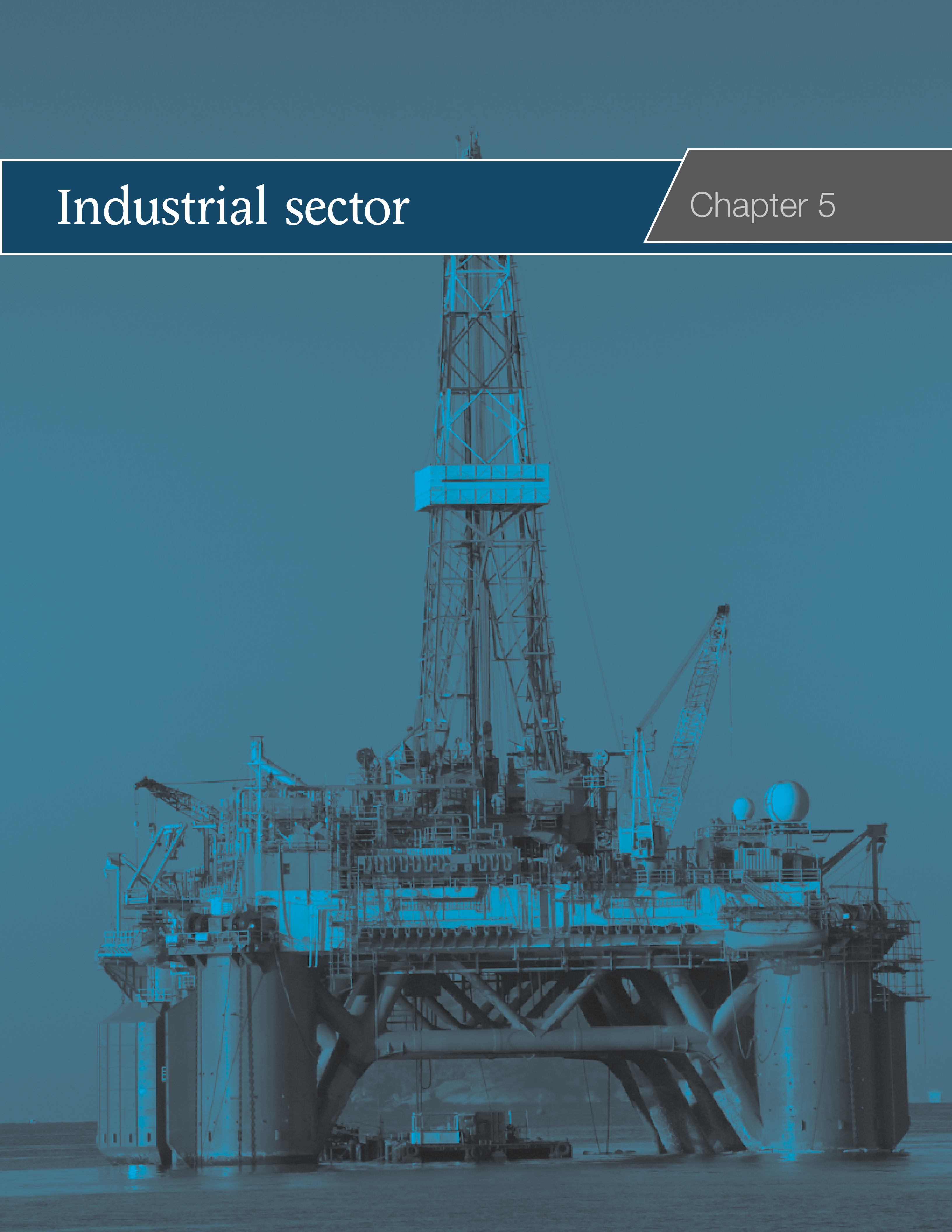


* "Service level effect" refers to the increased use of auxiliary equipment and office equipment.

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

Industrial sector

Chapter 5



Overview – Industrial energy use and GHG emissions

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

The industrial sector includes all manufacturing, mining, forestry and construction activities. In 2010 alone, these industries spent $36.9 billion for energy. Total energy use by industry accounted for 38 percent of the total energy use (see Figure 5.1) and 34 percent of end-use GHG emissions (see Figure 5.2).

Figure 5.1 – Secondary energy use by sector, 2010

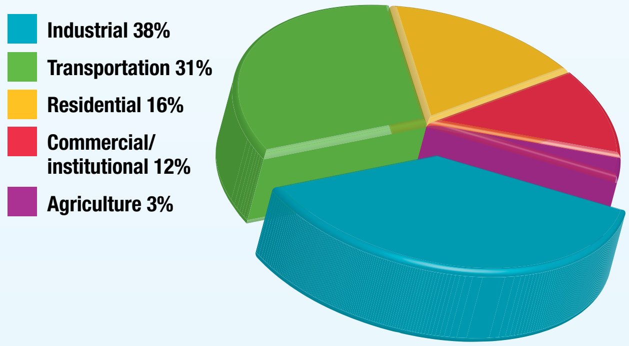
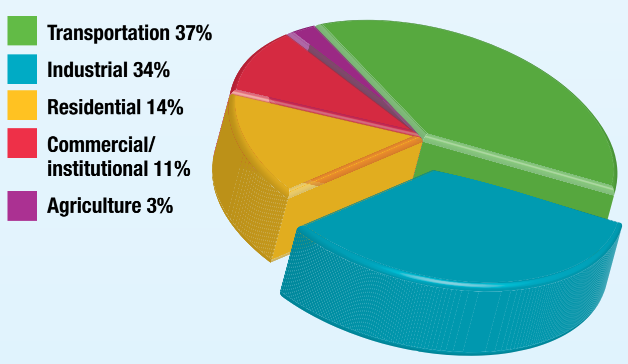


Figure 5.2 – GHG emissions by sector, 2010



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

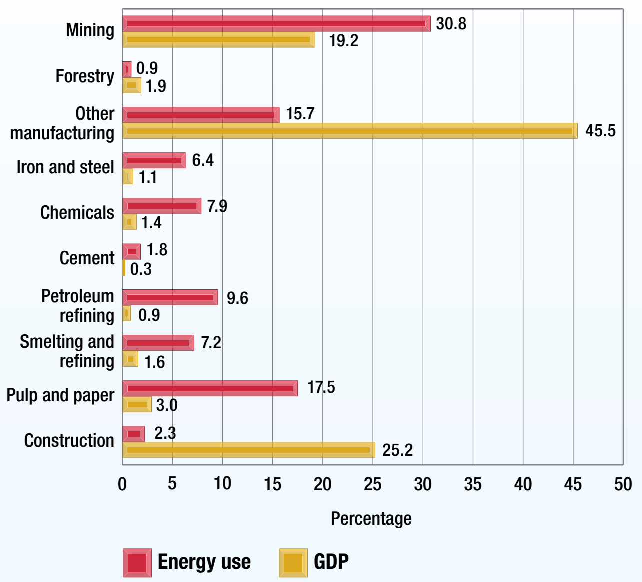
In 2010, the industrial sector's share of GDP accounted for 24 percent of the Canadian total (excluding agriculture). The main contributor to industrial GDP was "other manufacturing," which includes the food and beverage, textile, computer and electronic industries among others. Construction and mining were the only other two industries that contributed more than 10 percent to the industrial sector's GDP (see Figure 5.3).

Although GDP is an indicator of economic activity, a notable characteristic of the industrial sector is that the industries with the highest activity level do not necessarily use the most energy. For example, the pulp and paper industry is responsible for 18 percent of industrial energy use, but only 3 percent of economic activity. In contrast, an industry such as construction is responsible for 25 percent of the economic activity, but only 2 percent of industrial energy use (see Figure 5.3).

Capacity utilization

During the recession of 2008–2009, energy intensity increased 6.6 percent while industrial capacity utilization fell from 77.5 percent to 71.4 percent. This highlighted the need to include capacity utilization in our factorization analysis of Canadian industry. While we currently lack the data to conduct this analysis at a detailed level, we were able to factor out the capacity utilization effect at the aggregate level. The results are presented in this chapter.

Figure 5.3 – Distribution of energy use and activity by industry, 2010



Variation of fuel use by industry

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

Natural gas and electricity were the main fuels used in the industrial sector in 2010, meeting 34 percent and 22 percent, respectively, of the energy needs of the sector. Wood waste and pulping liquor (13 percent) and still gas and petroleum coke (15 percent) were the other most used fuel types.

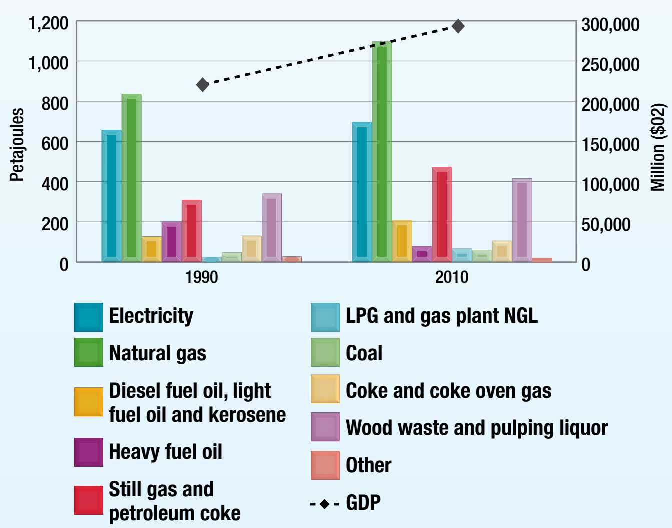
The type of energy used varies greatly depending on the industries in which it is used. Although electricity is used across the entire sector, it is the smelting and refining industry that requires the most electricity, accounting for almost 27 percent of the sector's electricity use.

Wood waste and pulping liquor are primarily used 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 2010, industrial energy use increased 19 percent, from 2,710.0 PJ to 3,227.6 PJ. The associated end-use GHGs increased 20 percent; from 138.1 Mt to 165.9 Mt. GDP increased 33 percent from $221 billion ($2002) in 1990 to $294 billion ($2002) in 2010 (see Figure 5.4).

Figure 5.4 – Industrial energy use by fuel type and GDP, 1990 and 2010



In most cases, fuel shares remained relatively constant between 1990 and 2010 as fuel consumption increased for most fuel types during this period. The exceptions were heavy fuel oil (HFO), which experienced a 61 percent decrease, and coke and coke oven gas, which decreased 20 percent.

One reason for the decline in use of HFO was that the pulp and paper industry, the largest user of HFO, adopted alternate forms of fuels such as pulping liquor. Fuel switching was facilitated by the use of interruptible contracts, with energy suppliers allowing the industry to react to changes in relative prices of fuels. In 2009, the Government of Canada created the Pulp and Paper Green Transformation Program (PPGTP),[8] which offered pulp and paper mills funding of $0.16/litre of black liquor burned.

Forestry, mining, and smelting and refining have all experienced large growth in energy use since 1990. However, forestry consumes proportionately less energy than mining and smelting and refining. The trends for these main contributors to energy demand are now described in greater detail, along with the trends for the pulp and paper industry and other manufacturing.

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.[9]

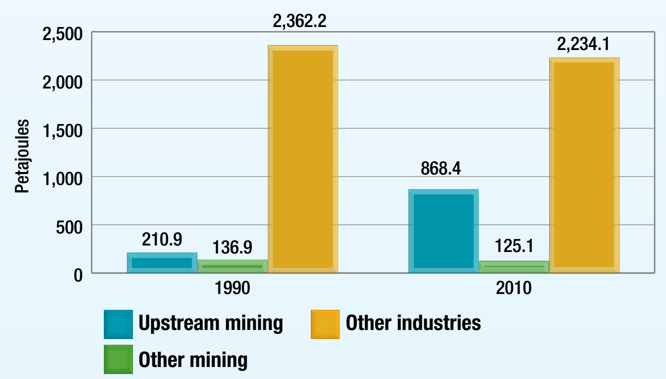
Since 1990, the mining industry's energy consumption and its associated end-use emissions both grew 186 percent. The GDP of the mining industry increased 45 percent over the 1990–2010 period, from $38.9 billion ($2002) to $56.5 billion ($2002), compared to a 33 percent increase for the entire industrial sector.

Upstream mining was the biggest contributor to mining's GDP, representing 90 percent ($50.6 billion) in 2010. 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 that have lowered production costs and by additional revenue from higher crude oil prices.

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 232,000 m^3/day by 2010. This increase is the principal factor explaining the increase of 312 percent in the energy used by the upstream mining industry since 1990 (see Figure 5.5).

Figure 5.5 – Industrial energy use by selected industry, 1990 and 2010



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

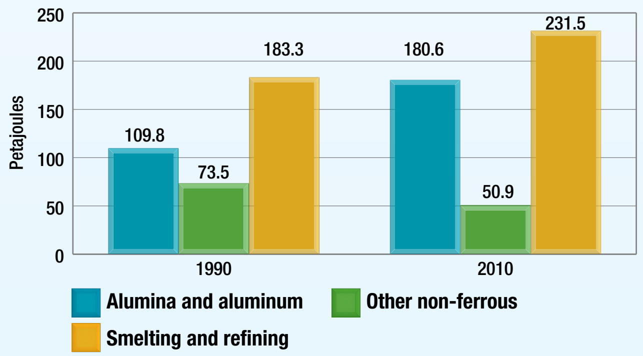
[9] NAICS code 21 excluding 213118, 213119 and part of 212326

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 was mainly driven by economic growth, as the GDP increased from $2.8 billion ($2002) in 1990 to $4.7 billion ($2002) in 2010 – a 68 percent increase. During the same period, associated GHG emissions increased 17 percent.

Figure 5.6 – Smelting and refining energy use by selected industry, 1990 and 2010



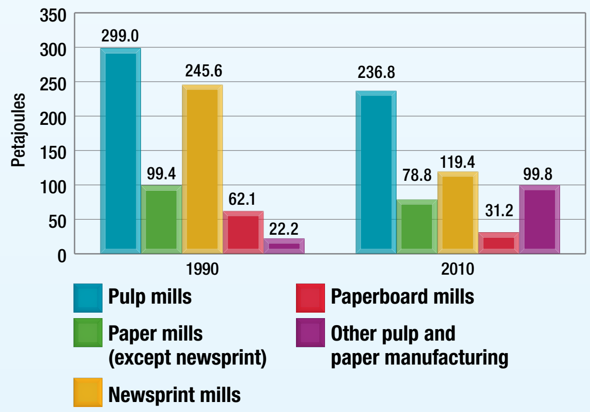
The production of aluminum grew 89 percent between 1990 and 2010 and is responsible for most of the 65 percent growth in energy use in this subsector since 1990 (see Figure 5.6).

Trends – Pulp and paper energy use and GHG emissions

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

Pulp and paper production decreased its energy use by 22 percent since 1990, and now represents 18 percent of sectoral energy use. The largest decline came from the newsprint mill industry, with a 51 percent decrease since 1990 (see Figure 5.7). GHG emissions decreased 49 percent since 1990 for the sector as a whole.

Figure 5.7 – Energy consumption by subsector of the pulp and paper industry, 1990 and 2010



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 decreased from 551.1 PJ to 506.5 PJ between 1990 and 2010. GHG emissions declined from 28.5 Mt to 22.3 Mt, while GDP increased from $102.3 billion ($2002) to $133.7 billion ($2002) since 1990.

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

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

The wood products industry represented 10 percent of the other manufacturing subsector's energy use with 50.6 PJ. Its average annual increase is 0.7 percent.

This year, data from the Industrial Consumption of Energy survey was integrated into the *Report on Energy Supply and Demand* (RESD) from 1995 onward. As a result, some energy use that was previously attributed to "other manufacturing" is now allocated to the other industries in the manufacturing sector.

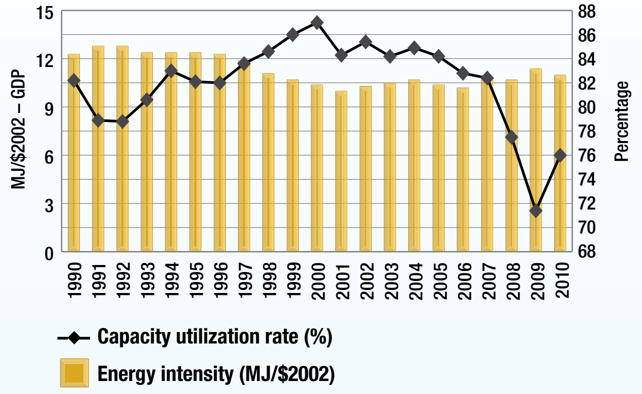
Industrial energy intensity and efficiency

Energy intensity

Several factors influenced the trends in energy use and energy intensity. Since 1990, energy intensity decreased at an average annual rate of 0.5 percent, from 12.3 MJ/$2002 – GDP in 1990 to 11.0 MJ/$2002 – GDP in 2010 (see Figure 5.8). Note that between 2009 and 2010, energy intensity decreased 3.3 percent, while capacity utilization rose 6.4 percentage points to 76.0 percent. This is still below the pre-recession 82.4 percent capacity utilization[10] seen in 2007.

[10] The rates of capacity use are measures of the intensity with which industries use their production capacity. Capacity use is the percentage of actual to potential output.

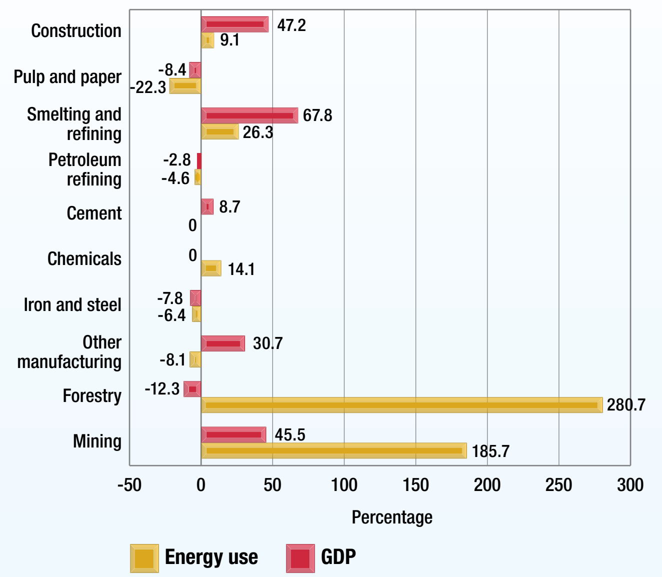
Figure 5.8 – Capacity utilization and energy intensity per year



At the aggregate industry level, 6 of the 10 industries reduced their energy intensity[11] over the 1990 to 2010 period. Four industries experienced an increase: mining, chemical manufacturing, forestry, and iron and steel. The biggest increase in energy intensity was 133 percent in forestry. Figure 5.9 illustrates that energy use in forestry increased 281 percent, while GDP fell 12 percent. In the mining sector, the move toward unconventional crude oil production contributed to the increase in the energy intensity.

Gains in energy efficiency and a shift toward less energy-intensive activities were contributing factors in the subsectors that decreased their energy intensity. 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.

Figure 5.9 – Change in GDP and energy use, 1990–2010



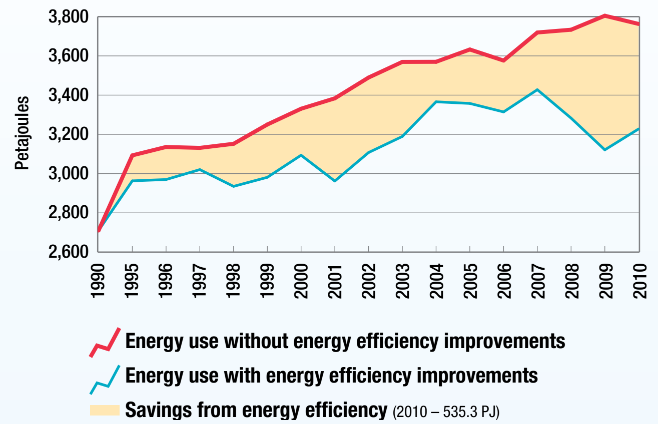
Energy efficiency

In 2010, Canadian industry saved $6.1 billion in energy costs due to energy efficiency improvements. Industry saved 535.3 PJ of energy or 27.5 Mt of GHG emissions. As indicated earlier, this year's analysis incorporates an assessment of the influence of variation in capacity utilization.[12]

[11] MJ/($2002) – GDP

[12] See Appendix B for the definition of capacity utilization.

Figure 5.10 – Industrial energy use, with and without energy efficiency improvements, 1990–2010

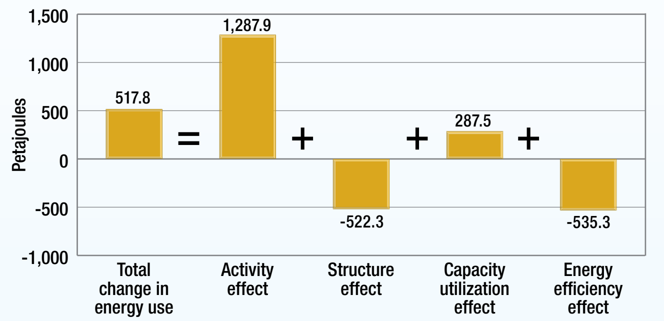


Note: 1991–1994 data are not available.

Figure 5.11 illustrates the influence that various factors had on the change in industrial energy use between 1990 and 2010. These effects are the

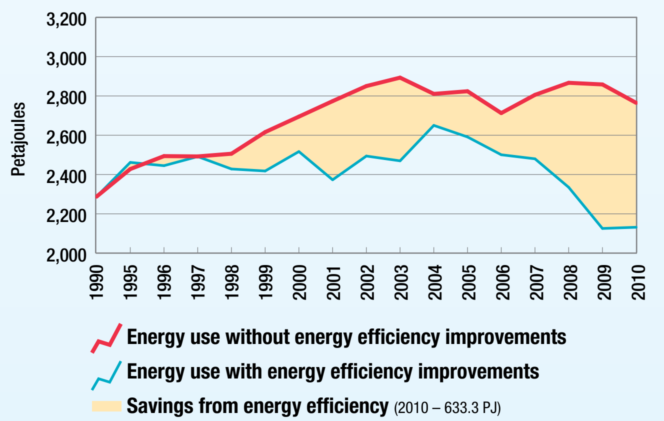
- **activity effect** – Activity (the mix of GDP, GO and production units) increased the energy use by 48 percent or 1,287.9 PJ and GHG emissions by 66.2 Mt.
- **structure effect** – The structural changes in the industrial sector, specifically, a relative decrease in the activity share of energy-intensive industries, helped the sector to reduce its energy use and GHG emissions by 522.3 PJ and 26.9 Mt, respectively.
- **capacity utilization effect** – The capacity utilization effect increased industrial energy use by 287.5 PJ and emitted 14.8 Mt more GHGs.
- **energy efficiency effect** – Improvements in the energy efficiency of the industrial sector avoided 535.3 PJ of energy use and 27.5 Mt of GHG emissions.

Figure 5.11 – Impact of activity, structure, energy efficiency and capacity utilization on the change in industrial energy use, 1990–2010



Furthermore, manufacturing energy efficiency savings grow to 633.3 PJ in 2010 if we factor out capacity utilization.

Figure 5.12 – Manufacturing energy use, with and without energy efficiency improvements, 1990–2010

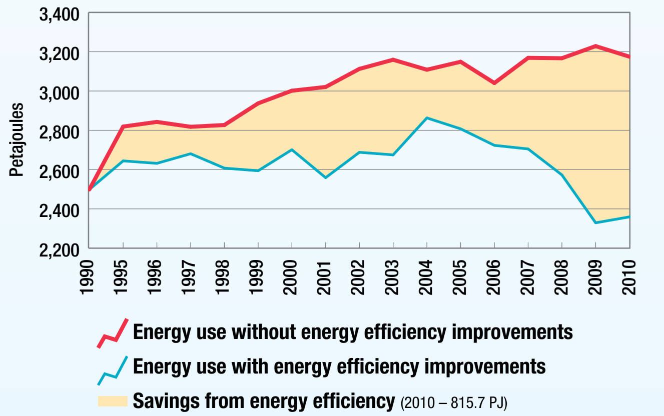


Note: 1991–1994 data are not available.

Also, to provide a better assessment of energy efficiency gains from the rest of the industry, the factorisation analysis was produced without the upstream mining sector and with capacity utilization factored out.

Without upstream mining, Canadian industries improved energy efficiency by 35 percent, which represents 815.7 PJ of savings (see Figure 5.13).

Figure 5.13 – Industrial energy use, with and without energy efficiency improvements (without upstream mining), 1990–2010

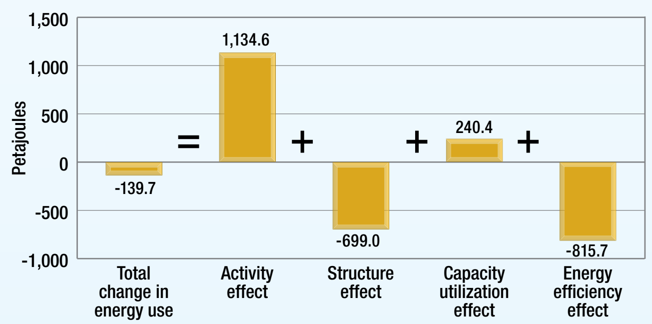


Note: 1991–1994 data are not available.

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 the energy use by 1,134.6 PJ and GHG emissions by 58.3 Mt.
- **structure effect –** The structural changes in the industrial sector helped the sector to reduce its energy use and GHG emissions by 699.0 PJ and 35.9 Mt, respectively.
- **capacity utilization effect –** The capacity utilization effect increased energy use by 240.4 PJ and emitted 12.4 Mt more GHGs.
- **energy efficiency effect –** Improvements in the energy efficiency of the industrial sector avoided 815.7 PJ of energy use and 41.9 Mt of GHG emissions.

Figure 5.14 – Impact of activity, structure, energy efficiency and capacity utilization on the change in industrial energy use (without upstream mining), 1990–2010



Transportation sector

Chapter 6

6 Transportation sector

Overview – Energy consumption and GHG emissions of the transportation sector

Though the transportation sector is second to the industrial sector in energy consumption, it was first in energy expenditure in 2010.

The transportation sector is diverse and covers several modes of transport including road, air, rail and maritime. In Canada, these modes of transport are used for transporting both people and goods. This chapter describes the energy consumption for the transportation of both these entities.

In 2010, Canadians, individuals and businesses, spent $70.7 billion on fuel for transportation, making it the largest expenditure of all the sectors in the country. This expenditure was 91 percent higher than that of the industrial sector. This can be explained by the particularly high cost of fuels compared with those of other energy sources in the other sectors.

The transportation sector comes second, at 31 percent (see Figure 6.1), in energy consumption in Canada and first, at 37 percent (see Figure 6.2), in the emission of associated greenhouse gases (GHG). This sector produces a greater portion of GHG emissions because the main fuels consumed for transportation are more GHG-intensive compared with other sectors of the economy.

Figure 6.1 Energy consumption by sector, 2010

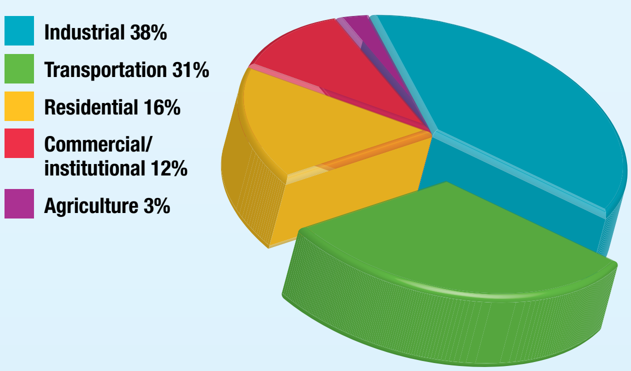
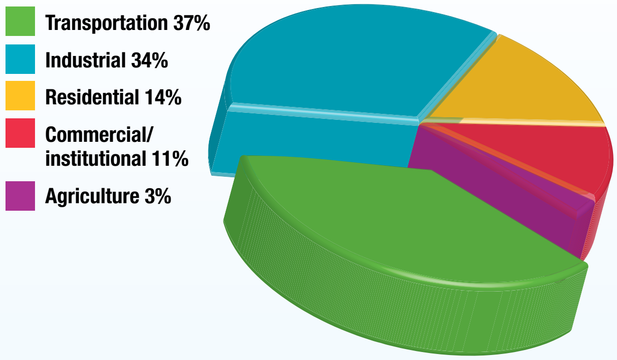
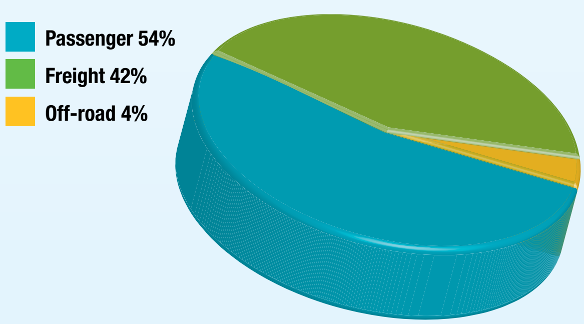


Figure 6.2 GHG emissions by sector, 2010



In this sector, the modes of passenger transportation accounted for 54 percent of the total energy consumption while the subsector of freight transportation accounted for 42 percent (see Figure 6.3). The remaining 4 percent of energy consumption was used by off-road vehicles. This category includes all the machines whose main use is not on public roads such as snowmobiles and lawn mowers. Off-road transportation has not been analyzed in this report due to the lack of data available for this category and the low share of energy consumption by off-road vehicles.

Figure 6.3 Energy consumption by subsector, 2010



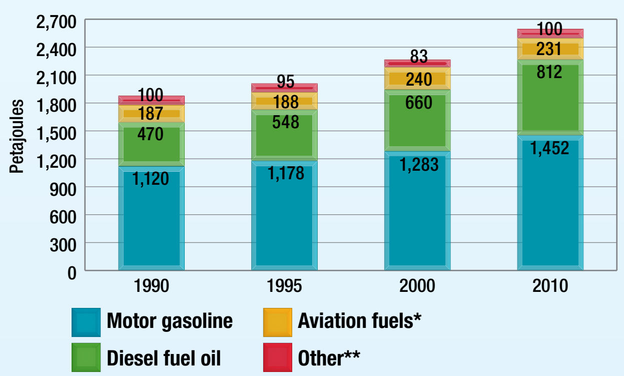
Trends – Energy consumption and GHG emissions of the transportation sector

Growth of freight transportation has increased the demand for energy in the transportation sector.

Between 1990 and 2010, the total energy consumption for the transportation sector increased 38 percent, from 1,877.9 petajoules (PJ) to 2,595.0 PJ, and associated GHG emissions increased 36 percent, from 131.4 megatons (Mt) to 179.2 Mt.

Among the subsectors, freight transportation experienced more rapid growth, representing 63 percent of the increase in energy consumption in the transportation sector. Furthermore, the growing preference to use heavy-duty trucks, which typically consume more energy compared with other modes of transportation, in itself accounts for 74 percent of the increase in energy consumption of freight transportation and 47 percent of all transportation.

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



* Aviation fuels include aviation turbine fuel and aviation gasoline.

** "Other" includes electricity, natural gas, residual fuel oils and propane.

Growth of the freight transportation sector has contributed to an increase of 73 percent in the demand for diesel fuel.

As Figure 6.4 shows, motor gasoline and diesel are the main energy types consumed in the transportation sector, representing 87 percent of the total consumption. Aviation turbine fuel, residual fuel oils, propane, aviation gasoline, electricity and natural gas are also shown in order of the quantities consumed. Motor gasoline dominates the market with 56 percent of all transportation energy, followed by diesel with 31 percent and, lastly, other energy sources accounting for 13 percent.

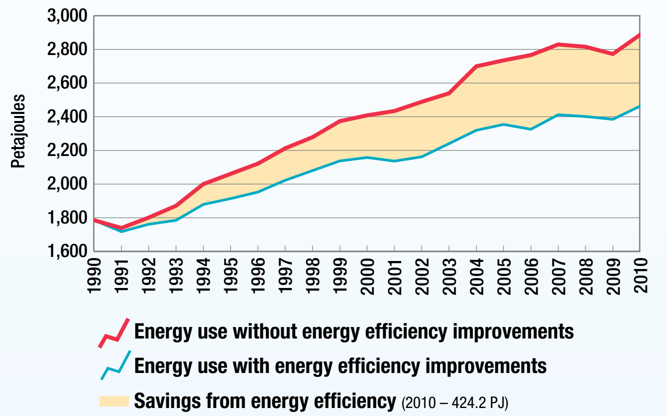
During the period from 1990 to 2010, diesel consumption increased 73 percent, particularly because of the increasing use of heavy-duty vehicles on Canadian roads, which alone contributed to 98 percent of this increase. Moreover, motor gasoline consumption increased 30 percent, with passenger vehicles and freight transportation vehicles accounting for over half (184.5 PJ) and about a third (102.4 PJ) of that figure, respectively. Consumption of aviation gasoline, propane and electricity declined over the same period.

Energy efficiency in the transportation sector

Energy efficiency improvements in the transportation sector resulted in energy savings of 424.2 PJ or $11.6 billion for Canada in 2010.

Between 1990 and 2010, energy efficiency in the transportation sector improved by 24 percent, which resulted in energy savings worth $11.6 billion, or 424.2 PJ of energy (see Figure 6.5). These savings were largely due to some energy efficiency improvements in trucks used for freight transportation and in light-duty vehicles used in passenger transportation.

Figure 6.5 – Energy consumption of the transportation sector, with and without energy efficiency improvements, 1990–2010*



Note: The presented data do not include off-road vehicles and non-commercial airline aviation.

Trends – Energy consumption and GHG emissions for passenger transportation

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

With regard to the passenger transportation subsector, energy consumption is related to passenger-kilometres (Pkm). Pkm is calculated by multiplying the number of passengers carried by the distance covered. Consequently, when two passengers are travelling in the same vehicle and are transported across a distance of 10 kilometres, it is the equivalent of 20 Pkm. When the Pkm number rises, an increase in energy consumption is normally observed, unless there have been improvements in energy efficiency to compensate for the activity increase.

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

Figure 6.6 – Energy indicators for passenger transportation, 1990 and 2010*

1990

- 14.2 million vehicles
- 19.4 percent are light trucks
- 17,632 km/year on average per vehicle
- 386.7 billion Pkm covered
- 0.68 vehicles per person aged 18 years and over

2010

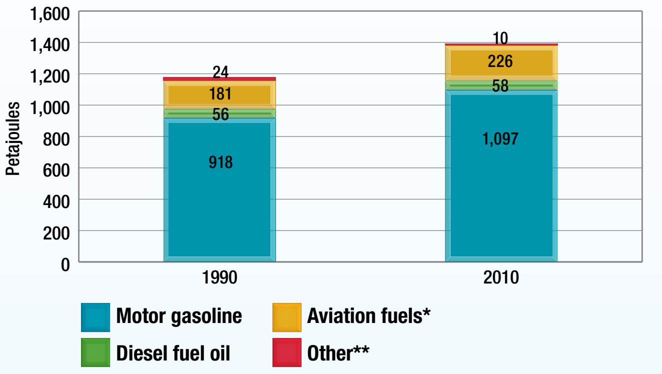
- 19.4 million vehicles
- 34.7 percent are light trucks
- 17,099 km/year on average per vehicle
- 539.1 billion Pkm covered
- 0.72 vehicles per person aged 18 years and over

* Data presented exclude air transport, transport by bus or transport by rail.

Figure 6.6 shows a slight increase in the number of vehicles per person aged 18 years and over, from 0.68 vehicles in 1990 to 0.72 in 2010. Moreover, the distance covered in Pkm by light vehicles for passenger transportation (excluding urban transportation and coaches) increased on average by 1.7 percent per year. The distance covered in Pkm for urban transportation and coaches increased on average by 1.6 percent per year between 1990 and 2010. Consequently, the market share of public transit has not shown any significant change in the past 20 years. The energy consumption for passenger transportation increased by 18 percent, from 1,179.0 to 1,390.3 PJ between 1990 and 2010. The increase in the associated GHG emissions was 15 percent, from 81.7 to 94.1 Mt.

The mix of fuels used in the passenger transportation subsector has remained relatively constant. Motor gasoline has been the main energy source, representing 79 percent of the combination of fuels used in 2010, followed by aviation turbine fuel and diesel (see Figure 6.7).

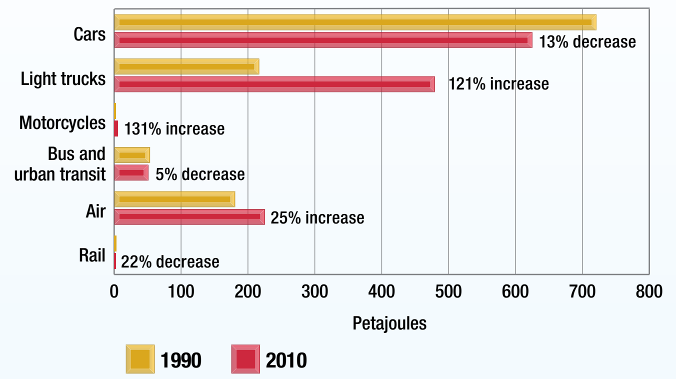
Figure 6.7 – Energy consumption for passenger transportation by fuel type, 1990 and 2010



* Aviation fuels include aviation turbine fuel and aviation gasoline.

** "Other" includes electricity, natural gas, residual fuel oils and propane.

Figure 6.8 – Energy consumption for passenger transportation by mode of transportation, 1990 and 2010



More Canadians are driving minivans and sport utility vehicles.

The choices made by Canadians to meet their transportation needs are contributing to an increase in energy consumption. A growing number of Canadians bought light trucks (including minivans and sport utility vehicles [SUVs]) rather than vehicles that have better ranking in fuel consumption. In 2010, light-truck sales comprised 46 percent of new vehicles sold for passenger transportation, compared to 26 percent in 1990. This shift from cars to light trucks has resulted in a significant increase in passenger-transportation energy consumption. Between 1990 and 2010, energy consumption associated with the use of light trucks increased at a faster pace than that associated with any other mode of passenger transportation, representing an increase of 121 percent (see Figure 6.8).

Air transport is becoming more popular.

Since 1990, Canadians are increasingly using air transport and for longer trips on average.[13] This sector has shown a significant increase of Pkm (104 percent). However, during the same period, the increase in energy consumption was lower (25 percent), which indicates growing efficiency in the industry. Two important factors contributed to this improvement. The first factor resides in the increasing effort by carriers to adapt the size of the aircraft based on the market size. The second factor is the implementation in 1994 and 1995 of the "Open Skies" agreement between Canada and the Unites States, which allowed the addition of many short-haul routes operated by regional air carriers that use smaller aircraft.[14]

[13] Statistics Canada, Civil Aviation, Annual Operating and Financial Statistics, Canadian Air Carriers, Levels I to III: 2009, Ottawa, December 2011 (Catalogue no. 51-004-X).

[14] Transport Canada, *Assumptions Report 2007-2021: Final Report*, Ottawa, December 2007.

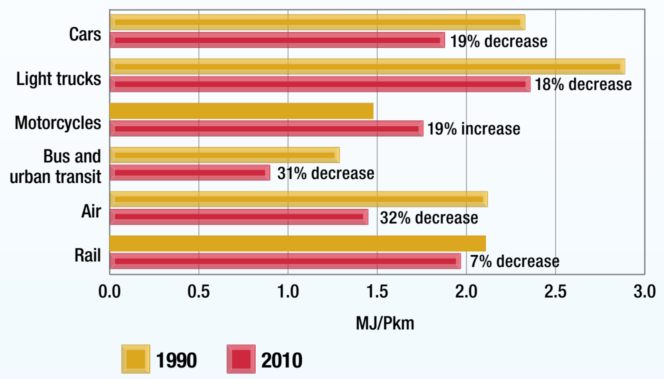
Energy intensity and energy efficiency for passenger transportation

Energy intensity

Energy intensity in the context of passenger transportation is defined as the amount of energy used to move one person over a distance of one kilometre. Between 1990 and 2010, energy intensity declined by 19 percent, from 2.3 megajoules (MJ) per Pkm covered to 1.9 MJ/Pkm. Improved fuel performance of the vehicles is the main reason for this reduction. The average fuel performance is measured by the quantity of litres consumed to cover a distance of 100 km (L/100 km).

Figure 6.9 indicates that all the modes of transportation, with the exception of motorcycles, saw a reduction of energy intensity from 1990 through 2010. The mode of transportation showing the greatest improvement was air transport, where the energy intensity decreased by 32 percent, followed by coaches and urban transportation, which recorded a decrease of 31 percent. In third place, cars shed almost a fifth of their energy intensity compared to their 1990 level, at 19 percent. They were closely followed by light trucks, which recorded a decrease of 18 percent. Finally, the energy intensity of rail transport decreased 7 percent while that of motorcycles increased 19 percent.

Figure 6.9 – Energy intensity for passenger transportation by mode of transportation, 1990 and 2010



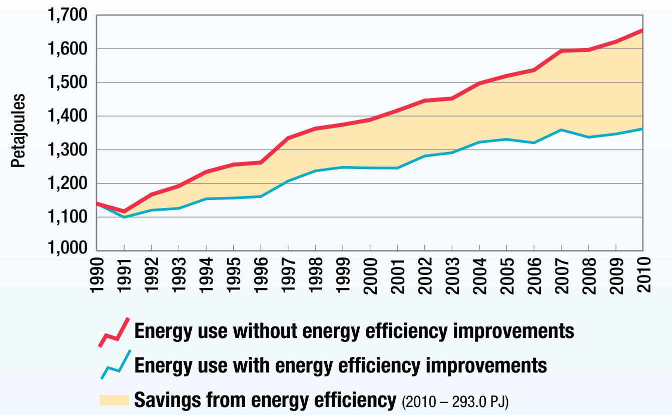
Energy efficiency

Improvements in energy efficiency for passenger transportation generated energy savings of 293.0 PJ or $8.2 billion in the transportation sector in 2010.

The amount of energy consumed for passenger transportation increased by 18 percent, from 1,179.0 PJ in 1990 to 1,390.3 PJ in 2010. Furthermore, the GHG emissions associated with this energy consumption increased by 15 percent, from 81.7 to 94.1 Mt.[15] Figure 6.10 shows that, without the improvements in energy efficiency, energy consumption during this period would have increased by 45 percent instead of 20 percent.

[15] Electricity represents only 0.2 percent of the total energy consumption for passenger transportation and is mainly used in urban transportation.

Figure 6.10 – Energy consumption for passenger transportation, with and without improvements in energy efficiency, 1990–2010

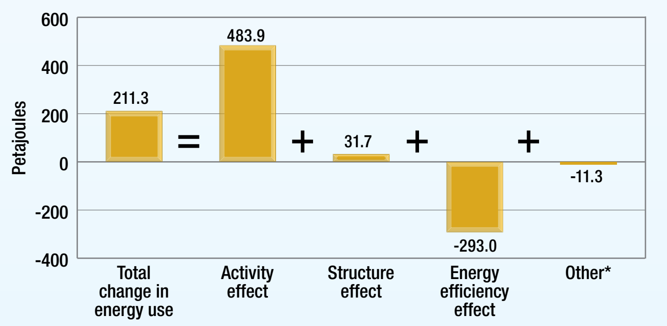


Note: The presented data do not include non-commercial airline aviation.

Figure 6.11 indicates the impact of various factors on the change in energy consumption of the passenger transportation subsector between 1990 and 2010. The effects of those factors can be enumerated as follows:

- **activity effect** – The effect of activity, i.e. the number of Pkm travelled, translated into an increase in energy consumption of 42 percent or 483.9 PJ, and in the associated GHG emissions of 32.7 Mt. This increase in Pkms is mainly due to a 171 percent increase in the activity of light trucks and a 104 percent increase in air transport activities.
- **structure effect** – Changes in the combination of the modes of transportation, i.e. the relative shares of Pkm attributed to air, rail and road transport, are used to measure the structural changes. Hence, an overall change of structure would decrease (or increase) energy consumption if the relative share of a more (or less) efficient mode increases in relation to that of the others. The relative shares of Pkm travelled increased significantly for passenger air transport and light trucks. The overall structural effect was positive, given the growing taste for minivans and SUVs, which consume more fuel than other modes of transportation. Consequently, the analyses show an increase of 31.7 PJ in energy consumption and an increase of 2.1 Mt in associated GHG emissions attributable to the effect of structure.
- **energy efficiency effect** –Improvements in energy efficiency in passenger transportation generated energy savings of 293.0 PJ and avoided 19.8 Mt of associated GHG emissions. The light-vehicle segment (automobiles, light trucks and motorcycles) for passenger transportation accounted for 68 percent of those savings.

Figure 6.11 – Impact of activity, structure and energy efficiency on the change in energy consumption in the passenger transportation subsector, 1990–2010



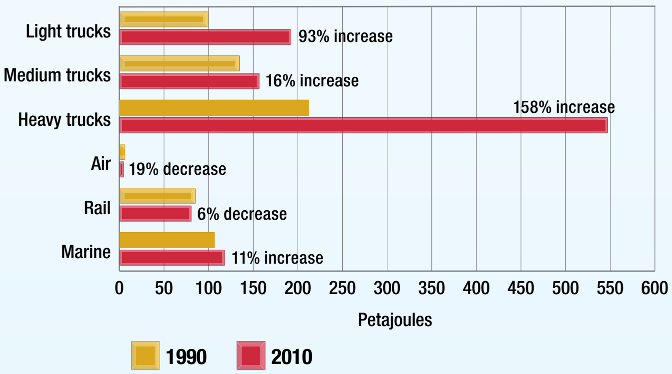
* "Other" refers to non-commercial air transport, which is included in the value for the abovementioned "Overall change in energy consumption," but excluded from the factorization analysis.

Trends – Energy consumption and GHG emissions for freight transportation

In Canada, the freight transportation subsector includes four modes of transportation: road, air, maritime and rail. Transportation by truck is divided into three types: light truck, medium truck and heavy truck. The energy consumption for freight transportation is linked to tonne-kilometres (Tkm). One Tkm describes the transportation of one tonne of freight over a distance of one kilometre.

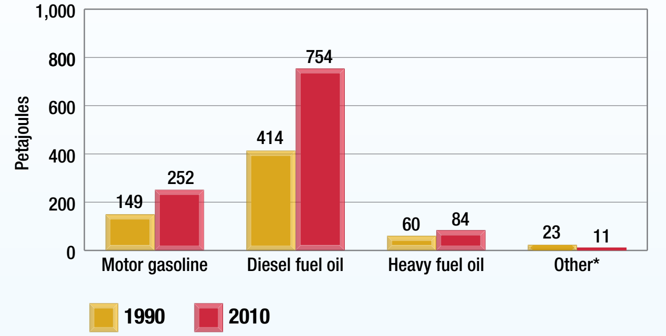
The freight transportation energy use increased by 70 percent, from 645.6 PJ in 1990 to 1,100.7 PJ in 2010. Consequently, there has been a 70 percent increase of associated GHG emissions, from 46.0 Mt in 1990 to 78.1 Mt in 2010. Figure 6.12 shows the energy-consumption increase for all the modes of freight transportation, with the exception of rail and air transport, which declined by 6 percent and 19 percent respectively. The energy consumption of heavy and light trucks increased sharply, accounting for almost half the energy consumed for freight transportation in 2010.

Figure 6.12 – Energy consumption for freight transportation by mode, 1990 and 2010



The mix of fuels used in the freight transportation subsector remained relatively constant between 1990 and 2010. Diesel was the main energy source, representing 69 percent of all the fuels consumed for freight transportation (see Figure 6.13).

Figure 6.13 – Energy consumption for freight transportation by fuel type, 1990 and 2010



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

Just-in-time delivery is stimulating the demand for transportation using heavy trucks.

Adoption of the just-in-time stocking scheme by many businesses has had a significant impact on the freight transportation subsector. Such a system generally requires less inventory storage space because the orders are delivered at the moment they are required for production.

Using transport vehicles as virtual warehouses requires a transportation system that is "in-time" and very efficient. This need is usually met by using heavy trucks and the use of this type of truck for freight transportation has therefore increased considerably during this period. Between 1990 and 2010, the number of heavy trucks increased 20 percent, and the average distance travelled increased 16 percent, reaching 83,330 km per year. However, heavy trucks are not only travelling greater distances but also transporting more freight because the number of trailers is increasing. These factors have a major impact on the number of Tkm and the energy consumption of the freight transportation subsector attributable to heavy trucks.

Figure 6.14 – Energy indicators for motor freight, 1990 and 2010

1990

- 1.9 million freight trucks
- 297,000 heavy trucks
- 72,005 km per year on average for heavy trucks
- 103.3 billion Tkm travelled

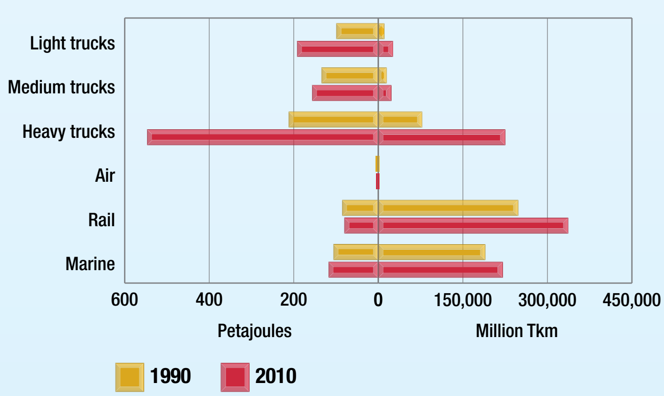
2010

- 3.4 million freight trucks
- 357,000 heavy trucks
- 83,330 km per year on average for heavy trucks
- 274.8 billion Tkm travelled

Rail transport remains the main mode of freight transportation in Canada.

For many goods, such as coal and cereals, trucks are not an efficient mode of transportation. Rail and maritime transport continue to be the modes of choice. They therefore have an important place in the freight transportation sector. Rail transport holds the first position in terms of Tkm of freight transported with 337.0 billion Tkm in 2010, 39 percent more than in 1990. In second position, heavy trucks transported 225.4 billion Tkm in 2010, which is 190 percent more than in 1990. In third position, maritime transport was used to ship 221.1 billion Tkm in 2010, which is an increase of 17 percent compared with 1990.

Figure 6.15 – Energy consumption for freight transportation in relation to the activity by mode, 1990 and 2010



Since 1990, all the modes of freight transportation have become more efficient with respect to energy consumption, based on the number of Tkm. Figure 6.15 shows that the energy efficiency for rail and maritime transport is higher than that of trucks for freight transportation. In fact, these two modes of transport have high activity levels and relatively low energy consumption. Moreover, the average energy consumption for heavy trucks changed from 42.5 L of fuel per 100 km in 1990 to 33.4 L in 2010.

Energy efficiency for freight transportation

In 2010, improvements in the energy efficiency for freight transportation have translated into energy savings of 131.2 PJ or $3.4 billion in the transportation sector.

Between 1990 and 2010, energy consumption for freight transportation increased by 70 percent, from 645.6 PJ to 1,100.7 PJ. Without the improvements in energy efficiency, the energy consumption would have increased by 91 percent, which is 20 percent more than that observed in 2010 (see Figure 6.16).

Figure 6.16 – Energy consumption for freight transportation, with and without improvements in energy efficiency, 1990–2010

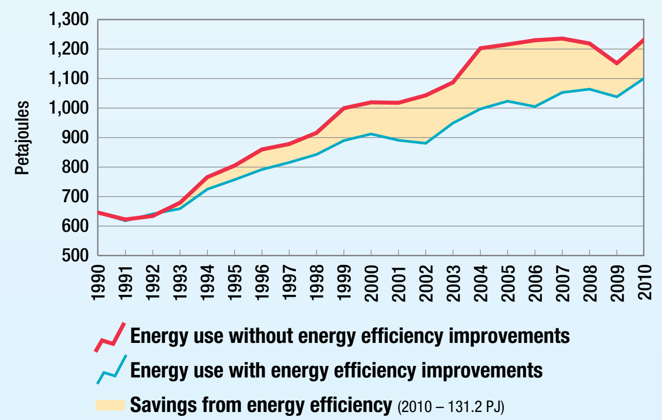


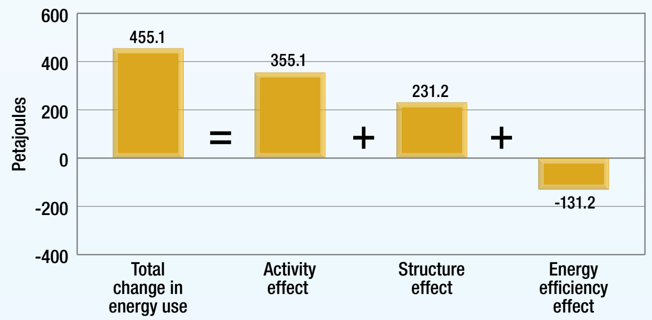
Figure 6.17 shows the impact of various factors on the change in energy consumption of the freight transportation subsector between 1990 and 2010. The effects of those factors can be enumerated as follows:

- **activity effect –** The effect on activity, i.e. the number of Tkm transported, translated into an increase in energy consumption of 55 percent, or 355.1 PJ, and in the associated GHG emissions of 25.2 Mt. This increase in the number of Tkm transported is mainly due to a 190 percent increase in the activity of heavy trucks and a 57 percent increase in the activity of medium trucks.

- **structure effect –** Changes in the combination of the modes of transportation, i.e. the relative shares of Tkm attributed to air, maritime, rail and road transport, are used to measure the structural changes. Hence, an overall change of structure would result in a decrease (or increase) in energy consumption if the relative share of a more (or less) efficient mode increases in relation to that of the others. The change between the modes is a result of the increase of the relative share of freight transported by heavy trucks compared with other modes. The overall structural effect was positive given the growth of exchange between Canada and the United States and just-in-time delivery demanded by clients, thus contributing to an increase in the use of road transport, which consumes more energy per Tkm than other modes. Consequently, the analyses show an increase of 231.2 PJ in energy consumption and an increase of 16.4 Mt in associated GHG emissions attributable to the effect of structure.

- **energy efficiency effect –** Due to improvements in energy efficiency in freight transportation, energy savings of 131.2 PJ could be achieved and associated GHG emissions could be reduced by 9.3 Mt. The road vehicle segment (light trucks, medium trucks and heavy trucks) for freight transportation accounted for 73 percent of those savings.

Figure 6.17 – Impact of activity, structure and energy efficiency on the change in energy consumption in the freight transportation subsector, 1990–2010



Appendices

A Appendix A: Reconciliation of data

Figure A.1. – Reconciliation of data with Canada's* Report on Energy Supply and Demand in Canada *– 2010 (petajoules)

	RESD data (PJ)	Residential wood (PJ)	Commercial & public admin. diesel (PJ)	Industrial, commercial & public admin. aviation fuels (PJ)	Industrial, commercial & public admin. motor gasoline (PJ)	LFO – Canadian airlines, railways and road transport and urban transit (PJ)	LFO – retail pump sales (PJ)	RFO – retail pump sales (PJ)	HFO – Railways and road transport and urban transit (PJ)	Pipeline fuels (PJ)	Wood, waste & pulping liquor (PJ)	Waste fuels used in cement industry (PJ)	Re-allocation of producer consumption by refineries and mining industries (PJ)	Other adjustments (PJ)	Data presented in this report (PJ)
Sector															
Residential	1,264	94					3								1,361
Commercial/ institutional	1,138		(43)	(22)	(18)	2	0	(0)	0					0	1,057
Industrial	2,337			(6)	(18)		0		1		418	4	491		3,228
Transportation	2,622		43	28	37	(2)	(4)	0	(2)	(124)				(3)	2,595
Agriculture	246						0							(8)	239
Final demand	***7,607***	***94***	***0***	***0***	***0***	***0***	***0***	***0***	***(1)***	(124)	***418***	***4***	***491***	***(10)***	***8,479***
Non-energy	933														933
Producer consumption	1,178									124			(491)		811
Net supply	***9,718***	***94***	***0***	***0***	***0***	***0***	***0***	***0***	***(1)***	***0***	***418***	***4***	***0***	***(10)***	***10,223***
Fuel conversion															
Electricity, steam and coal/coke input fuels[1]	3,944								1						3,945
Electricity, steam and coal/coke production[2]	(2,209)														(2,209)
Total primary	***11,453***	***94***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***418***	***4***	***0***	***(10)***	***11,960***

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) representing the sum of Agriculture energy source fuels

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

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

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

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

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

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

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

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

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

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

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

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

Appendix B: Glossary of terms

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

Compact fluorescent lamp (CFL), also known as compact fluorescent light bulb: A compact fluorescent bulb is a smaller version of a fluorescent lamp. These bulbs use 67 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).

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.

Appendix B: Glossary of terms

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).

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/m³ (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.

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 1×10^{15} joules (see Joule).

Pulping liquor: This substance consists primarily of lignin, other wood constituents and chemicals that are by-products of the manufacture of chemical pulp. It can produce steam for industrial processes when burned in a boiler and/or produce electricity through thermal generation.

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

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

Service level: This term characterizes the increased penetration of auxiliary equipment in commercial/institutional buildings and the increased penetration of appliances and space cooling units in residential dwellings.

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

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

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

Appendix B: Glossary of terms

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.

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.

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

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

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

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

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

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

Watt (W): A watt is a unit of power equal to one joule of energy per second. For example, a 40-watt light bulb uses 40 watts of electricity (see Kilowatt hour).

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

Appendix C: List of abbreviations

C

$2002	constant 2002 dollars
bbl.	barrel
CANSIM	Canadian Socio-Economic Information Management System
CFL	compact fluorescent lamp, also known as compact fluorescent light bulb
DVD	digital video disc or digital versatile disc
GDP	gross domestic product
GHG	greenhouse gas
GJ	gigajoule = 1×10^9 joules
GO	gross output
GWh	gigawatt hour = 1×10^9 Wh
ICE	Industrial Consumption of Energy survey
km	kilometre
kW	kilowatt
kWh	kilowatt hour = 1×10^3 Wh
L	litre
LPG	liquefied petroleum gases
m^2	square metre
m^3	cubic metre
MJ	megajoule = 1×10^6 joules
Mt of CO_2e	megatonne of carbon dioxide equivalent = 1×10^6 tonnes
NRCan	Natural Resources Canada
OEE	Office of Energy Efficiency
PJ	petajoule = 1×10^{15} joules
Pkm	passenger-kilometre
RESD	Report on Energy Supply and Demand in Canada
TJ	terajoule = 1×10^{12} joules
Tkm	tonne-kilometre
VCR	videocassette recorder
W	watt
Wh	watt-hour