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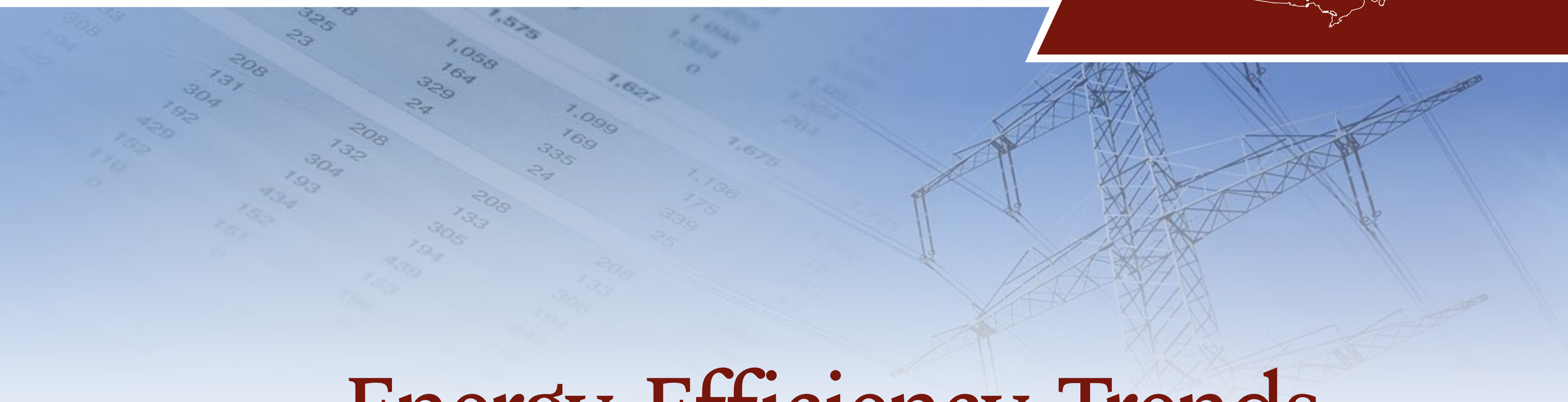

Energy Efficiency Trends in Canada 1990 to 2009

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Canada

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Preface

This 15th edition of *Energy Efficiency Trends in Canada* delivers on Canada's commitment to provide a comprehensive summary of secondary energy use and related greenhouse gas (GHG) emissions in Canada. It also tracks trends in energy efficiency. This year's edition is produced electronically and in paper format.

For more secondary energy use statistics, see the comprehensive energy use database. The database includes most of the historical energy use and GHG emissions data used by Natural Resource Canada's (NRCan's) Office of Energy Efficiency (OEE). This database can be viewed at oee.nrcan.gc.ca/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 2009 period is the most recent year for which data are available.

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 Bob Blain and Michel Francoeur providing overall direction.

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Introduction

Chapter 1

1 Introduction

Canadians spent $152 billion on energy in 2009.

Energy accounts for a large segment of spending by households, businesses and industries alike. In 2009, Canadians spent about $152 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 2009, this report also analyses the energy intensity and efficiency trends between 1990 and 2009. 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).

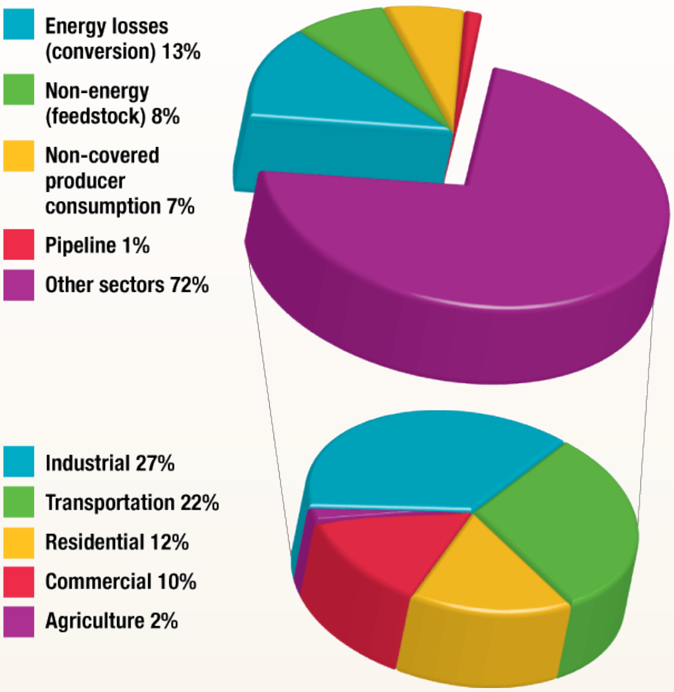
It also includes the energy used to bring energy supplies to the consumer (e.g. pipeline). Further, it entails the energy used to feed industrial production processes (e.g. the natural gas used as feedstock by the chemical industries). In 2009, the total amount of primary energy consumed was estimated at 11,896.7 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 agriculture sectors. Secondary energy use accounted for almost 72 percent of the primary energy use in 2009, or 8,541.6 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 (page 3).

[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, 2009



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 690.6 megatonnes (Mt) in 2009; 67 percent of this total (or 463.9 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, 1990–2009 – 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 shortcoming 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 2009 of energy use and GHG emissions is described, followed by the trends in energy use and GHG emissions from 1990 to 2009. 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 the OEE, *Improvement of the OEE/DPAD Decomposition Methodology*, 2005.

Energy use

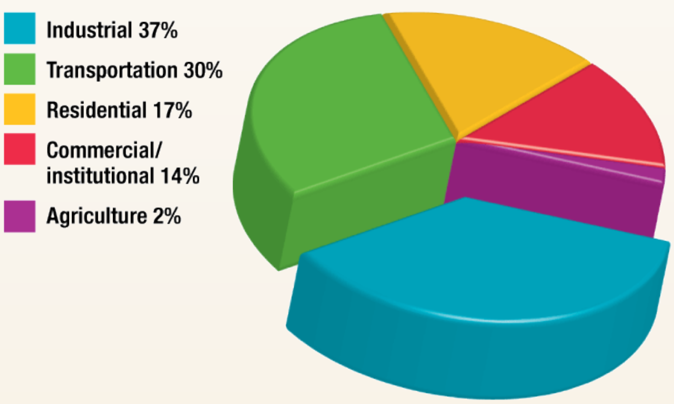
Chapter 2

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/institutional, industrial, transportation and agriculture. In 2009, these sectors used a total of 8,541.6 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 463.9 Mt in 2009.

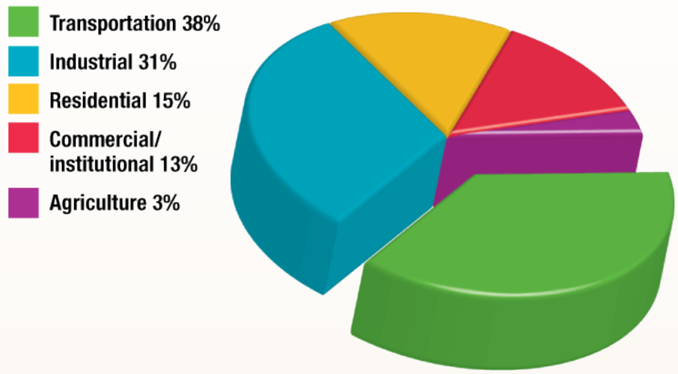
Figure 2.1 – Secondary energy use by sector, 2009



One petajoule is approximately equal to the energy used by more than 9000 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.

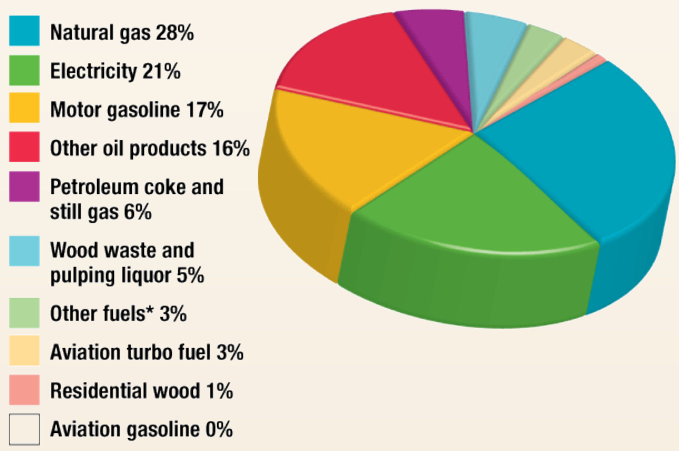
Figure 2.2 – GHG emissions by sector, 2009



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 2009, natural gas and electricity accounted for almost half the energy used in Canada (Figure 2.3). Motor gasoline and other oil products (diesel fuel oil, light fuel oil, kerosene and heavy fuel oil) represented approximately 33 percent of energy use.

Figure 2.3 – Secondary energy use by fuel, 2009



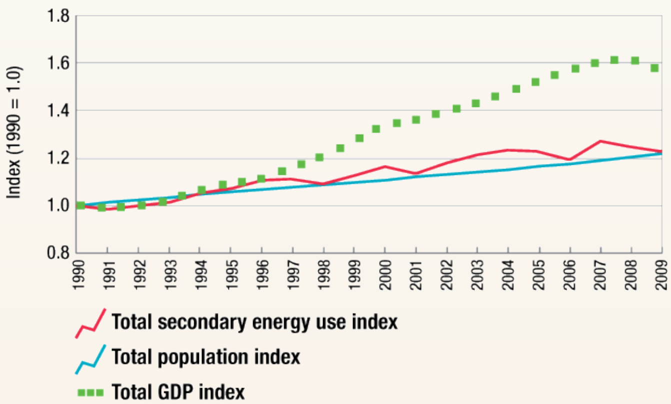
* "Other fuels" includes: coal, coke, coke oven gas, liquefied petroleum gas and gas plant natural gas liquids, and waste fuels from the cement industry.

Trends – Energy use and GHG emissions

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

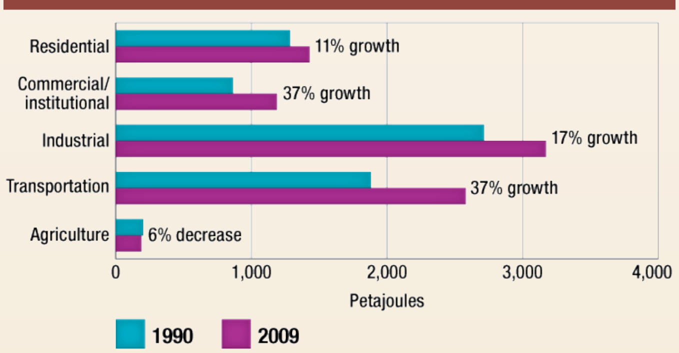
Between 1990 and 2009, energy use in Canada increased by 23 percent, from 6,936.1 PJ to 8,541.6 PJ (Figure 2.4). At the same time, the Canadian population grew 22 percent (approximately 1 percent per year) and GDP increased 57 percent (about 2 percent per year). More generally, energy use per unit of GDP declined, while energy use on a per capita basis increased.

Figure 2.4 – Total secondary energy use, Canadian population and GDP, 1990–2009



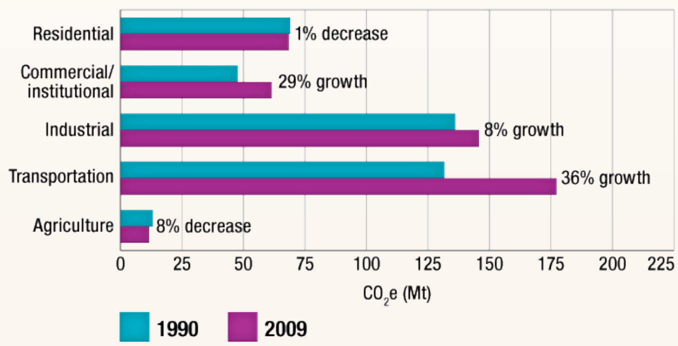
Energy use has been growing at the fastest rate in the transportation and commercial/ institutional sectors.

Figure 2.5 – Total secondary energy use and growth by sector, 1990 and 2009



The industrial sector uses the most energy in our economy, consuming 3,168.4 PJ of energy in 2009. However, energy use growth in the commercial/institutional and transportation sectors outpaced all other sectors. Over the 1990–2009 period, the commercial/institutional sector registered a 37 percent increase in energy use (Figure 2.5), driven mainly by a 170 percent increase in auxiliary equipment energy use. Transportation energy use grew by 37 percent primarily due to a 67 percent growth in freight energy use.

Figure 2.6 – Total GHG emissions and growth by sector, 1990 and 2009



Growth in energy use was reflected in growth of GHG emissions. In 2009, Canada's GHG emissions excluding electricity-related emissions declined 1 percent compared to 2008, while emissions including those from electricity generation fell 4 percent. As demand for electricity dropped 4.7 percent in 2009, the mix of electricity generation also changed. In particular, between 2008 and 2009, decline in electricity generated from coal contributed to 52 percent of the total decline in electricity generated. Consequently, total CO_2 emissions decreased 16 percent in 2009 compared to 2008. The CO_2 emissions avoided from the reduction of coal use contributed 83.6 percent to the total CO_2 decrease. The transportation sector experienced the highest growth in emissions at 36 percent followed by the commercial/ institutional sector at 29 percent (Figure 2.6).

The transportation sector accounted for the largest proportion, 38 percent, of energy-related emissions (178.3 Mt CO_2e), followed by the industrial sector, 31 percent (144.5 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

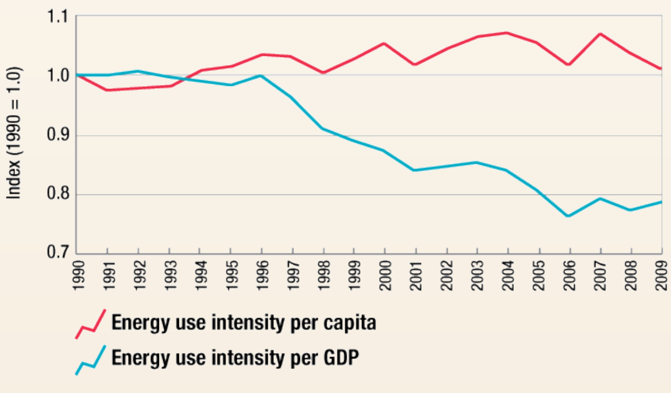
Canada improved its energy efficiency between 1990 and 2009. The following section discusses two indicators of energy efficiency: energy intensity and an energy efficiency measure using factorization.

Energy intensity

Canada's energy intensity improved 21 percent between 1990 and 2009. Despite this improvement, per capita energy use increased 1 percent.

Energy intensity, when defined as the amount of energy required per unit of activity (GDP), improved 21 percent between 1990 and 2009 (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 2009 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, 1990–2009



Conversely, the amount of energy required per capita, which is the energy intensity for each individual, increased 1 percent between 1990 and 2009 (Figure 2.7). This upward trend in part reflects the increasing use of electronic goods, increasing ownership of passenger light trucks and increasing distance and weight of goods transported by heavy trucks. In other words, although Canada is producing economic value more efficiently, each household is using a greater number of energy-consuming goods and services per capita compared to 1990. This is despite the fact that many electronic goods have become increasingly energy-efficient since 1990.

Energy efficiency

This edition of *Energy Efficiency Trends in Canada* marks a change in the factorization process that allows us to more accurately reflect changes in the pure energy efficiency effect. In particular, we have included a separate estimate of the impact of changes in capacity utilization with respect to energy use. The impact of capacity utilization became very noticeable in 2009 as the downturn in the industrial sector occurred, and many processes operated substantially below capacity but continued to require threshold levels in energy use. The analysis has been conducted back through time, which has the effect of smoothing out the trend in energy efficiency. Although detailed analysis is limited to the industrial sector because of data availability, the impact can be seen in the aggregate savings.

Energy efficiency has improved 24 percent since 1990. These improvements reduced energy use by approximately 1,560.4 PJ, decreased GHG emissions by 81.1 Mt and saved Canadians $26.8 billion in 2009.

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 the 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 –** Capacity utilization rate refers to the proportion of the installed production capacity that is in use. In 2009, sectors such as mining, transportation equipment and iron and steel showed significant declines. For more details on this, see Appendix B.
- **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 percent between 1990 and 2009 instead of 23 percent. These energy savings of 1,560.4 PJ are equivalent to the energy use of about 26 million cars and passenger light trucks in 2009.

Figure 2.8 – Secondary energy use, with and without energy efficiency improvements, 1990–2009

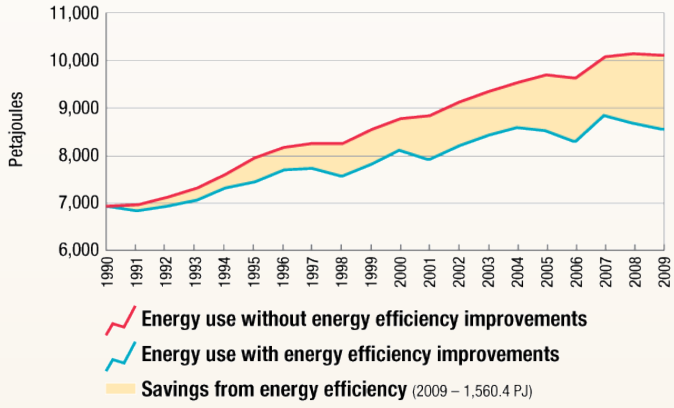


Figure 2.9 illustrates the relative impact of each effect on energy use over the 1990–2009 period for the economy as a whole. The following is a summary of and rationale for the results:

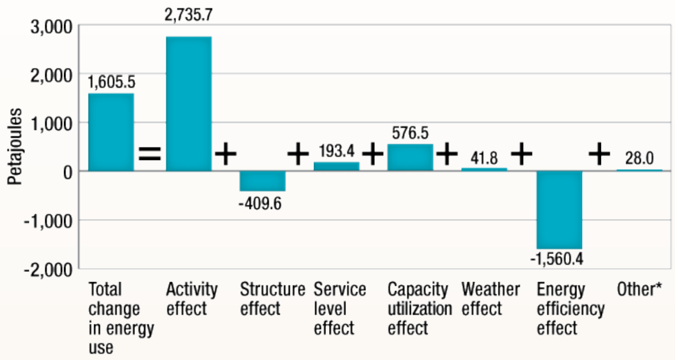
- **activity effect –** Canada's GDP grew 57 percent between 1990 and 2009. The overall growth in activity effect is estimated to have increased energy use by 39 percent, or 2,735.7 PJ, with a corresponding 144.6-Mt increase in GHG emissions.
- **structure effect –** Over the 1990–2009 period, a shift in production toward industries that are less energy-intensive resulted in a decrease of 409.6 PJ and an 11.5-Mt decrease in GHG emissions.
- **weather effect –** In 2009, the winter was colder and the summer was cooler than in 1990. The result was an overall increase of 41.8 PJ in energy demand for temperature control and a 2.0-Mt increase in GHG emissions.

- **service level effect** – From 1990 to 2009, changes in service level (e.g. increased use of computers, printers and photocopiers in the commercial/institutional sector) raised energy use by 193.4 PJ and increased GHG emissions by 9.7 Mt.

- **capacity utilization rate effect** – The overall decline in the capacity of utilization translated into 576.5 PJ in energy waste and thereby increased GHG emissions by 26.3 Mt.

- **energy efficiency effect** – As noted above, improvements in energy efficiency saved 1,560.4 PJ of energy and avoided 81.1 Mt of GHG emissions from 1990 to 2009.

Figure 2.9 – Summary of factors influencing the change in energy use, 1990–2009



* "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 2009.

In 2009, Canadians spent $26.8 billion on household energy needs. Total household energy use was 17 percent of all energy used (Figure 3.1), and total household GHG emissions were 15 percent of all secondary energy use-related GHGs emitted in Canada (Figure 3.2). Specifically, residential energy use was 1,422.3 PJ, emitting 67.9 Mt of GHGs.

Figure 3.1 – Energy use by sector, 2009

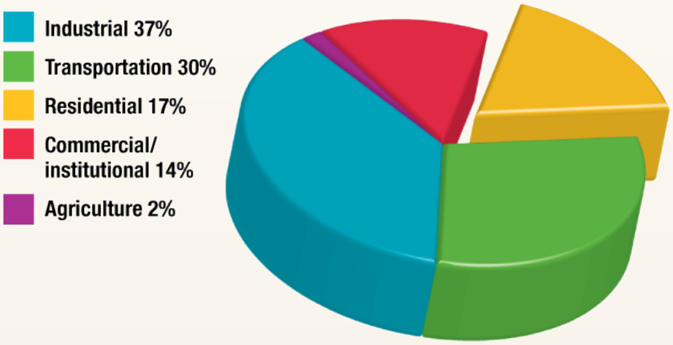
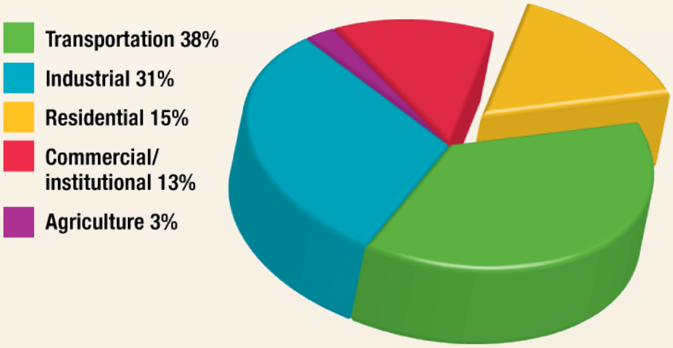
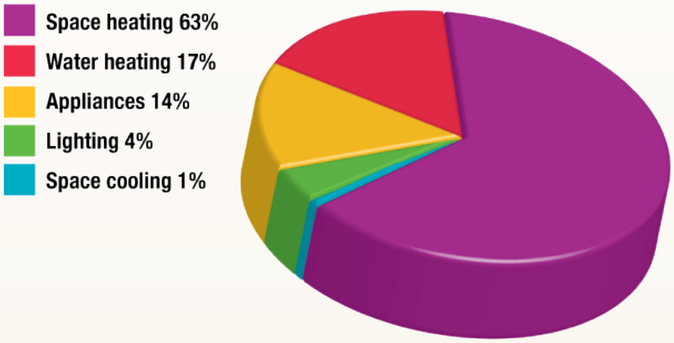


Figure 3.2 – GHG emissions by sector, 2009



Natural gas, electricity, wood, heating oil and propane were the sources of energy being used. Within a household, these forms of energy were used for a variety of activities, as seen in Figure 3.3. Because of Canada's cold climate, 63 percent of Canada's residential energy use was for space heating in 2009, 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, 2009



Trends – Residential energy use and GHG emissions

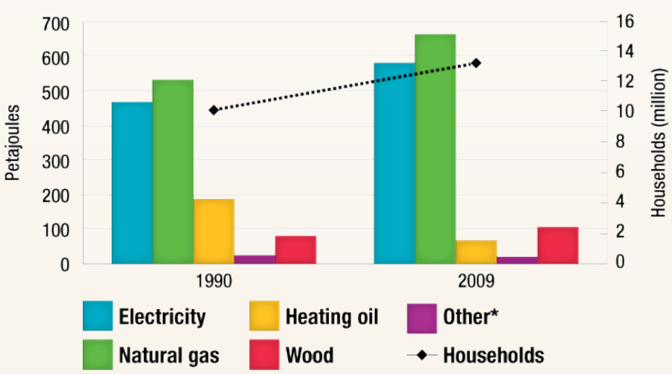
Population growth and fewer people per household led to a 36 percent rise in the number of households, which contributed to an 11 percent increase in residential energy use from 1990 to 2009.

The 3.5 million households added in Canada since 1990 is more than Quebec's total households.

Between 1990 and 2009, the population grew 22 percent (6.0 million people) and the number of households increased 36 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 11 percent, or 140.2 PJ, in residential energy use, from 1,282.1 PJ to 1,422.3 PJ. As homeowners gradually switched to cleaner energy sources, the associated GHG emissions decreased 0.8 percent, from 68.4 Mt to 67.9 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 87 percent of all residential energy use in 2009, compared with 78 percent in 1990, while heating oil saw its share decrease from 15 percent to 4 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 2009



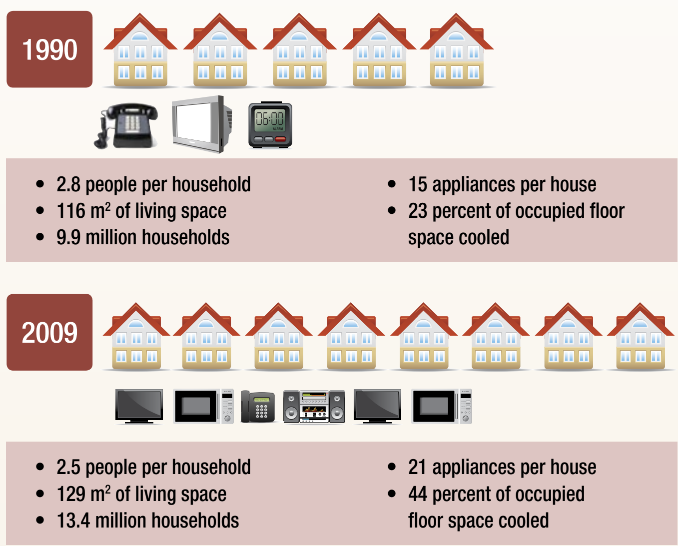
* "Other" includes coal and propane.

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 2009 was 11 percent greater than that in 1990. Specifically, average occupied living space in 1990 was 116 square metres (m^2) compared with 129 m^2 of living space in 2009 (Figure 3.5). At the same time, the number of individuals per household fell to 2.5 in 2009 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 2009

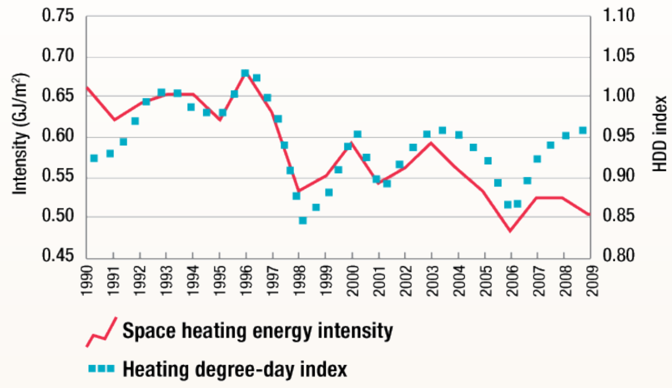


Trends – Residential space heating energy use

Despite a 24 percent decline in space heating energy intensity (GJ/m²), total space heating energy use increased 13 percent between 1990 and 2009.

The amount of energy used by the residential sector to heat each square metre of living space decreased significantly between 1990 and 2009. The decrease in space heating intensity from 0.66 gigajoules per square metre (GJ/m^2) to 0.50 GJ/m^2 (Figure 3.6) was mainly driven by energy efficiency gains, despite heating degree-days in 2009 being higher than in 1990.

Figure 3.6 – Space heating energy intensity and heating degree-day index, 1990–2009



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 2009, the proportion of medium- and high-efficiency gas furnaces installed in Canadian houses climbed from 10 percent to 86 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 2009.

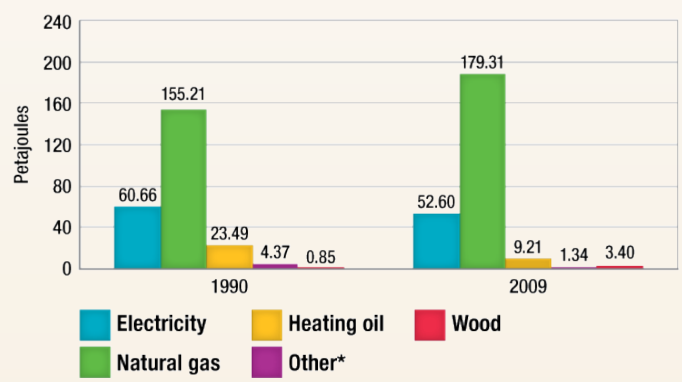
Although space heating intensity decreased 24 percent, this was not enough to compensate for the fact that the number of households increased 36 percent. Additionally, the average Canadian home was larger in 2009 than it was in 1990. Consequently, the energy required to heat all the dwellings in Canada increased 13 percent, from 792.3 PJ in 1990 to 893.2 PJ in 2009, which accounted for 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 26 percent decrease in the energy used per household for heating water (from 24.7 GJ per household in 1990 to 18.3 GJ per household in 2009).

Figure 3.7 – Water heating energy use by fuel type, 1990 and 2009



* "Other" includes coal and propane.

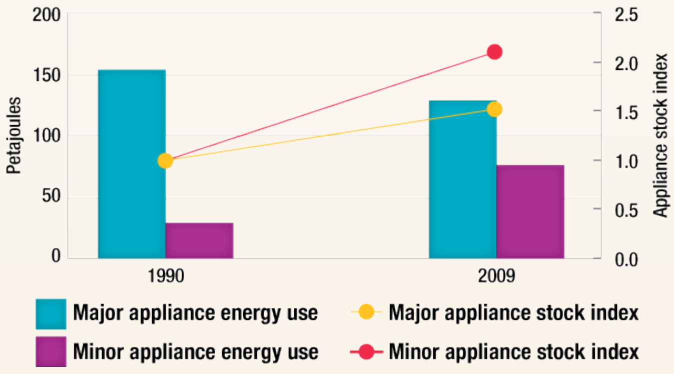
Although there was a decrease in per household energy used to heat water, the total number of households grew more quickly than energy efficiency improvements from new equipment. The result was an overall increase of 0.5 percent in residential water heating energy use, from 244.6 PJ to 245.8 PJ. In 2009, 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 2009 increased 49 percent (Figure 3.8). However, the total amount of energy that households used to power major appliances decreased 16 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 2009.

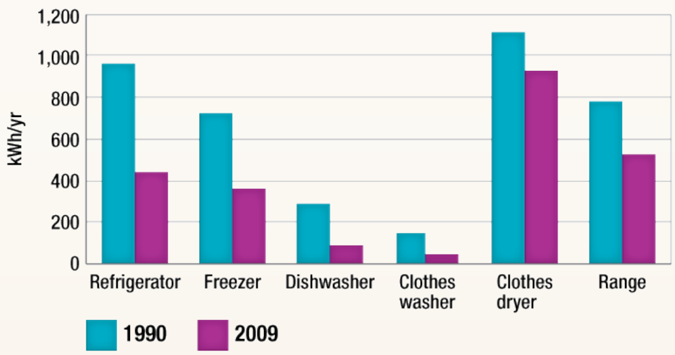
Figure 3.8 – Residential energy use and appliance stock index by appliance type, 1990 and 2009



The largest percentage decrease was in the unit energy use of clothes washers (Figure 3.9), which in 2009 used 73 percent less energy than in 1990 (from 134 kilowatt hours per year [kWh/yr] to 37 kWh/yr).[4] A new refrigerator in 1990 used an average of 956 kWh/yr versus 430 kWh/yr in 2009, a decrease of 55 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 2009. This increase of 46.5 PJ was equivalent to the energy required to provide lighting to all the Canadian homes in the mid-1980s.

Figure 3.9 – Unit energy consumption for new major electric appliances, 1990 and 2009



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 (+158 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 2009 they were present in more than four out of five households in Canada. Furthermore, the rapid penetration of digital TVs, DVDs and digital cable boxes also contributed to the increase.

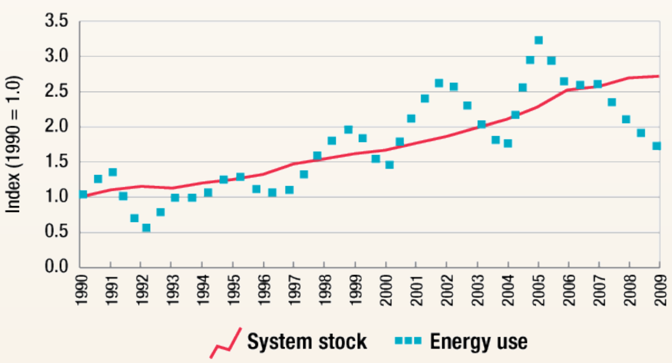
[4] Excludes hot water requirements.

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 757 million m^2 in 2009, from 267 million m^2 in 1990. The percentage of occupied floor space cooled rose from 23 percent in 1990 to 44 percent in 2009. As a result, even though the summer in 2009 was not as hot as in 1990, the energy required to cool Canadian homes rose 68 percent (Figure 3.10), from 10.4 PJ to 17.4 PJ, over the same period.

Figure 3.10 – Space cooling system stock and energy use, 1990–2009



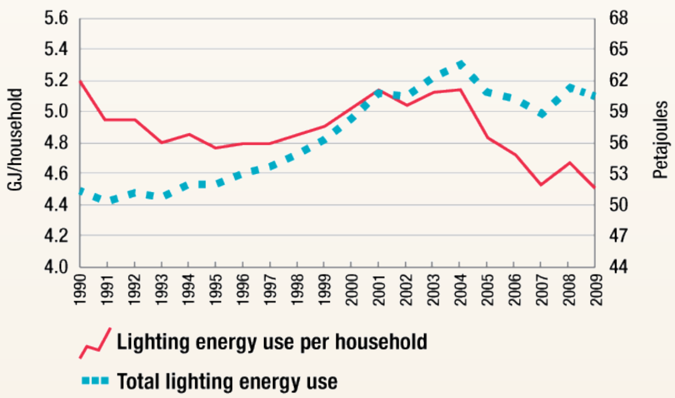
The increase in energy used for space cooling would have been more profound if not for efficiency improvements associated with room and central air conditioners. Compared with 1990, the stock of room and central air conditioners in 2009 were 48 and 26 percent more efficient, respectively.

Trends – Lighting energy use

The market share of energy-efficient lighting alternatives increased significantly between 1990 and 2009.

Despite a drop in lighting energy use per household, the energy required to light all the households in Canada increased 18 percent, from 51.4 PJ to 60.6 PJ (Figure 3.11). This was entirely due to the 36 percent increase in the number of households, as the energy required to light each household in Canada decreased 10 percent, from 5.2 GJ to 4.7 GJ.

Figure 3.11 – Lighting energy use per household and total lighting energy use, 1990–2009



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 24 percent of light bulbs used in 2009.

Figure 3.12 – Number of light bulbs per household by bulb type, 1990 and 2009

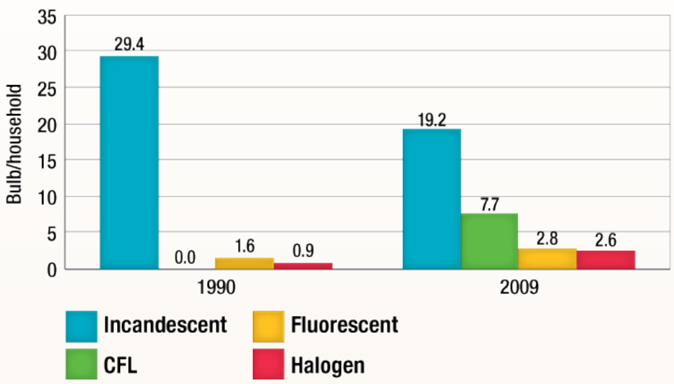
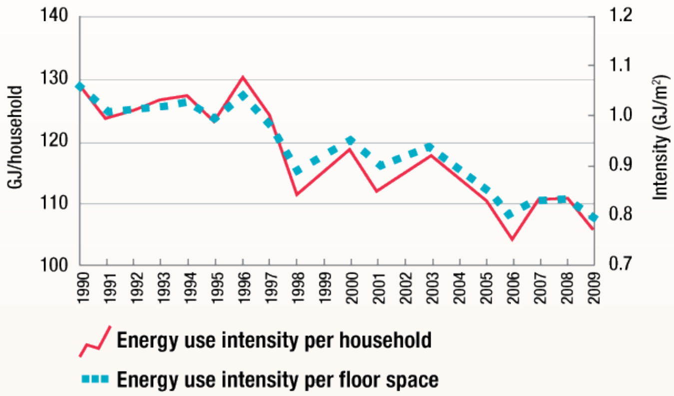


Figure 3.13 – Residential energy intensity per household and floor space, 1990–2009



Residential energy intensity and efficiency

Energy intensity

The average household has reduced its energy use by 18 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 18 percent, from 129.6 GJ per household in 1990 to 106.0 GJ in 2009 (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 25 percent, from 1.06 GJ to 0.79 GJ.

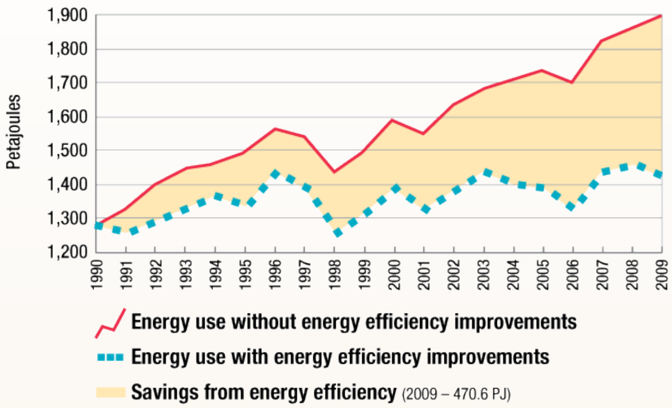
Energy efficiency

Energy efficiency improvements resulted in energy savings of $8.9 billion in the residential sector in 2009.

Energy efficiency improvements in the residential sector resulted in significant savings between 1990 and 2009. 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 37 percent from 1990 to 2009, allowing Canadians to save 470.6 PJ of energy (Figure 3.14) and $8.9 billion in energy costs in 2009.

Figure 3.14 – Residential energy use, with and without energy efficiency improvements, 1990–2009

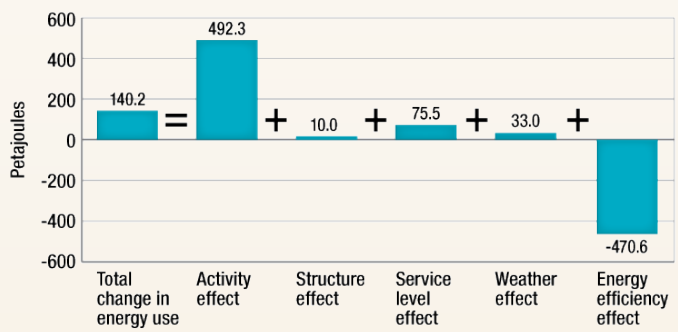


These energy efficiency savings translate into an average savings of $660 per Canadian household in 2009.

Figure 3.15 illustrates the influence that various factors had on the change in residential energy use between 1990 and 2009. These effects are as follows:

- **activity effect** – As measured by combining a mix of households and floor space, energy use increased 38 percent (492.3 PJ), and GHG emissions increased by 23.5 Mt. Growth in activity was driven by a 48 percent increase in floor area and by a rise of 36 percent in the number of households.
- **structure effect** – The increase in the relative share of single-family houses resulted in the sector using an additional 10.0 PJ of energy and emitting 0.5 Mt more GHGs.
- **weather effect** – In 2009, the winter was colder and the summer was cooler than in 1990. The net result was an overall increase in energy demand of 33.0 PJ, and GHG emissions rose by 1.6 Mt.
- **service level effect** – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 75.5 PJ of the increase in energy and a 3.6 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 470.6 PJ of energy and 22.4 Mt of GHG emissions.

Figure 3.15 – Impact of activity, structure, weather and energy efficiency on the change in residential energy use, 1990–2009



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.

In 2009, commercial business owners and institutions spent $24 billion on energy to provide services to Canadians. This represents approximately 3 percent of the value of GDP related to this sector. In 2009, this sector was responsible for 14 percent of the total energy use (Figure 4.1) in Canada and produced 13 percent of the associated GHG emissions (Figure 4.2).

Figure 4.1 – Secondary energy use by sector, 2009

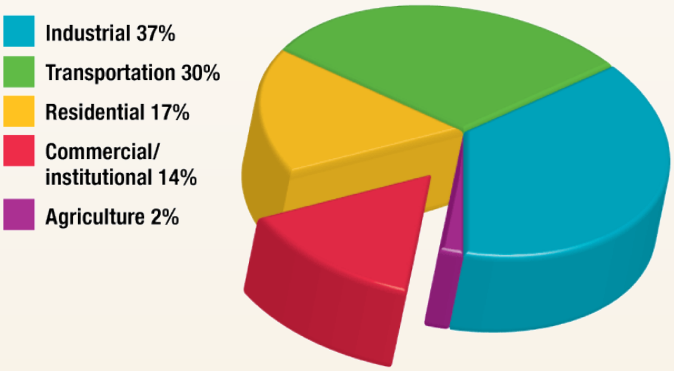
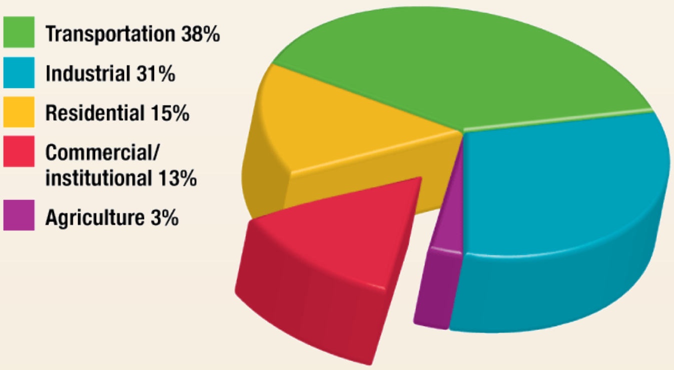
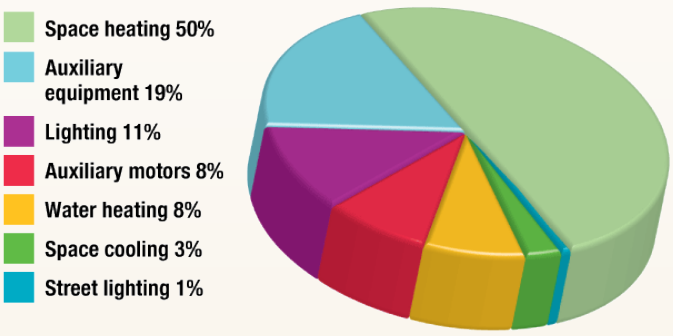


Figure 4.2 – GHG emissions by sector, 2009



In the commercial/institutional sector,[5] 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 half of the total energy used (Figure 4.3). Street lighting included in total energy use is excluded from the factorization analysis because it is not associated with floor space activity.

Figure 4.3 – Commercial/institutional energy use by end-use, 2009

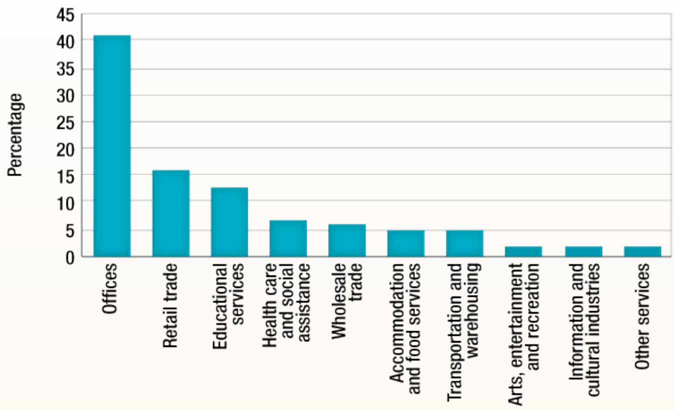


The commercial/institutional sector includes activities related to trade, finance, real estate, public administration, educational and commercial services. These activities have been grouped into 10 subsectors (see Figure 4.4 for a complete listing of activities).

Of these activities, offices, retail trade and educational services account for 70 percent of the total Canadian commercial/institutional floor space, which in 2009 was estimated at 709.5 million m^2.

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

Figure 4.4 – Commercial/institutional floor space by activity type, 2009



Trends – Commercial/institutional energy use and GHG emissions

The commercial/institutional sector consumed less than half of the energy used in the transportation sector but it grew as quickly as the transportation sector, which was the fastest growing sector with respect to energy use and GHG emissions between 1990 and 2009.

From 1990 to 2009, total commercial/institutional energy use increased 37 percent, from 867.0 PJ to 1,186.0 PJ, including street lighting. At the same time, GDP for the commercial/institutional sector grew 74 percent and floor space grew 39 percent. The GHG emissions associated with the sector's energy use, including electricity-related emissions, increased 29 percent over the same period. However, between 2008 and 2009, GHG emissions including electricity-related emissions decreased 5 percent. This was attributable to a combination of two factors: a marked drop in the emission factor related to electricity generation and a decrease in electricity consumption. The decrease in the emission factor was caused by a significant decrease in coal used to generate electricity in 2009. The decrease in electricity consumption was significant in Ontario, where total energy consumption decreased 6 percent in 2009 compared with 2008, while electricity consumption alone fell 10 percent. This was attributable mainly to a decrease in space cooling energy use because the summer was cooler in 2009 than in 2008. And, to a lesser extent, the 2008 recession indirectly affected some commercial and institutional activities.

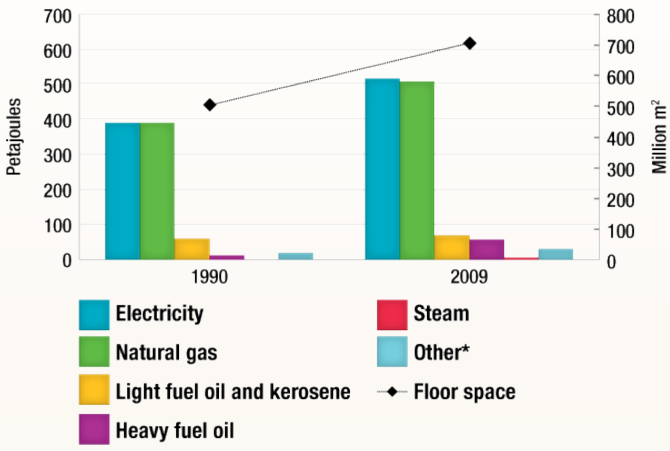
Natural gas and electricity continued to be the main energy sources for the commercial/institutional sector, accounting for 87 percent of total energy use (Figure 4.5). Electricity is the primary energy source for lighting, space cooling, auxiliary motors and equipment. Natural gas and the remaining 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 11 percent of the total energy use in the commercial/institutional sector in 2009. The bulk of these products were used in Quebec (43 percent). These products were used in a smaller proportion in the Atlantic provinces (23 percent) and Ontario (16 percent). According to the 2008 *Commercial and Institutional Consumption of Energy Survey* (CICES), petroleum products were used mainly in educational services (especially universities), health care, retail services and public administration.

However, rapid growth in these petroleum products has been observed since 1999 – especially in consumption of heavy fuel oil, which increased 224 percent.

One reason for these product increases may be that secondary distribution of fuel marketers is included in the commercial/institutional sector, but these marketers find their way out of the sector through re-sellers to industry and transportation. To help account for this activity, NRCan and Environment Canada sponsored Statistics Canada to conduct the *Survey of Secondary Distributors of Refined Petroleum Products* (SDRPP) in 2010. This survey could have a significant impact on the energy demand statistics for refined petroleum after the data have been integrated in the *Report on Energy Supply and Demand in Canada* (RESD).

Figure 4.5 – Commercial/institutional energy use by fuel type and floor space, 1990 and 2009



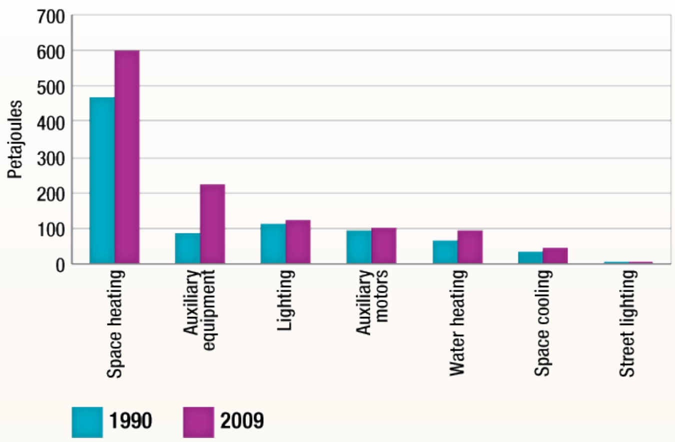
* "Other" includes coal and propane.

The rapid expansion of electronic equipment use, such as computers, faxes and printers, has added to energy use in Canada since 1990.

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

Energy used for space heating increased 26 percent between 1990 and 2009. While space heating continues to be the primary end-use in the sector, auxiliary equipment use has shown a large increase in energy requirement (170 percent) resulting, in part, from increasing computerization of work spaces (Figure 4.6).

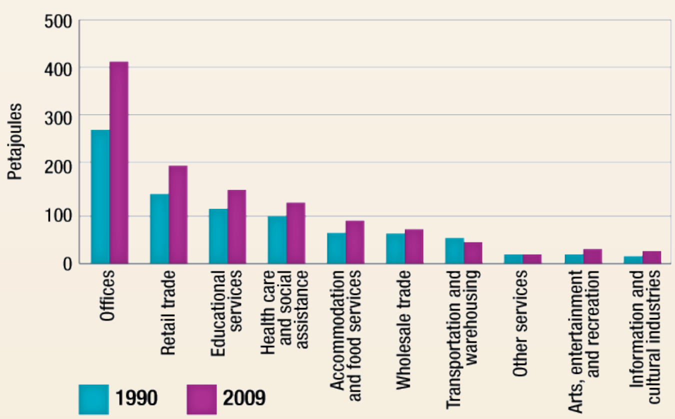
Figure 4.6 – Commercial/institutional energy use by end-use, 1990 and 2009



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 2009 (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 143.4 PJ more energy in 2009 than in 1990, followed by retail trade and educational services, which saw increases of 59 and 37 PJ, respectively.

Figure 4.7 – Commercial/institutional energy use by activity type, 1990 and 2009

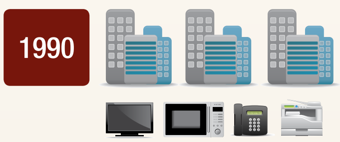


Thirteen million people worked in Canada's commercial/institutional sector in 2009.[6]

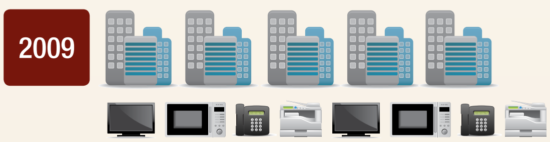
Several indicators can help describe the growth in energy use in the commercial/institutional sector, including the number of employees, floor space and GDP. Figure 4.8 shows that floor space had increased 39 percent since 1990 and the number of employees in this sector had increased 40 percent.

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 2009



Floor space: 509.9 million m²
Employees: 9 million
GDP: $477 billion ($2002)



Floor space: 709.5 million m²
Employees: 13 million
GDP: $829 billion ($2002)

Commercial/institutional energy intensity and efficiency

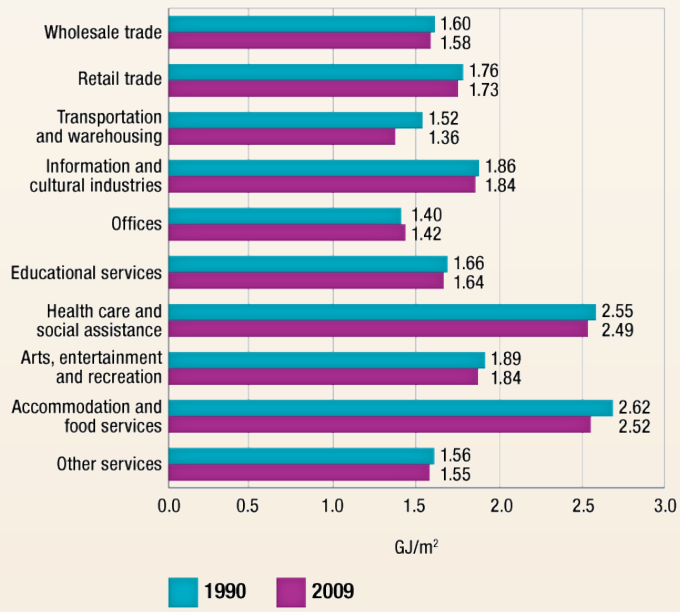
Energy intensity

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/m²).

As shown in Figure 4.9, accommodation and food services consumed 2.52 GJ/m² in 2009, followed by health care and social assistance, which consumed 2.49 GJ/m². They are the most energy-intensive activity types despite a slight decrease observed in the energy intensity of the 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 proliferation of electronic equipment with high energy requirements (such as medical scanners).

Figure 4.9 – Commercial/institutional energy intensity by activity type, 1990 and 2009



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

The commercial/institutional sector as a whole experienced a small 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 21 percent when measured against economic activity (PJ/GDP).

Energy efficiency

Energy efficiency improvements in Canada have resulted in energy savings of $3 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 146.9-PJ energy savings for this sector between 1990 and 2009 (Figure 4.10).

Figure 4.10 – Commercial/institutional energy use, with and without energy efficiency improvements, 1990–2009

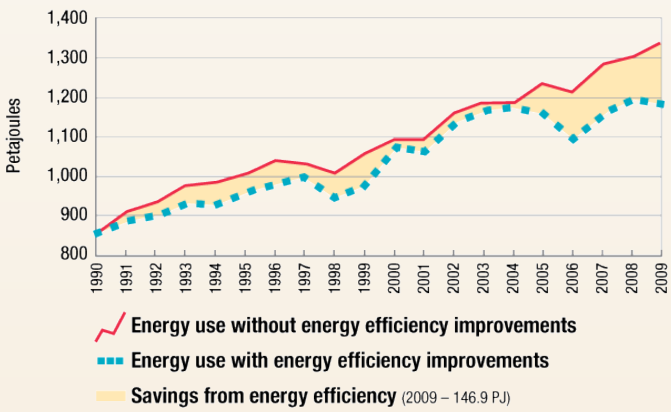
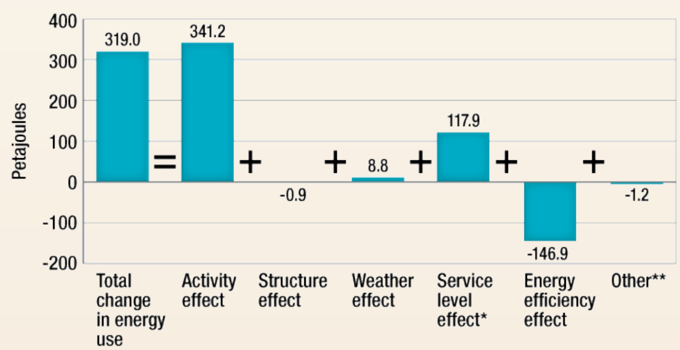


Figure 4.11 illustrates the influence that various factors had on the change in commercial/institutional sector energy use between 1990 and 2009. These effects are as follows:

- **activity effect** – A 39 percent increase in floor space led to a 40 percent (341.2 PJ) growth in energy use and a 17.5 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 2009, the winter was colder and the summer was cooler than in 1990. The net result was an 8.8 PJ increase in energy demand in the commercial/institutional sector, mainly for space conditioning, which had the effect of increasing GHG emissions by 0.5 Mt.
- **service level effect** – An increase in the service level of auxiliary equipment, which is the penetration rate of office equipment (e.g. computers, fax machines and photocopiers), led to a 117.9-PJ increase in energy use and a 6.1 Mt increase in GHG emissions.
- **energy efficiency effect** – Improvements in the energy efficiency of the commercial/institutional sector saved 146.9 PJ of energy and 7.5 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, 1990–2009



* "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 2009 alone, these industries spent $33.3 billion for energy. Total energy use by industry accounted for 37 percent of the total energy use (see Figure 5.1) and 31 percent of end-use GHG emissions (see Figure 5.2).

Figure 5.1 – Secondary energy use by sector, 2009

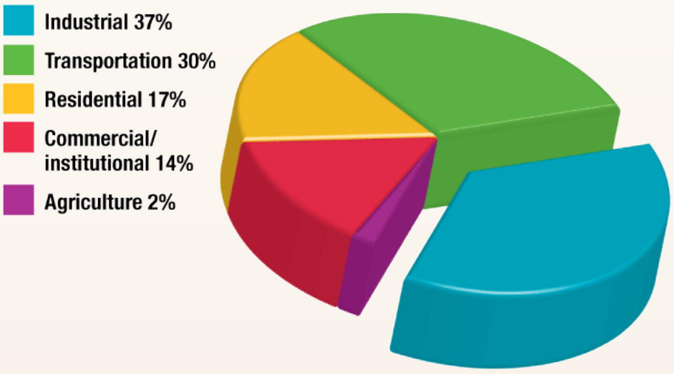
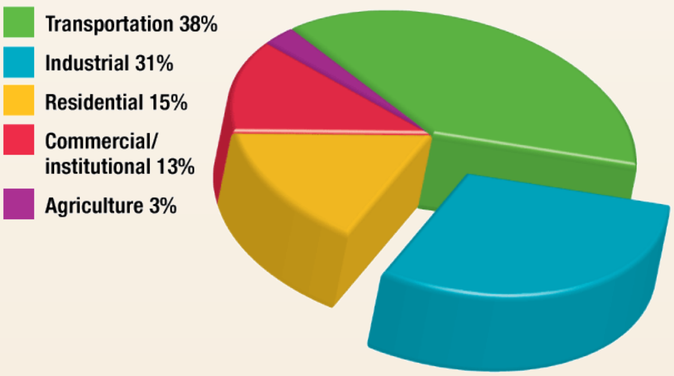


Figure 5.2 – GHG emissions by sector, 2009



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

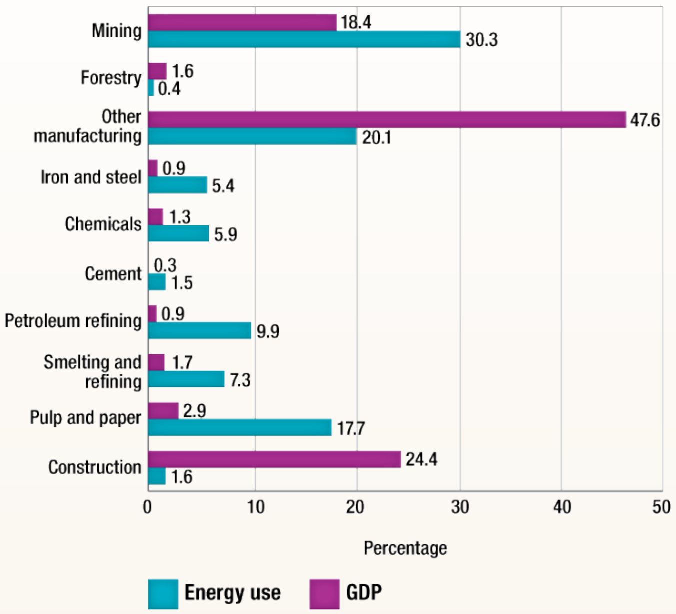
In 2009, the industrial sector's share of GDP accounted for 23 percent of the Canadian total (excluding agriculture). The main contributor to industrial GDP was "other manufacturing," which includes the food and beverage, textile, computer and electronic industries. Construction and mining were the only other 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 24 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 12 percent while industrial capacity utilization fell from 78.0 percent to 69.6 percent. Sectors such as mining, transportation equipment, and iron and steel showed significant declines in 2009. 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, 2009



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 2009, meeting 37 percent and 21 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.

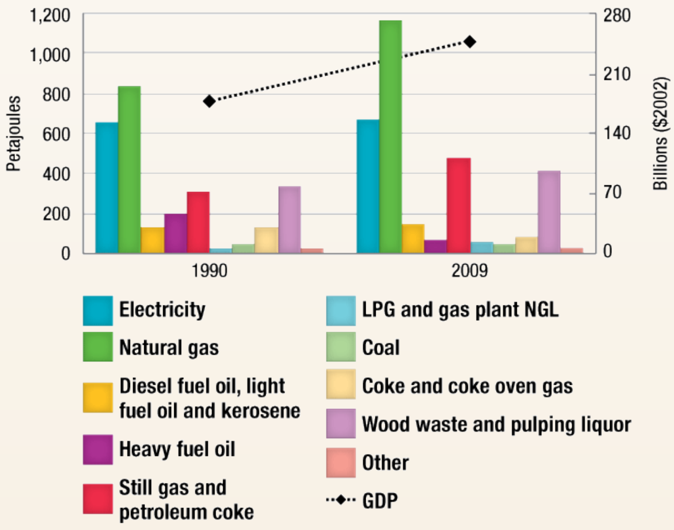
The type of energy used varies greatly depending on the industries in which it is used. Although electricity is used across the entire sector, the smelting and refining industry requires the most electricity, accounting for almost 28 percent of the sector's electricity use.

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 2009, industrial energy use increased 17 percent, from 2710.0 PJ to 3168.4 PJ. The associated end-use GHGs increased 8 percent, from 134.3 Mt to 144.5 Mt. GDP increased 25 percent, from $221 billion ($2002) in 1990 to $276 billion ($2002) in 2009 (see Figure 5.4).

Figure 5.4 – Industrial energy use by fuel type and GDP, 1990 and 2009



In most cases, fuel shares remained relatively constant between 1990 and 2009 because fuel consumption increased for most fuel types during this period. The exceptions were heavy fuel oil (HFO), which experienced a 67 percent decrease, and coke and coke oven gas, which decreased 30 percent.

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

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

Trends – Mining energy use and GHG emissions

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

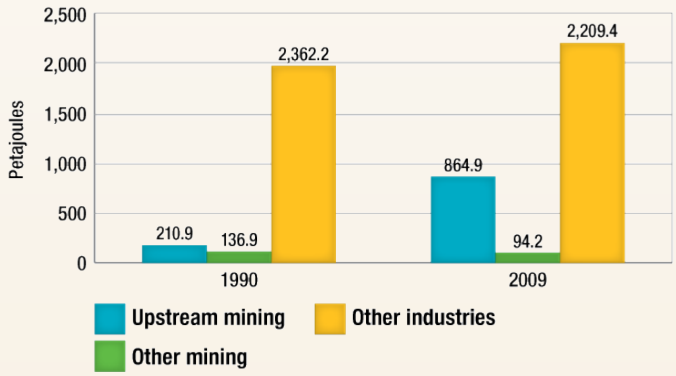
Since 1990, the mining industry's energy consumption grew 176 percent and its associated end-use emissions grew 154 percent. The GDP of the mining industry increased 30 percent over the 1990–2009 period, from $38.9 billion ($2002) to $50.6 billion ($2002), compared with a 25 percent increase for the entire industrial sector.

Upstream mining was the biggest contributor to mining's GDP, representing 90 percent ($45.4 billion) in 2009. Activity in the oil sands was the main driver in the increase in energy demand from the mining industries.

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

The production of bitumen and synthetic crude oil in 1985 was 35,000 cubic metres per day (m^3/day). It reached 71,000 m^3/day by 1996 and climbed to 212,000 m^3/day by 2009. This increase is the principal factor explaining the increase of 310 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 2009



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

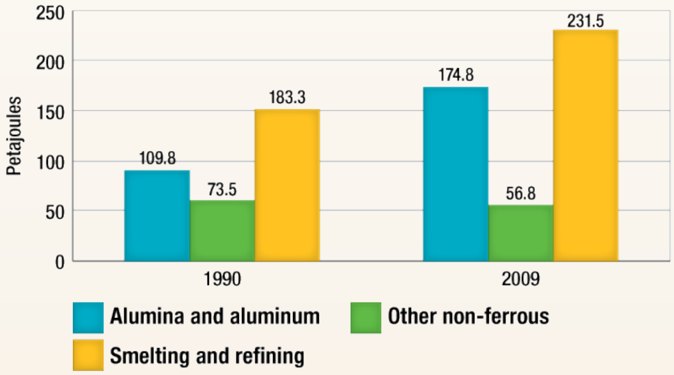
[8] NAICS code 21 excluding 213118, 213119 and part of 212326

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 \$4.6 billion (\$2002) in 2009 – a 67 percent increase. During the same period, associated GHG emissions increased 10 percent.

Figure 5.6 – Smelting and refining energy use by selected industry, 1990 and 2009



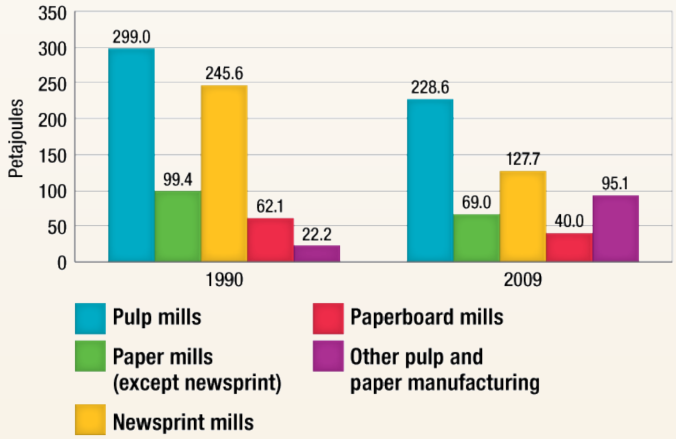
The production of aluminum grew 93 percent between 1990 and 2009 and is responsible for most of the 59 percent growth in energy use in this subsector since 1990 (see Figure 5.6).

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 has decreased its energy use by 23 percent since 1990 and now represents 18 percent of sectoral energy use. The largest decline came from the newsprint mill industry, with a 48 percent decrease since 1990 (see Figure 5.7). GHG emissions have decreased 57 percent since 1990 for the sector as a whole.

Figure 5.7 – Energy consumption by subsector of the pulp and paper industry, 1990 and 2009



Trends – Other manufacturing energy use and GHG emissions

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

Other manufacturing energy use increased from 551.1 PJ to 635.9 PJ between 1990 and 2009. GHG emissions were about 28 Mt in both 1990 and 2009, while GDP increased from $102.3 billion ($2002) to $131.3 billion ($2002).

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

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

The wood products industry represented 7 percent of the other manufacturing subsector's energy use, with 47.2 PJ. Its average annual increase was 0.3 percent.

Detailed energy use data are taken from the *Industrial Consumption of Energy* survey for 1990 and from 1995 onward. Data for 1991–1994 are from the Canadian Industrial End-Use Energy Data and Analysis Centre's (CIEEDAC's) report *Energy Intensity Indicators for Canadian Industry 1990–2009*. Previously, all detailed energy use data came from the CIEEDAC report. This means that detailed industry categories will not compare exactly with those of previous years.

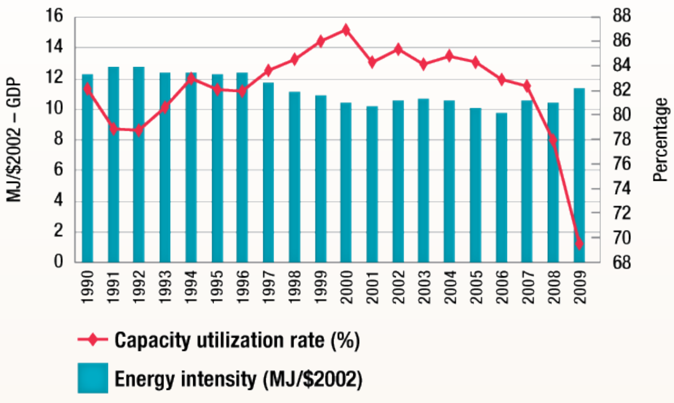
Industrial energy intensity and efficiency

Energy intensity

Several factors influenced the trends in energy use and energy intensity. Since 1990, energy intensity has decreased at an average annual rate of 0.3 percent, from 12.3 MJ/$2002 – GDP in 1990 to 11.5 MJ/$2002 – GDP in 2009 (see Figure 5.8). Note that between 2008 and 2009, energy intensity increased 12 percent, while capacity utilization fell 8.4 percentage points to 69.6 percent. This is well below the 78.9 percent capacity utilization[9] seen during the 1991 recession.

[9] 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.

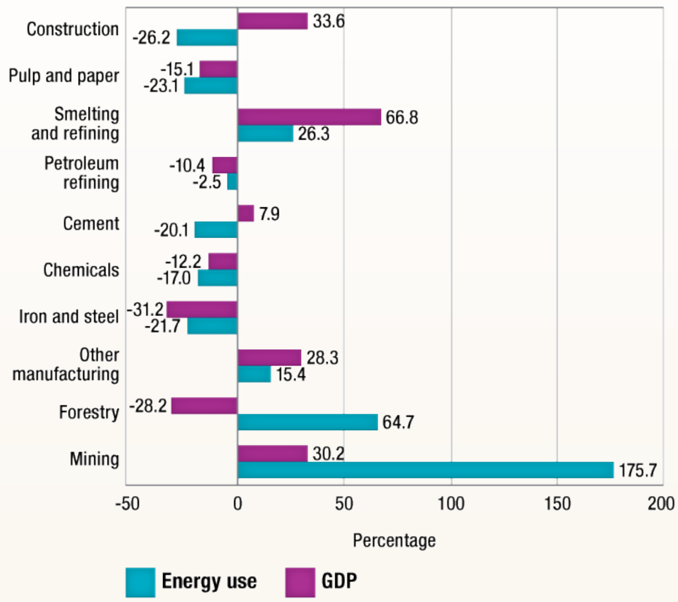
Figure 5.8 – Capacity utilization and energy intensity per year



At the aggregate industry level, 6 of the 10 industries reduced their energy intensity[10] over the 1990 to 2009 period. Four industries experienced an increase: mining, petroleum refining, forestry, and iron and steel. The biggest increase in energy intensity was 129 percent in forestry. Figure 5.9 illustrates that energy use in forestry increased 65 percent, while GDP fell 28 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.

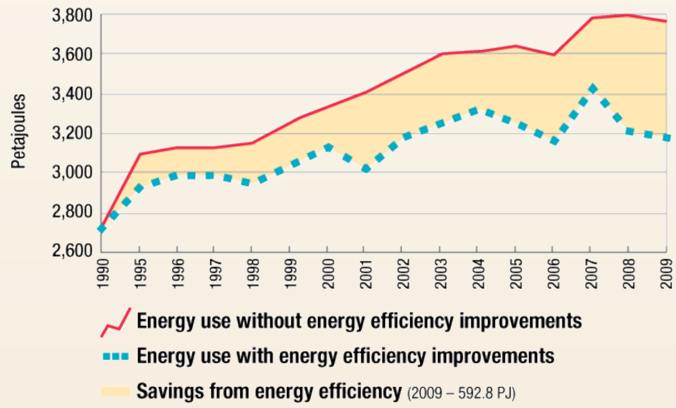
Figure 5.9 – Change in GDP and energy use, 1990–2009



Energy efficiency

In 2009, Canadian industry saved $6.2 billion in energy costs due to energy efficiency improvements. Industry saved 592.8 PJ of energy and 27.0 Mt of GHG emissions (see Figure 5.10). As indicated earlier, this year's analysis incorporates an assessment of the influence of variation in capacity utilization.[11]

Figure 5.10 – Industrial energy use, with and without energy efficiency improvements, 1990–2009



Note: 1991–1994 data are not available.

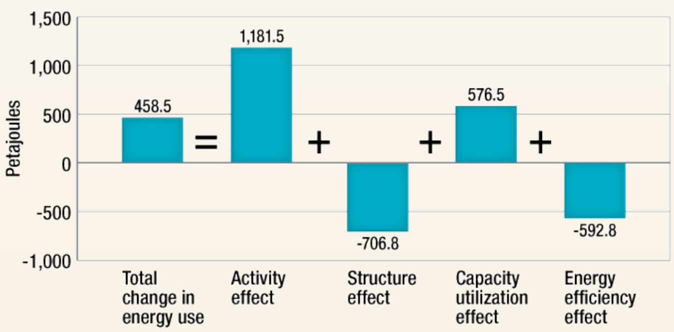
[10] MJ/($2002) – GDP

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

Figure 5.11 illustrates the influence that various factors had on the change in industrial energy use between 1990 and 2009. These effects are the

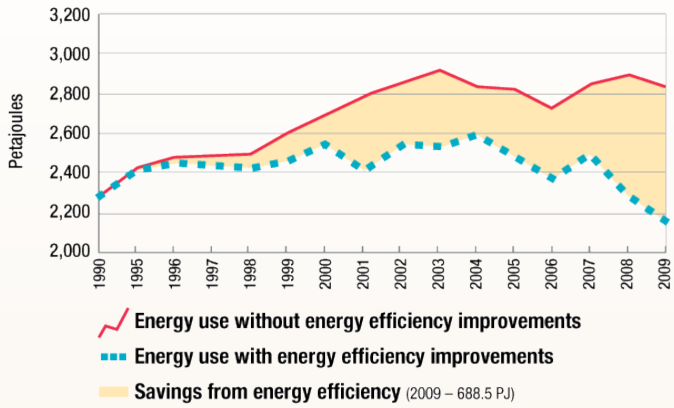
- **activity effect** – Activity (the mix of GDP, GO and production units) increased the energy use by 44 percent, or 1,181.5 PJ, and GHG emissions by 53.9 Mt.
- **structure effect** – The structural changes in the industrial sector, specifically, a relative decrease in the activity share of energy-intensive industries, helped the sector to reduce its energy use and GHG emissions by 706.8 PJ and 32.2 Mt, respectively.
- **capacity utilization effect** – The capacity utilization effect increased industrial energy use by 576.5 PJ and emitted 26.3 Mt more GHGs.
- **energy efficiency effect** – Improvements in the energy efficiency of the industrial sector avoided 592.8 PJ of energy use and 27.0 Mt of GHG emissions.

Figure 5.11 – Impact of activity, structure, energy efficiency and capacity utilization on the change in industrial energy use, 1990–2009



Furthermore, manufacturing energy efficiency savings grow to 688.5 PJ in 2009 if we factor out capacity utilization (see Figure 5.12).

Figure 5.12 – Manufacturing energy use, with and without energy efficiency improvements, 1990–2009

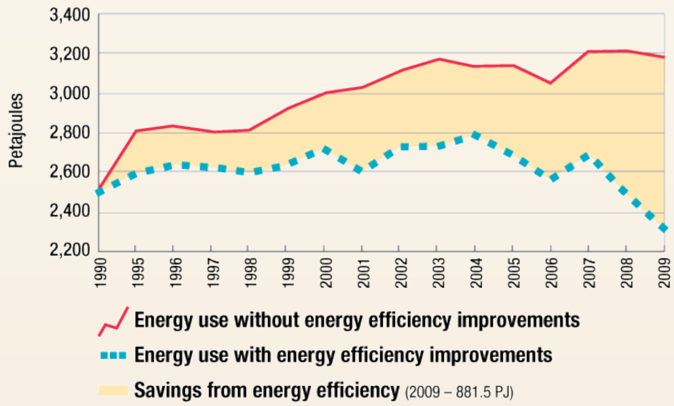


Note: 1991–1994 data are not available.

Also, to provide a better assessment of energy efficiency gains from the rest of the industry, the factorization 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 881.5 PJ of savings (see Figure 5.13).

Figure 5.13 – Industrial energy use, with and without energy efficiency improvements (without upstream mining), 1990–2009

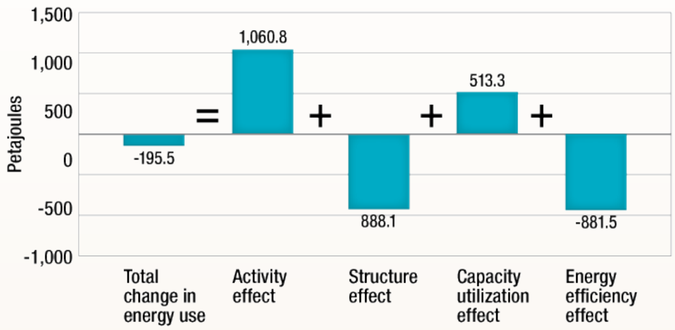


Note: 1991–1994 data not available.

Figure 5.14 presents the 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 1,060.8 PJ and GHG emissions by 47.2 Mt.
- **structure effect** – The structural changes in the industrial sector helped the sector to reduce its energy use and GHG emissions by 888.1 PJ and 39.5 Mt, respectively.
- **capacity utilization effect** – The capacity utilization effect increased energy use by 513.3 PJ and emitted 26.3 Mt more GHGs.
- **energy efficiency effect** – Improvements in the energy efficiency of the industrial sector avoided 881.5 PJ of energy use and 39.2 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), 1990–2009



Transportation sector

Chapter 6

Overview – Transportation energy use and GHG emissions

Transportation was second to the industrial sector in terms of energy use but was first in terms of the amount spent on energy in 2009.

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

In 2009, Canadians (individuals and companies) spent $63.4 billion on transportation energy, the most of any sector in Canada and 90 percent more than the industrial sector. This high level of spending is a result of the notably higher price of transportation fuels compared with the price of energy used in other sectors.

The transportation sector accounted for the second largest amount of energy use in Canada, 30 percent of the total (Figure 6.1), and the largest amount of energy-related GHG emissions, 38 percent (Figure 6.2). This sector produces a larger share of the GHG emissions because the main fuels used for transportation are more GHG-intensive compared with those for other sectors of the economy.

Figure 6.1 – Secondary energy use by sector, 2009

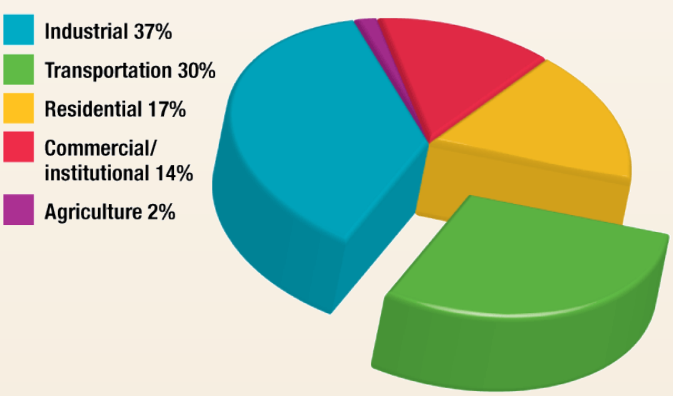
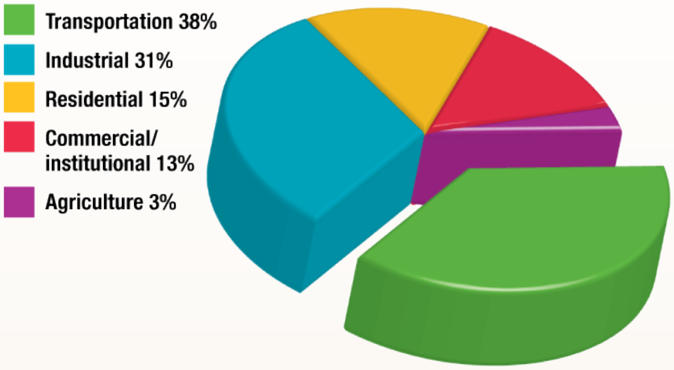
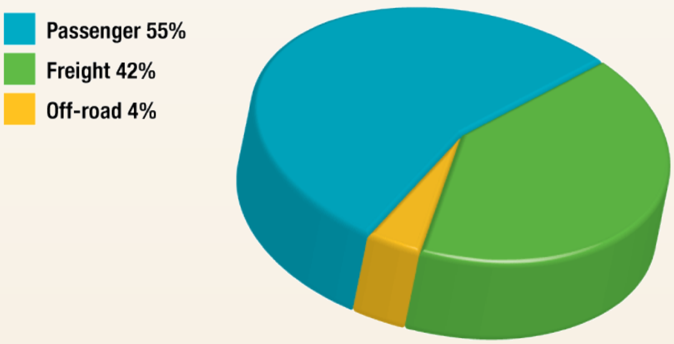


Figure 6.2 – GHG emissions by sector, 2009



In the transportation sector, passenger modes consumed 55 percent of total energy use, while the freight subsector accounted for 42 percent and off-road vehicles used the remaining 4 percent (Figure 6.3). Off-road vehicles include all vehicles that are principally used off public roads, such as snowmobiles and lawnmowers. Off-road transportation is not analysed in this report, because few data are available for these vehicles and their share of energy consumption is small.

Figure 6.3 – Energy use by subsector, 2009



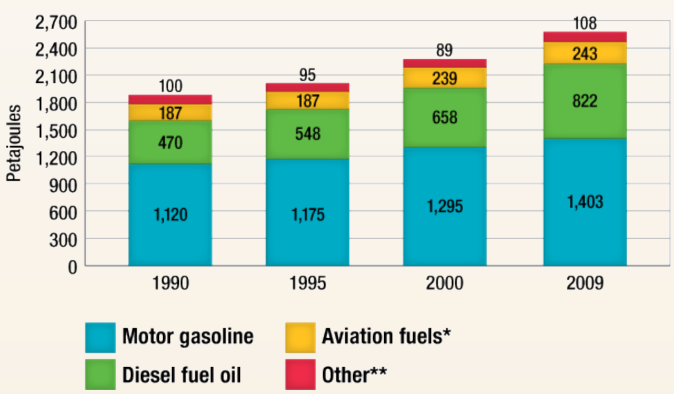
Trends – Transportation energy use and GHG emissions

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

Between 1990 and 2009, total transportation energy use increased 37 percent, from 1,877.9 PJ to 2,576.6 PJ, and the associated GHG emissions rose 36 percent, from 131.4 Mt to 178.3 Mt.

Freight was the fastest growing subsector, accounting for 62 percent of the change in total transportation energy use. The increased use of heavy trucks, which are relatively more energy-intensive when compared with the other modes, accounts alone for 81 percent of this increase in freight energy use and 50 percent of the increase in total transportation.

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



* "Aviation fuels" includes aviation turbo fuel and aviation gasoline.

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

Growth in freight transportation contributed to a 75 percent increase in the demand for diesel fuel.

Motor gasoline and diesel fuel oil, as seen in Figure 6.4, are the main fuels used in the transportation sector, accounting for 86 percent of the total energy use. In order of amount used, aviation turbo fuel, heavy fuel oil (HFO), ethanol, propane, aviation gasoline, electricity and natural gas are also reported. Motor gasoline dominates the market with 54 percent of the total transportation energy, followed by diesel at 32 percent and finally by other energy sources, which account for 14 percent.

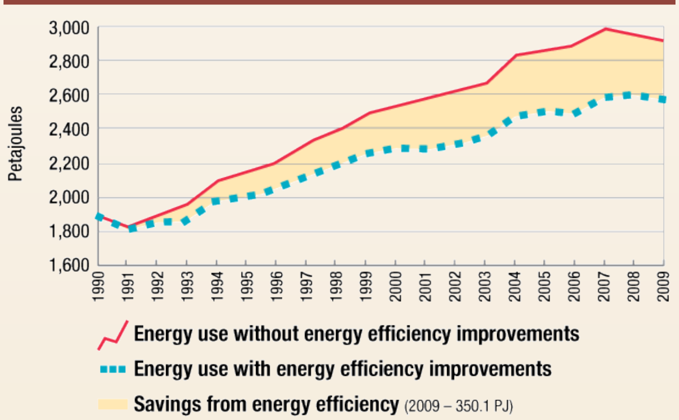
Between 1990 and 2009, diesel fuel consumption increased 75 percent due to more widespread use of heavy trucks on Canadian roads, which alone accounts for more than 99 percent of this increase. However, motor gasoline use has increased 25 percent, of which more than a half (152.4 PJ) can be attributed to passenger vehicles and about a third (90.9 PJ) to freight transportation. Aviation gasoline, propane, HFO and electricity are transportation fuels whose consumption decreased over the period.

Transportation energy efficiency

Energy efficiency improvements in transportation resulted in energy savings of 350.1 PJ, or $8.7 billion, for Canada in 2009.

Between 1990 and 2009, energy efficiency in the transportation sector improved 19 percent, leading to savings of $8.7 billion, or 350.1 PJ of energy (Figure 6.5). These savings were largely a result of improvements in the energy efficiency of passenger light-duty vehicles. Savings generated by this improvement had a significant impact on total energy use because they comprised a large share of vehicles on the road.

Figure 6.5 – Transportation energy use, with and without energy efficiency improvements, 1990–2009



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

Trends – Passenger transportation energy use and GHG emissions

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

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

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

Figure 6.6 – Passenger transportation energy indicators, 1990 and 2009

1990

- 14.2 million vehicles
- 19.3 percent are light trucks
- 17,746 km/yr on average
- 375.9 billion Pkm travelled
- 0.68 vehicles per person aged 18 years and older

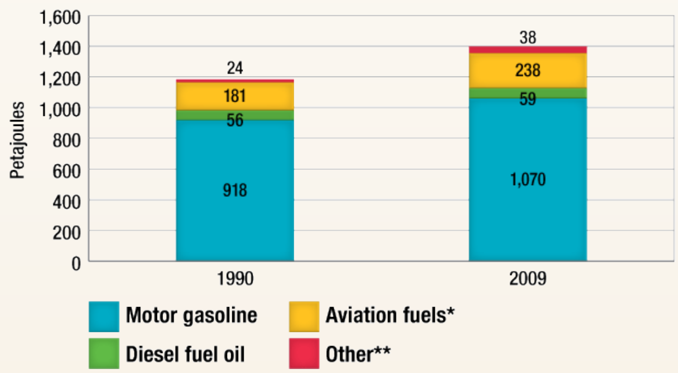
2009

- 19.2 million vehicles
- 33.6 percent are light trucks
- 17,373 km/yr on average
- 594.1 billion Pkm travelled
- 0.71 vehicles per person aged 18 years and older

Between 1990 and 2009, the number of vehicles per person aged 18 years and older increased slightly, from 0.68 in 1990 to 0.71 by 2009. The distance in passenger-kilometres accumulated by light-weight vehicles for the purpose of passenger transportation (excluding urban transportation and buses) increased on average by 2.0 percent per year. The distance in passenger-kilometres for urban transportation and buses increased on average by 1.9 percent per year in the same period. There is therefore a relative decrease in the share of public transit. The energy use for passenger transportation rose by 19 percent, from 1,179.0 PJ to 1,405.8 PJ between 1990 and 2009. The associated GHG emissions increase was 17 percent, from 81.7 to 95.5 Mt.

The mix of fuels for passenger transport has remained relatively constant. Motor gasoline was the main source of energy, representing 76 percent of the fuel mix in 2009, followed by aviation turbo fuel and diesel fuel (Figure 6.7).

Figure 6.7 – Passenger transportation energy use by fuel type, 1990 and 2009



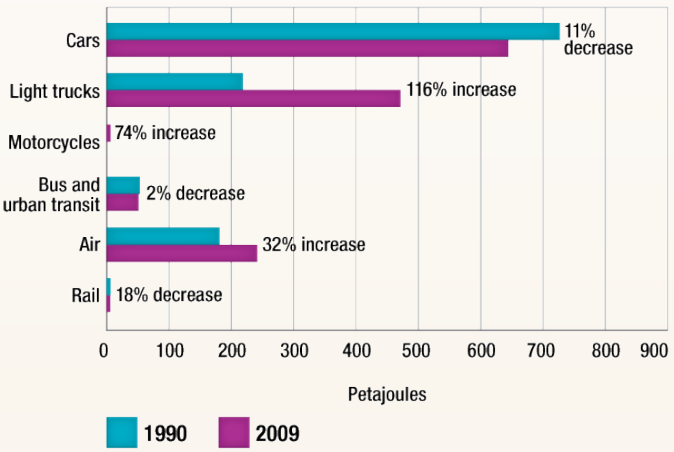
* "Aviation fuels" includes aviation turbo fuel and aviation gasoline.

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

More Canadians drive minivans and SUVs.

The choices that Canadians make to meet their transportation needs contribute to the growth in energy use. A greater share of Canadians bought light trucks (including minivans and sport utility vehicles [SUVs]), which usually have less favourable fuel consumption ratings than cars. In 2009, 41 percent of all new passenger vehicle sales were light trucks, compared with 26 percent in 1990. This change, characterized by a shift away from the use of cars to the use of light trucks, brought about a large increase in passenger transportation energy use. Between 1990 and 2009, light-truck energy use increased more quickly than any other passenger transportation mode, rising 116 percent (Figure 6.8).

Figure 6.8 – Passenger transportation energy use by mode, 1990 and 2009



Air transport is rising in popularity.

Canadians have been steadily increasing their use of air transportation since 1990. Between 1990 and 2009, aviation passengers' activity increased 84 percent.

However, in the same period, growth in energy use was significantly less at 32 percent, pointing to the increasing efficiency of the industry. Two key factors have contributed to this improvement in efficiency. The first factor is the growing effort on the part of carriers to match their aircraft size with the size of the market by increasing their overall load factor. The second factor is the implementation of the "Open Skies" agreement between Canada and the United States, which came into effect in 1994–1995. The agreement made it possible to add several short routes provided by regional carriers with smaller aircraft.[12]

Passenger transportation energy intensity and efficiency

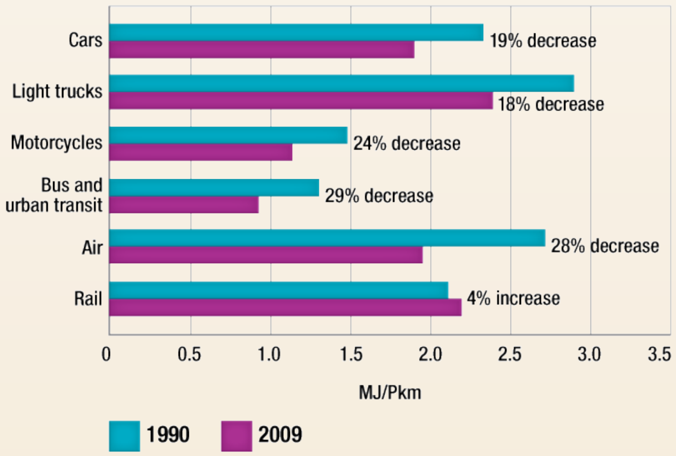
Energy intensity

Passenger transportation energy intensity is defined as the amount of energy required to move one person over 1 kilometre. Between 1990 and 2009, energy intensity decreased by 17 percent, from 2.3 MJ per Pkm travelled to 1.9 MJ/Pkm. An improvement in vehicle fuel efficiency is the main reason for this change. Average fuel efficiency is measured by litres used per 100 kilometres (L/100 km).

Figure 6.9 shows that the average fuel efficiency improved for all types of transportation except rail for the period 1990–2009. Bus and urban transit achieved the greatest improvement in energy intensity with a decrease of 29 percent, followed by air transportation with 28 percent. In third place are motorcycles with a reduction of 24 percent. Finally, cars and light trucks improved by 19 percent and 18 percent, respectively. Passenger rail intensity was 4 percent higher than in 1990.

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

Figure 6.9 – Passenger transportation energy intensity, by modes, 1990 and 2009



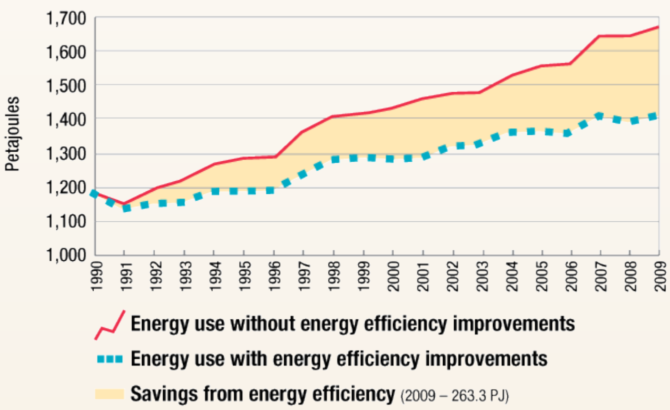
[12] Transport Canada, *Assumptions Report 2007–2021: Final Report*, Ottawa, December 2007.

Energy efficiency

Energy efficiency improvements in passenger transportation generated energy savings of 263.3 PJ, or $6.7 billion, in the transportation sector in 2009.

The amount of energy used for passenger travel increased 19 percent, rising from 1,179.0 PJ in 1990 to 1,405.8 PJ in 2009. Also, energy-related GHG emissions increased 17 percent, from 81.7 Mt to 95.5 Mt.[13] As seen in Figure 6.10, without energy efficiency improvements, energy use would have increased 42 percent during the period, instead of the observed 19 percent.

Figure 6.10 – Passenger transportation energy use, with and without energy efficiency improvements, 1990–2009

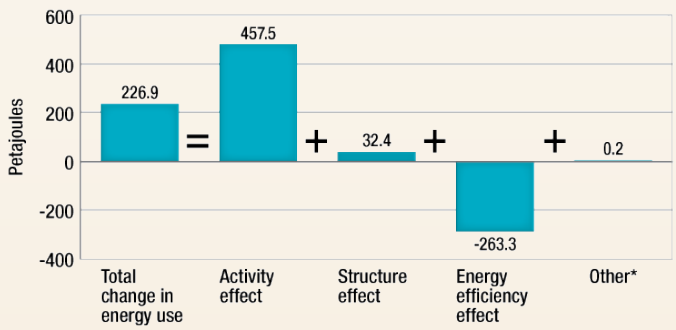


Note: The presented data do not include non-commercial airline aviation.

Figure 6.11 illustrates the influence of various factors on the change in passenger transportation energy use between 1990 and 2009. These effects are the following:

- **activity effect** – The activity effect (i.e. passenger-kilometres travelled) increased energy use by 45 percent, or 457.5 PJ, with a corresponding 31.1-Mt increase in GHG emissions. This rise in passenger-kilometres (and therefore, activity effect) is mainly due to an increase of 161 percent in the light-truck activity and 84 percent in air transportation.
- **structure effect** – Changes to the mix of transportation modes, or the relative share of passenger-kilometres travelled by air, rail and road, are used to measure changes in structure. Therefore, an overall change in the structure would result in a decrease (increase) in energy use if a relative share of a more (or less) efficient transportation mode increases relative to other modes. The relative shares of passenger-kilometres have seen a strong increase in passenger air transportation and light trucks. The overall effect on the structure was positive, given that the popularity of minivans and SUVs increased the activity share of light trucks compared with other modes, contributing to a 32.4-PJ increase in energy consumption and a 2.2-Mt increase in GHG emissions.
- **energy efficiency effect** – Improvements in the energy efficiency of passenger transportation produced energy savings of 263.3 PJ and helped prevent the release of 17.9 Mt of energy-related GHG emissions. The light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation represented 73 percent of these energy savings.

Figure 6.11 – Impact of activity, structure and energy efficiency on the change in passenger transportation energy use, 1990–2009



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

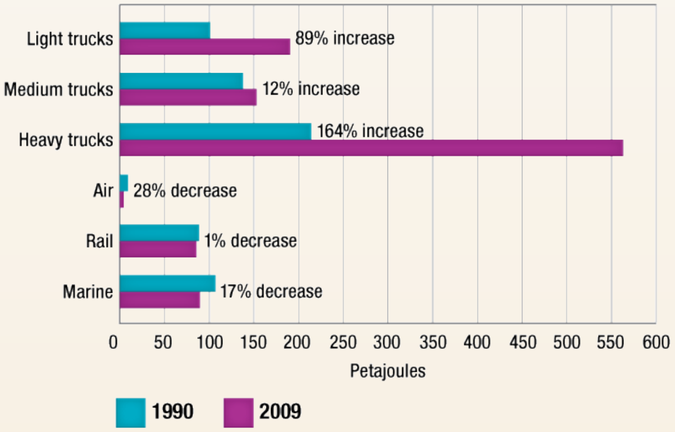
[13] Electricity accounts for only 0.2 percent of total passenger transportation energy use and is used, for the most part, for urban transit.

Trends – Freight transportation energy use and GHG emissions

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

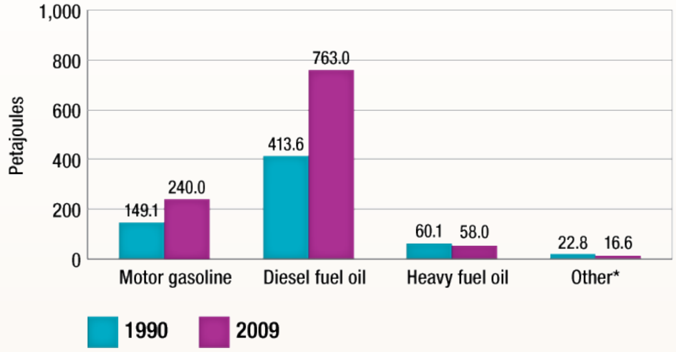
Freight energy use increased 67 percent, from 645.6 PJ in 1990 to 1,077.6 PJ in 2009. As a result, energy-related GHG emissions produced by freight transportation increased 66 percent, from 46.0 Mt in 1990 to 76.5 Mt in 2009. Figure 6.12 illustrates that energy use increased for all modes of freight trucking. Heavy and light trucks showed the largest increase in energy use, accounting for the majority of energy consumed for freight transportation in 2009. However, marine, rail and air declined 17 percent, 1 percent and 28 percent, respectively.

Figure 6.12 – Freight transportation energy use by mode, 1990 and 2009



The mix of fuels used in the freight subsector remained relatively constant between 1990 and 2009. Diesel fuel continued to be the main source of energy, comprising 71 percent of the fuel consumed for freight transportation in 2009 (Figure 6.13).

Figure 6.13 – Freight transportation energy use by fuel type, 1990 and 2009



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

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

The move toward just-in-time inventory for many companies has had a major impact on the freight subsector. Just-in-time inventory limits the use of warehouse space for inventory and instead relies on orders arriving at the company just as they are required for production. By using transportation vehicles as virtual warehouses, companies require an efficient and on-time transportation system, such needs usually being met by the use of heavy trucks. As a result, heavy truck use for freight transportation has been increasingly significant over the period between 1990 and 2009 (Figure 6.14).

During the same period, the number of heavy trucks increased 19 percent, and the average distance travelled increased 15 percent to reach 82,863 km per year. However, heavy trucks are not only travelling longer distances but also carrying more freight as the number of trailers they pull increases. These factors are having a major impact on the tonne-kilometres and energy use that heavy trucks are contributing to the freight subsector.

Figure 6.14 – Freight transportation energy indicators, 1990 and 2009

1990

- 1.9 million freight trucks
- 297,000 heavy trucks
- 72,005 km/yr on average for heavy trucks
- 103.3 billion truck Tkm travelled

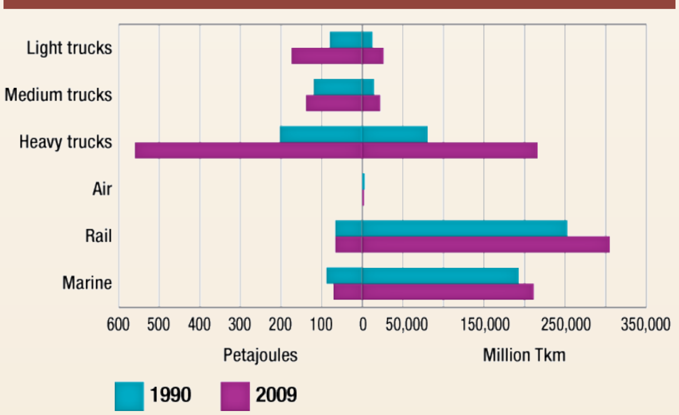
2009

- 3.3 million freight trucks
- 353,000 heavy trucks
- 82,863 km/yr on average for heavy trucks
- 258.9 billion truck Tkm travelled

Rail remains the main mode for moving goods in Canada.

For many commodities, such as coal and grain, trucks are not an efficient means of transportation. Instead, rail and marine are still heavily relied upon. As a result, they make up the largest portions of the freight sector's activity. Rail ranks first in terms of tonne-kilometres in transported goods, with 299.6 billion Tkm in 2009, or 21 percent more than in 1990. The use of heavy trucks surpassed all other modes, with a 173 percent growth since 1990. In third position, marine transportation was used for 208.0 billion Tkm in 2009, an increase of 10 percent relative to 1990.

Figure 6.15 – Freight transportation energy use versus activity by mode, 1990 and 2009



Since 1990, all modes of freight transportation have become more efficient in terms of energy use relative to tonne-kilometres moved. Figure 6.15 shows that the relative efficiency of rail and marine is greater than that of trucks at moving goods. These two modes of transportation have two of the highest levels of activity and a relatively low energy use. However, over the period, trucks increased in efficiency because their on-road average fuel consumption improved, from 42.5 L/100 km in 1990 to 33.4 L/100 km in 2009.

Freight transportation energy efficiency

Energy efficiency improvements in freight transportation resulted in energy savings of 86.8 PJ, or $2 billion, in the transportation sector in 2009.

Between 1990 and 2009, energy use by freight transportation increased 67 percent, from 645.6 PJ to 1,077.6 PJ. Without energy efficiency improvements, energy use would have increased 80 percent, or 13 percent more than observed in 2009 (Figure 6.16).

Figure 6.16 – Freight transportation energy use, with and without energy efficiency improvements, 1990–2009

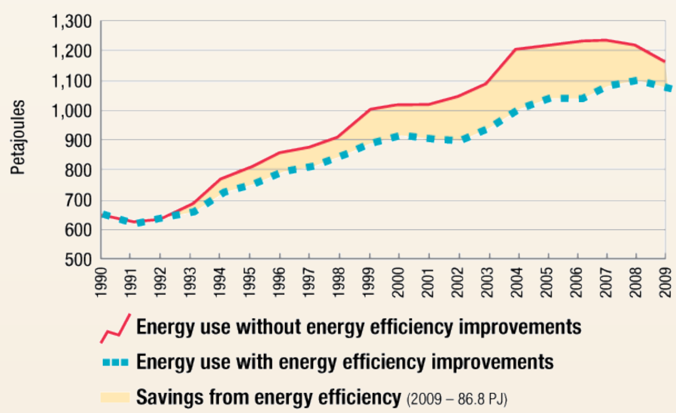


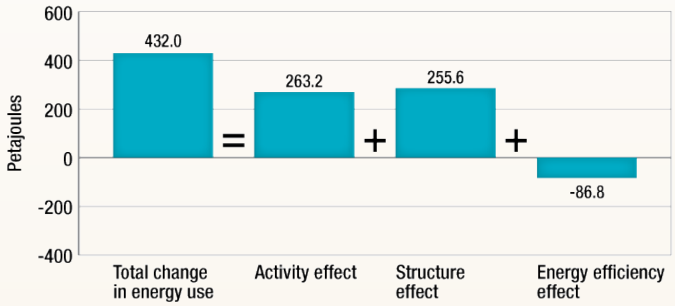
Figure 6.17 illustrates the influence that various factors had on the change in freight transportation energy use between 1990 and 2009. These effects are the following:

- **activity effect** – The activity effect (i.e. tonne-kilometres moved) increased energy use by 41 percent, or 263.2 PJ, and caused a corresponding 18.7-Mt increase in GHG emissions. This increase in the number of tonne-kilometres was mainly due to an increase of 173 percent in heavy-trucks activity and an increase of 41 percent in medium-trucks activity.

- **structure effect** – Changes to the mix of transportation modes, or the relative share of tonne-kilometres travelled by air, marine, rail and road, are used to measure changes in structure. Therefore, an overall change in the structure would result in a decrease (increase) in energy use if a relative share of a more (or less) efficient transportation mode increases relative to other modes. The shift between modes was the increase in the share of freight moved by heavy trucks relative to other modes. The overall effect on the structure was positive, given the increase in Canada-United States trade and the just-in-time delivery demanded by clients, thus contributing to a more intensive use of truck transportation. Therefore, the analyses show an increase of 255.6 PJ in energy use and 18.1 Mt more in GHG emissions due to the structure effect.

- **energy efficiency effect** – Improvements in the energy efficiency of freight transportation saved 86.8 PJ of energy and 6.2 Mt of GHG emissions. Improvements in freight trucks, mainly light and medium, were a large contributor, representing 79 percent of the savings.

Figure 6.17 – Impact of activity, structure and energy efficiency on the change in freight transportation energy use, 1990–2009



Appendices

Appendix A: Reconciliation of data

Table A.1 Reconciliation of data with Canada's *Report on Energy Supply and Demand in Canada* (RESD) – 2009

	RESD data (PJ)	Residential wood (PJ)	Commercial & public admin. diesel (PJ)	Commercial & public admin. aviation fuels (PJ)	Commercial & public admin. motor gasoline (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)	Data presented in this report (PJ)
Sector										
Residential	1,316	106								1,422
Commercial/ institutional	1,503		(207)	(39)	(71)					1,186
Industrial	2,245						418	4	502	3,168
Transportation	2,396		207	39	71	(136)				2,577
Agriculture	188									188
Final demand	***7,648***	***106***	***0***	***0***	***0***	***(136)***	***418***	***4***	***502***	***8,542***
Non-energy	902									902
Producer consumption	1,278					136			(502)	912
Net supply	***9,828***	***106***	***0***	***0***	***0***	***0***	***418***	***4***	***0***	***10,356***
Fuel conversion										
Electricity, steam and coal/coke input fuels[1]	3,791									3,791
Electricity, steam and coal/coke production[2]	(2,250)									(2,250)
Total primary	***11,369***	***106***	***0***	***0***	***0***	***0***	***418***	***4***	***0***	***11,897***

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 sector: 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.

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.

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.

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

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

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

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

Appendix B: Glossary of terms

Commercial/institutional sector: The commercial/institutional sector in Canada includes activities related to trade, finance, real estate, public administration, educational 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.

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.

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 report, 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.

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.

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

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

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

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

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

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.

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.

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).

Gross domestic product (GDP): This measure is the total value of goods and services produced within Canada during a given year. It is also referred to as annual economic output or, more simply, output. To avoid counting the same output more than once, GDP includes only final goods and services – not those that are used to make another product. GDP figures are reported in constant 2002 dollars.

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

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

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

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

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

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

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.

Appendix B: Glossary of terms

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 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.

Light-duty vehicle (LDV): This segment of passenger transportation vehicles includes small cars, large cars, motorcycles and light trucks.

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

Liquefied petroleum gases (LPG) and gas plant natural gas liquids (NGL): Propane and butane are liquefied gases extracted from natural gas (i.e. gas plant NGL) or from refined petroleum products (i.e. LPG) at the processing plant.

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

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

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

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

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

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

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 all-terrain vehicles. 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 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.

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.

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.

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 with another is considered a structural change; in the electricity generation sector, a relative increase in production from one fuel process compared with another is considered a structural change.

Appendix B: Glossary of terms

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

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

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

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

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

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

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

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, saw-mills and plywood mills.

Appendix C: Abbreviations

\$2002	constant 2002 dollars
CFL	compact fluorescent lamp, also known as compact fluorescent light bulb
CIEEDAC	Canadian Industrial End-Use Energy Data and Analysis Centre
DVD	digital video disc or digital versatile disc
GDP	gross domestic product
GHG	greenhouse gas
GJ	gigajoule = 1×10^9 joules
GO	gross output
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
NAICS	North American Industry Classification System
NGL	natural gas liquids
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

Notes