Independent Statistics & Analysis
U.S. Energy Information Administration

Issues in International Energy Consumption Analysis: Canadian Energy Demand

June 2015

Independent Statistics & Analysis
www.eia.gov

U.S. Department of Energy
Washington, DC 20585

This report was based on Natural Resources Canada 2009 data (accessed in 2012). For more current data see

Handbook tables:

http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

Comprehensive tables:

http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/list.cfm?attr=0

Table of Contents

Figures

Tables

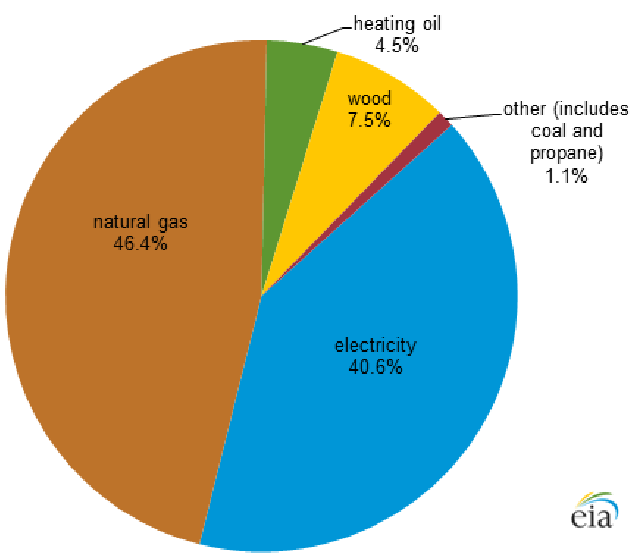
Overview

The residential sector is one of the main end-use sectors in Canada, accounting for 16.7% of total end-use site energy consumption in 2009 (computed from Natural Resources Canada (NRCan) 2012. pp, 4-5). In that year, the residential sector accounted for 54.5% of buildings total site energy consumption. Between 1990 and 2009, Canadian household energy consumption grew by less than 11%. Nonetheless, households accounted for 14.6% of total energy-related greenhouse gas emissions[1] in Canada in 2009 (computed from NRCan 2012). This is the U.S. Energy Information Administration's second study to help provide a better understanding of the factors affecting residential energy consumption and intensity in North America (mainly the United States[2] and Canada) by using similar methodology for analyses in both countries.

Energy consumption in Canada

In 2009, Canadian households consumed about 1.35 quadrillion Btu (quads) of site energy[3], mainly natural gas, electricity, wood, and fuel oil (Figure 1). Space heating and water heating accounted for more than 80% of this consumption (Figure 2). Household energy consumption grew slower than the number of household and floorspace, which decreased the aggregate energy intensity over the 19-year period. Between 1990 and 2009 households' site energy increased by 10.4%.[4] Over this same interval, the number of buildings grew by 30.4% and total floorspace by 39.3%. As a result, aggregate energy intensity decreased by 20.1% on a per building basis and by 28.9% on a per square foot basis.

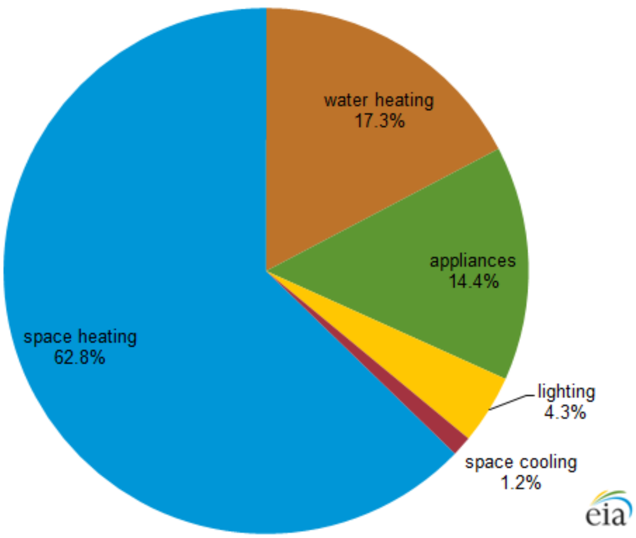
Figure 1. Distribution of household energy consumption by energy source, 2009



Source: Natural Resources Canada 2011, Table 1.

[1] Including electricity-related emissions.
[2] U.S. analyses are presented in Hojjati and Wade (2012).
[3] Site energy does not include losses that occur in the generation, transmission, and distribution of energy.
[4] All reported percentage changes related to decomposition are logarithmic.

Figure 2. Distribution of household energy consumption by end use, 2009



Source: Natural Resources Canada 2011, Table 2.

Methodology

The aggregate intensity changes do not account for several important structural changes affecting energy intensity that the decomposed intensity results quantify. This analysis follows Hojjati and Wade (2012) which analyzed U.S. residential energy consumption and distinguished among four component categories[5] affecting energy use: activity, structural changes, intensity, and weather effects:

- Activity is defined as number of households
- Structural changes represent the shifts in the mix of housing types, the regional distribution of households, and the floorspace per household
- Energy intensity is the ratio of energy consumption to floorspace
- Weather reflects seasonal fluctuation in weather.

Decomposition methods based on Ang & Choi (1997) were applied to isolate the effects of these factors on aggregate energy intensity. The methodology is summarized in Appendix B.

Data sources and considerations

The analyses in this study are based on the NRCan comprehensive database available on the web. NRCan data are the most detailed historical energy-related data available for the residential sector in Canada.[6] NRCan detailed data for the 1990-to-2009 period are used for this analysis. Hence, analyses of national and regional level NRCan data from 1990 to 2009 are the main focus of this report. The following section describes trends in NRCan data over the period of analysis. After reviewing trends, the

---

[5] Although household behavior such as energy conservation and responses to change in energy prices affect changes in energy consumption, these factors are not considered in these decomposition analyses.

[6] NRCan energy consumption data were converted from Petajoule to quadrillion Btu using a conversion factor of a BTU=1,055.055 852 62 Joule. Floorspace data were converted from square meters to square feet using a conversion factor of 1 square foot = 0.09290304 square meters.

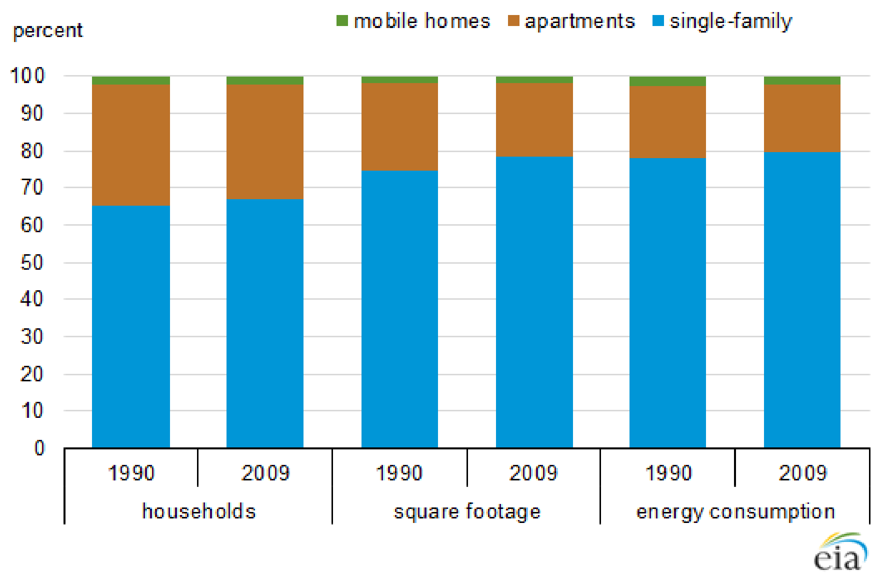
results of the decomposition analyses are presented. The analyses in this study are based on Natural Resources Canada 2009 data (accessed in 2012).

Factors affecting household energy consumption

Housing types

NRCan data includes four types of housing units – single-family attached, single-family detached, apartments, and mobiles. Combined single-family units accounted for about 67.2% of the households, 78.3% of floorspace, and almost 80% of site energy consumption in 2009 (Figure 3). Of the remaining households, 30.9% were apartments and 1.9% were mobile homes.

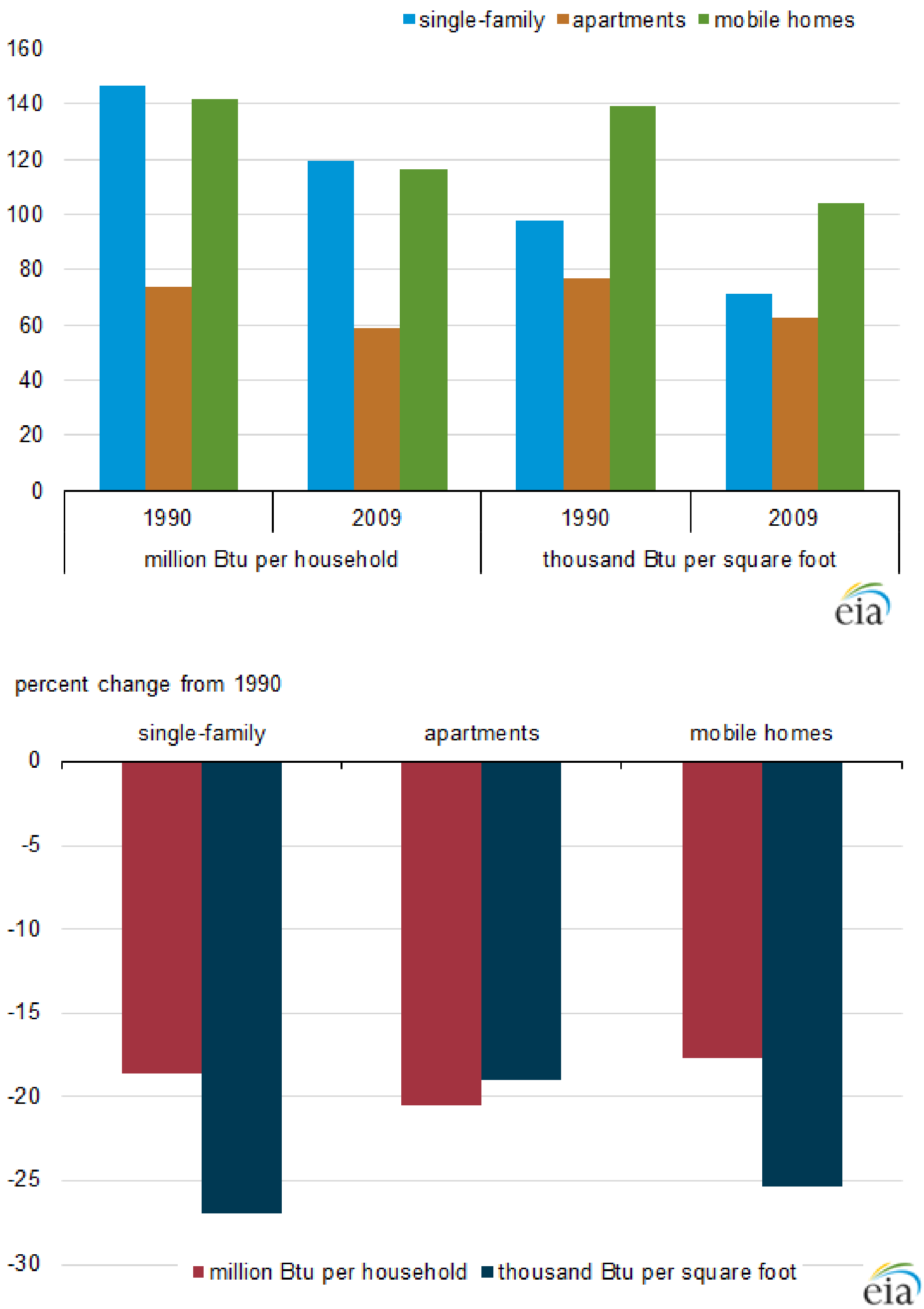
Figure 3. Distribution of households, floorspace, and energy consumption by housing type in 1990 and 2009



Source: Natural Resources Canada 2011, Tables 20, 24, 39, 42, 45, and 48.

Energy consumption per household was greatest for single-family homes and about two times higher than that of apartments (Figure 4). However, per square foot energy consumption in mobile homes was higher than that of single-family and apartments. The single-family shares for the number of households, floorspace, and energy consumption have shown modest growth since 1990, averaging increases of 0.1%, 0.2%, and 0.1% per year, respectively. The share of apartments for these three indicators declined by 0.3%, 0.8%, and 0.4% and those of mobile home declined by 0.5%, 0.4%, and 0.4% per year, respectively. Because energy intensity across building type varies, changes in the composition of building types have the potential to affect the aggregate energy intensity.

Figure 4. Household energy consumption intensity by housing type: 1990 and 2009 and percent change, 1990-2009

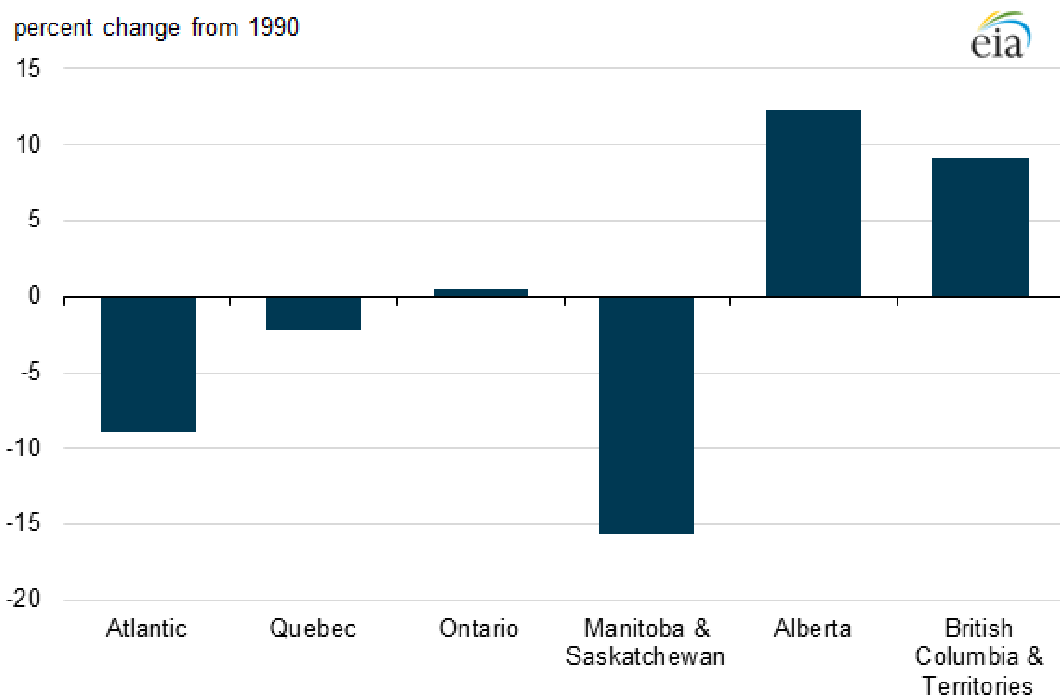


Source: Computed from Natural Resources Canada 2011, Tables 20, 24, 39, 42, 45, and 48.

Regional distribution

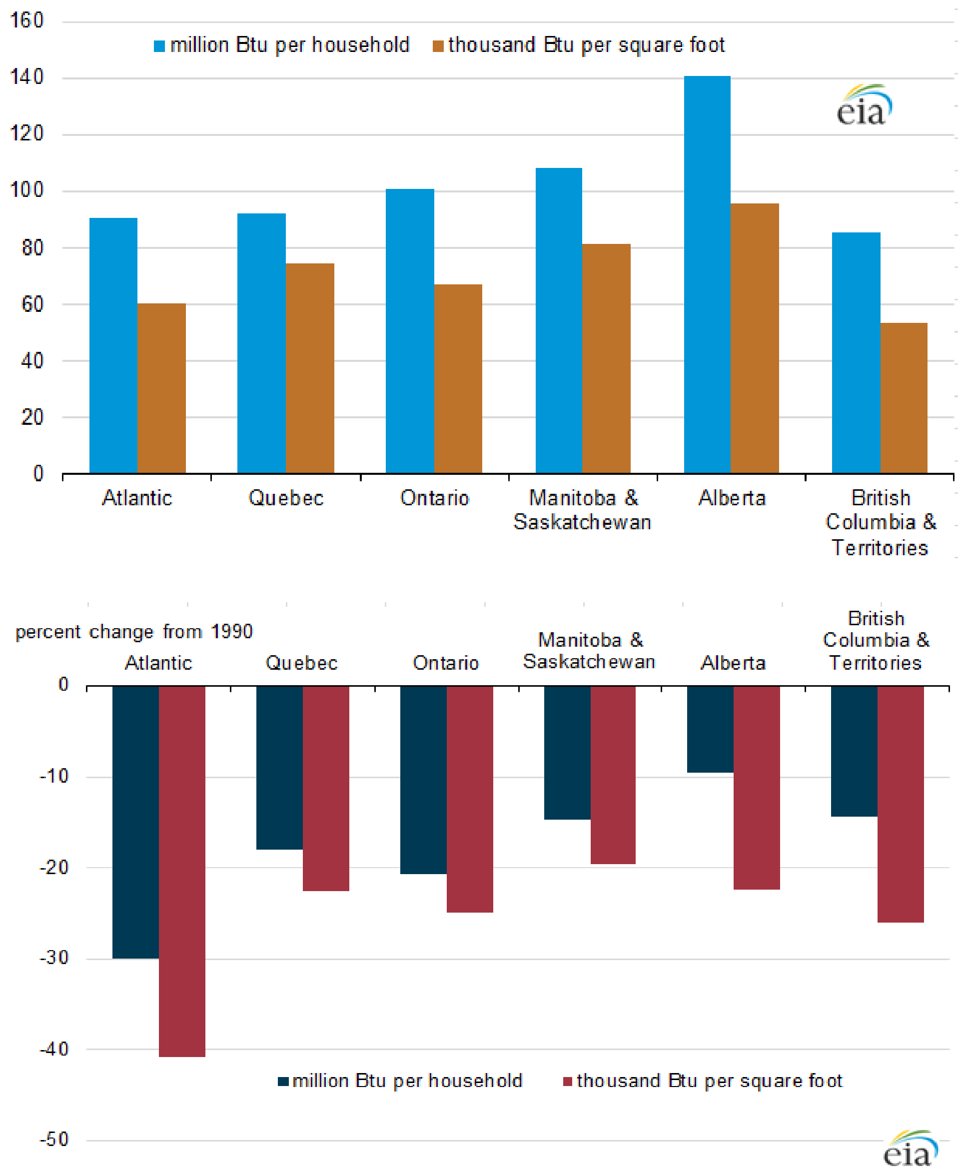
In this analysis, six Canadian geographical regions are considered: Atlantic, Quebec, Ontario, Manitoba and Saskatchewan, Alberta, and British Columbia and Territories. Households were not equally distributed across the regions. More than 62% of the households were located in Ontario and Quebec over the 19-year period. In 2009, 36.9% of households were located in Ontario, 25.3% in Quebec, 13.8% in British Columbia and Territories, 10.3% in Alberta, 7.2% in Atlantic, and 6.5% in Manitoba and Saskatchewan. Between 1990 and 2009, household shares shifted to Alberta, British Columbia and Territories, and slightly to Ontario (Figure. 5). This shift has implications for aggregate energy intensity because energy intensity per square foot and per household are higher in Alberta and lower in British Columbia and Territories than in other regions (Figure. 6).

Figure 5. Percent change in distribution of housing by region, 1990-2009



Source: Computed from Natural Resources Canada 2011, regional Table 14.

Figure 6. Household energy consumption intensity by regions, 2009 and percent change, 1990-2009



Source: Computed from Natural Resources Canada 2011, regional Tables 1 and 14.

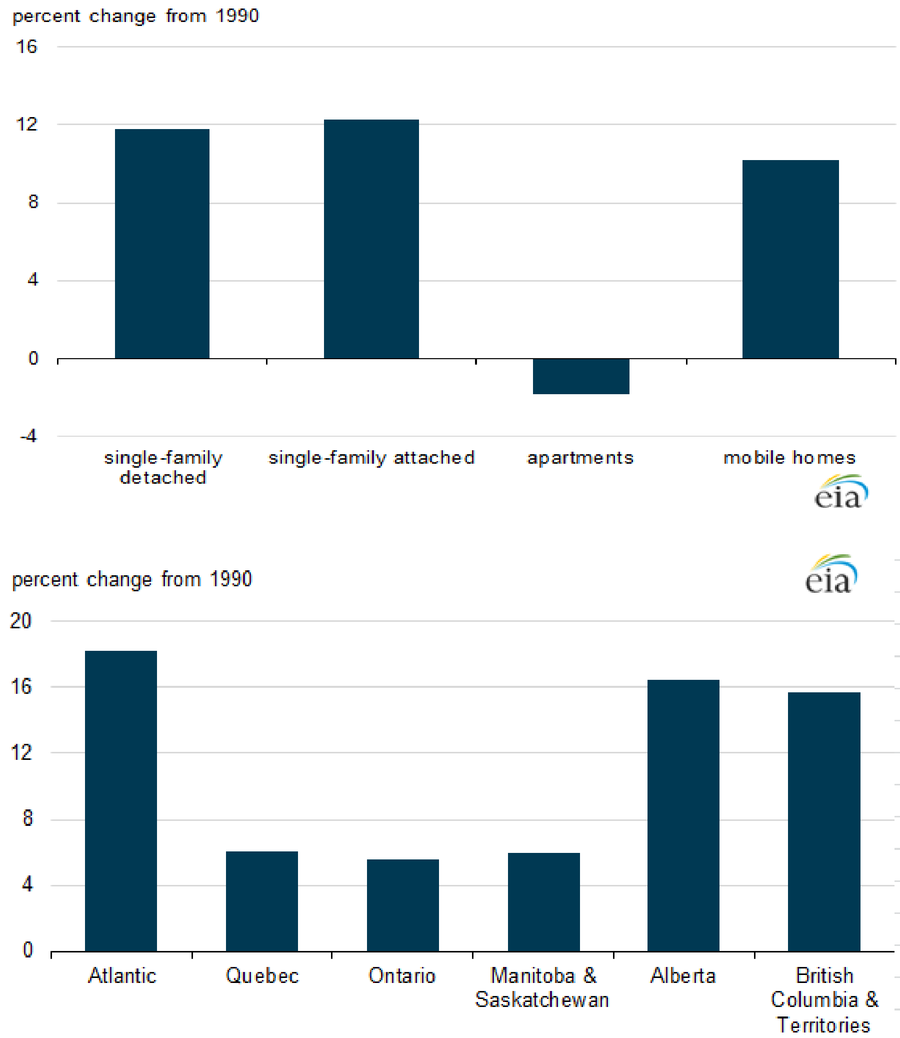
In 2009, Quebec and Ontario accounted for about 60% of total Canadian household energy consumption. Because the changes in distribution of households in these two regions are less pronounced, the impact of change in regional distribution should not be expected to be highly significant. However, energy intensities per square foot and per household have changed over the 19 years of study.

Size effect

Over the 19-year period, aggregate average floorspace per household grew by about 9%. During the same time period, there were wide variations in the average floorspace growth across the housing types and regions (Figure 7). Average size of single-family homes grew faster than other housing types, and single-family homes were the most prevalent type of housing unit. The average size of homes in the

Atlantic region increased more than three times faster than the average size of homes in Ontario (Figure 7).

Figure 7. Growth in average floorspace per household by housing types and regions, 1990 to 2009



Source: Computed from Natural Resources Canada 2011, regional Tables 1 and 24.

Weather effects

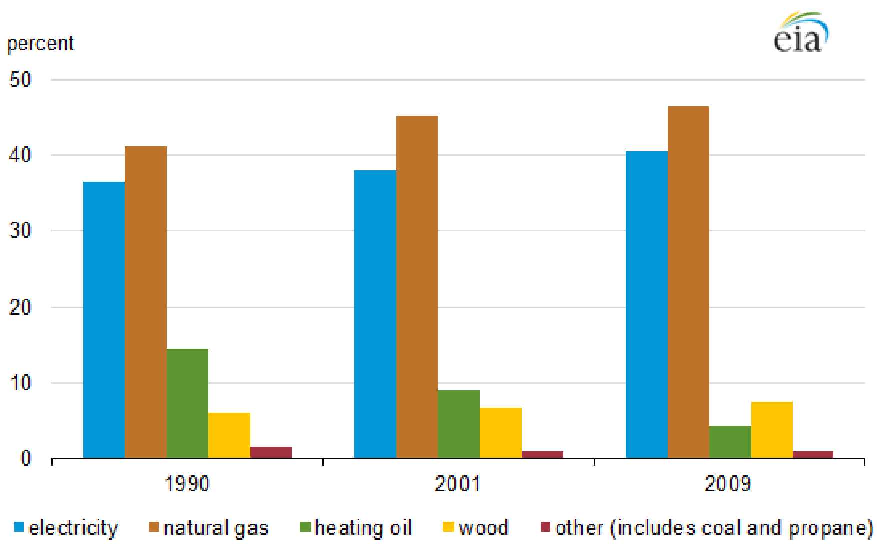
Weather is a key factor driving annual fluctuations in energy use for space heating and cooling demand. There were variations in weather across time and regions. Overall, the winter and summer of 2009 were colder than during 1990. The average heating degree day index (HDD) was 4.7% higher, while the average cooling degree day (CDD) was 11.6 % lower.[7] Thus, weather effects should be included in the decomposition analyses.

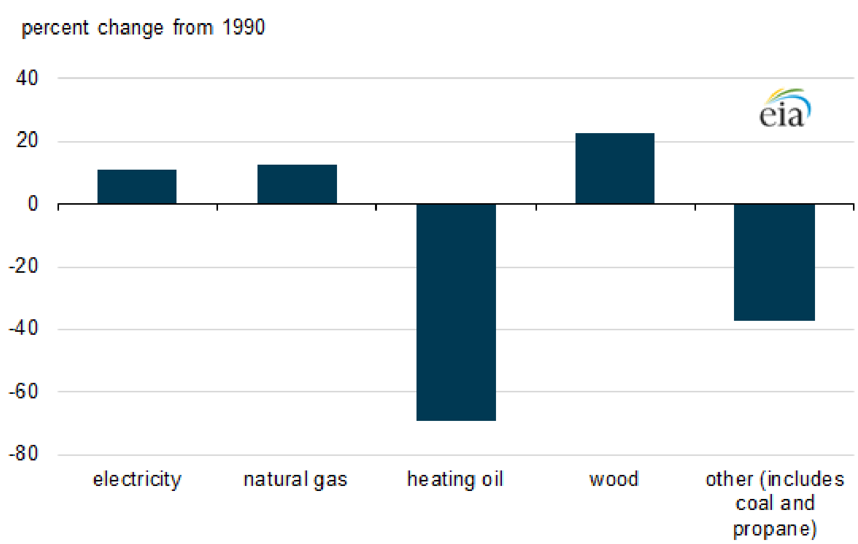
[7] The HDD (CDD) index is a measure of how cold (hot) a year was relative to normal. The HDD (CDD) normal refers to a weighted average of the 1951 to 1980 HDDs (CDDs) observed in a number of weather stations in Canada (NRCan 2011).

Fuel source change

The mix of household energy sources has changed over the 19-year period. In 1990, site electricity accounted for 36.5% of total site energy consumption, and natural gas accounted for 41.2%. In 2009, the share of electricity increased to 40.6%, and the natural gas share increased to 46.4% (Figure 8). Although the share of electricity, natural gas, and wood consumption increased consistently over this period, natural gas remained the main household fuel (Figure 8). There were differences across the regions. Electricity accounted for major shares of energy consumption in Quebec throughout this period and since 1995 in the Atlantic region, while natural gas was the main source of energy consumption in all other regions.

Figure 8. Fuel shares of total site energy in Canadian households 1990, 2001, and 2009 and percent change, 1990-2009





Source: Computed from Natural Resources Canada 2011, national Tables 27, 33, 34, and 37.

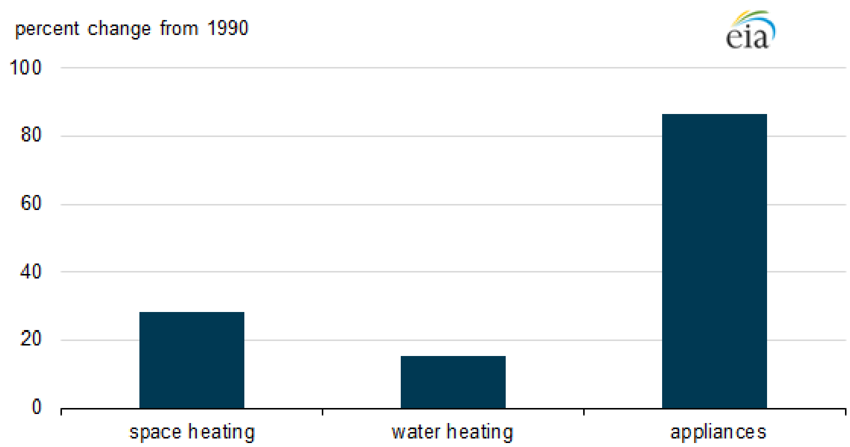
The share of households using natural gas across all end uses increased between 1990 and 2009, however the increase in natural gas consumption was relatively modest for the main end uses—space heating and water heating (Table 1 and Figure 9). The growth in natural gas consumption was stronger for appliances—ranges and clothes dryers. However, in 2009 appliances accounted for about 1% of total natural gas consumption, while space heating accounted for more than 70% of household natural gas consumption.

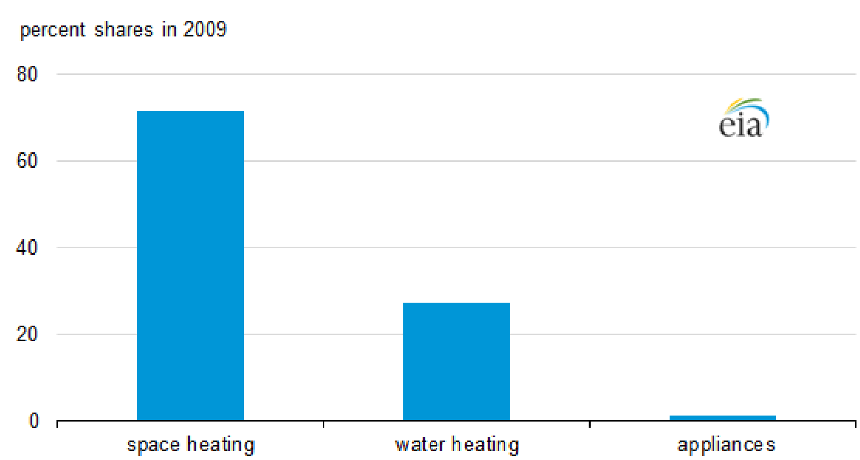
Table 1. Per-household stocks of natural gas appliances and other end uses[a], 1990, 2001, and 2009

	1990	2001	2009
Clothes Dryer	0.02	0.03	0.03
Range	0.04	0.06	0.09
Heating Systems	0.46	0.49	0.49
Water Heating	0.44	0.49	0.51

Note: [a]The ratio of the number of natural gas appliances (end uses) to the total number of households.
Source: Computed from NRCan 2011, national Tables 20, 27, 33 and 37.

Figure 9. Percent change in household natural gas consumption between 1990 and 2009 and distribution of natural gas consumption in 2009 by end use

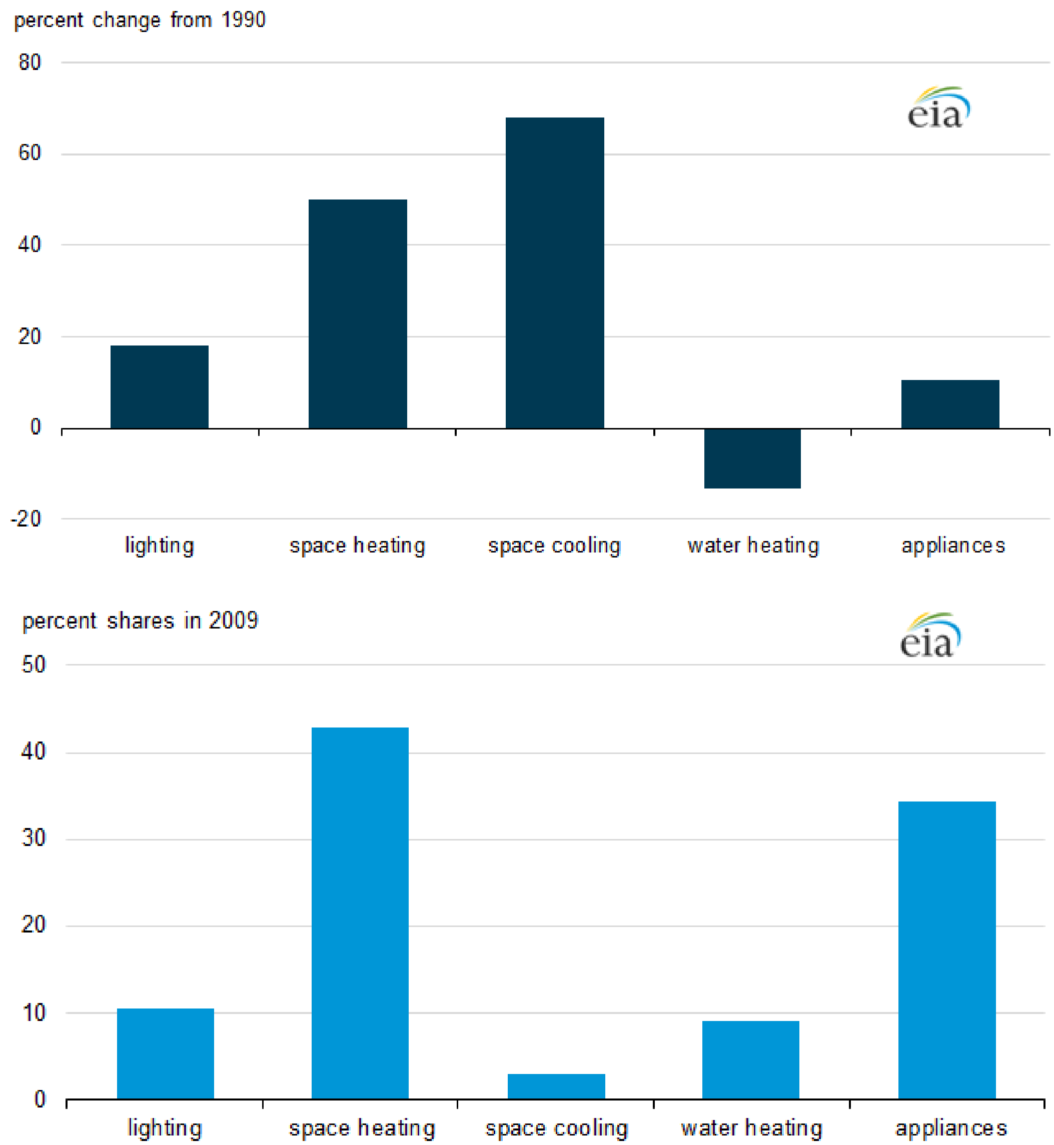




Source: Computed from Natural Resources Canada 2011, national Tables 27, 33, 34, and 37.

With the exception of water heating, total electricity consumption for all end uses increased between 1990 and 2009 (Figure 10). Space cooling electricity had the largest growth over the 19-year period, but it accounted for only 3.0% of household electricity consumption in 2009. Despite the increase in per household stocks for most appliances and end uses (Table 2), electricity consumption per household decreased between 1990 and 2009. This decrease was partially affected by per unit energy efficiency of most equipment and appliances, which improved significantly over this period.

Figure 10. Percent change in household electricity consumption between 1990 and 2009 and distribution of electricity consumption in 2009 by end use



Source: Computed from Natural Resources Canada 2011, national Tables 1, 5, 6, 7, 14, and 17.

Table 2. Per-household stocks of selected electrical appliances and end uses[a], 1990 and 2009

	1990	2001	2009
Refrigerator	1.2	1.2	1.3
Freezer	0.6	0.6	0.5
Dishwasher	0.4	0.5	0.6
Clothes washer	0.7	0.8	0.8
Clothes dryer	0.7	0.8	0.8
Range	0.9	0.9	0.9
Other Appliances[b]	10.1	13.4	15.9
Central air conditioning	0.1	0.2	0.3
Room air conditioning	0.1	0.1	0.2
Water heating	0.6	0.5	0.5
Space heating (electric baseboard)	0.3	0.3	0.3
Space heating (heat pump)	0.02	0.04	0.05

Note: [a]The ratio of the number of electrical appliances (end uses) to the total number of households.
[b]Includes small appliances such as microwaves, televisions, cable boxes, video cassette recorders, stereo systems, and computers.
Source: Computed from NRCan 2011, national Tables 20, 27, 33, 34, and 37.

This paper does not consider a separate decomposition by the fuel mix used by households, although intensity effects are expected to change by fuel type. In the absence of data on the number of households using natural gas and fuel consumption by type of housing, separate decompositions for electricity consumption at the national level are provided in Appendix A to show the fuel-specific characteristics.

Results

The following section presents several decompositions of changes in energy consumption for Canadian households. First the changes for the national and regional levels for the 1990-to-2009 period are analyzed. Then similar results are discussed for sub-periods split at 2001, the year in which ENERGY STAR was introduced in Canada.

Decomposition of effects for total energy 1990-2009

National

Figure 11 shows the national results for the 1990-to-2009 period when household energy consumption increased by 10.4%. The increase in the number of households was the main driver of the increase in energy consumption, followed by growth in the average size of buildings. The decomposed household effect, 30.4%, is the same as the aggregate effect, but the decomposed effect of floorspace per household is 8.4% compared with 8.9% growth in aggregate floorspace per household. This is the result of changes in housing-type mix and regional distributions.

The main offsetting factor was the estimated 32.1% decline in energy intensity per square foot. The decline in the decomposed intensity estimate was more than the 28.9% estimated decline in the aggregate intensity. Aggregate intensity changes are influenced by intensity changes in each region and housing type as well as by changes in the regional distribution, housing-type mix, and weather.

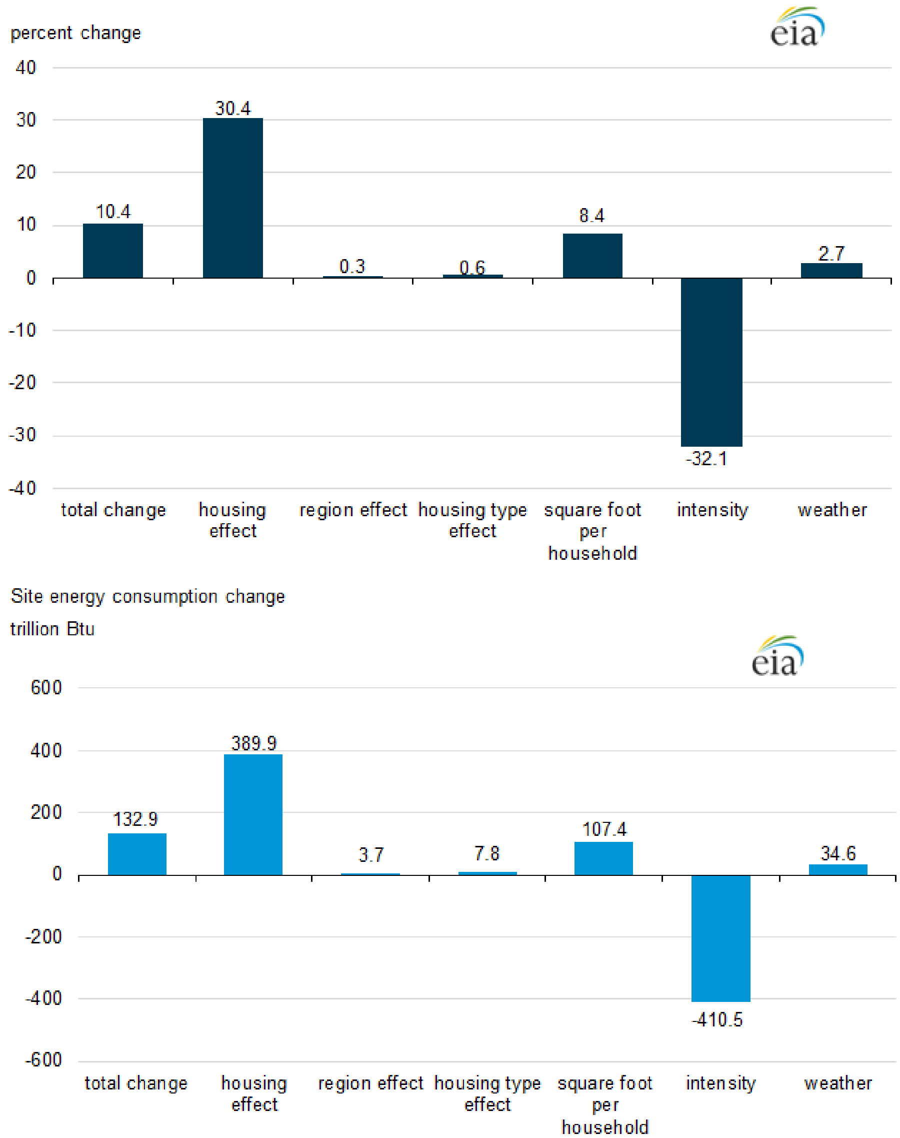
Energy intensity per square foot was also affected by other factors such as improvements in energy efficiency of buildings and fuel prices, which are not considered in our analysis. Various energy efficiency standards for residential equipment became effective particularly after 1995.[8] Besides mandated minimum efficiency standards, technologies have also improved over the 19-year period. Other programs such as ENERGY STAR, voluntary and mandatory energy labeling, and promotional programs have resulted in household usage of more efficient equipment and appliances.

The weather effect was positive, increasing 2009 consumption relative to 1990 by 2.7% (Figure 11). The winter and the summer of 2009 were colder than in 1990; the net weather effect was an overall increase in energy use over the 19-year period. Similarly, the housing type mix and the change in regional distribution of households acted to increase energy consumption by 0.6% and 0.3%, respectively.

Households consumed 1.35 quadrillion Btu of energy in 2009. Had energy intensity per square foot remained at the 1990 level, households would have instead used an additional 0.4 quadrillion Btu of energy. This amount of avoided energy use is equivalent to the 2009 household total energy consumption in the Quebec, Manitoba, and Saskatchewan regions.

[8] NRCan has promoted energy efficiency since the late 1970s. Canada's appliance efficiency program was initiated in 1978 by introducing the EnergyGuide label, which required manufacturers of major appliances to report the monthly energy consumption for each model (NRCan accessed 2012). The 1992 Energy Efficiency Act, the first comprehensive law on energy efficiency, became effective in 1995. It covered more than 30 products including space heating and cooling equipment, and water heating (Shui and Evans 2009). The ENERGY STAR program was introduced in Canada in 2001. Since 2002, the number of items eligible for the ENERGY STAR label has significantly increased (IEA 2009).

Figure 11. Decomposition of change in total energy consumption, 1990-2009



Source: Computed from Natural Resources Canada 2011, national and regional Table 1.

Regional

Table 3 summarizes the decomposition of effects at the regional level for the 1990-to-2009 period. There were significant variations across the regions. Total consumption in Alberta, British Columbia and territories, Quebec, and Ontario increased over the 19-year period, while consumption decreased in the Atlantic region and Manitoba and Saskatchewan. The increase in total consumption in Quebec and Ontario (the two regions with the highest energy consumption) was below the national level. British Columbia, which had the lowest energy consumption per household over the 19-year period, had the second-largest growth in energy consumption, mainly because of rapid growth in the number of households and the increase in the average floorspace. The change in the mix of housing types had greater effects in British Columbia and Territories, Quebec, and Alberta. The main reducing factor in all regions was energy intensity, which varied widely across the regions. It ranged from a decline of 25.4% in Manitoba and Saskatchewan to a decline of 54.3% in the Atlantic region. Similar to national analysis for the total interval, the decline in the decomposed intensity estimates for all regions was more than the decline from the aggregate intensity estimates.

Table 3. Decomposition of total energy by regions, 1990-2009

	Atlantic	Quebec	Ontario	Manitoba and Saskatchewan	Alberta	British Columbia and Territories
				percent change		
Total Change	-14.5	8.5	7.7	-2.5	32.0	23.5
Housing Effect	21.1	28.3	31.0	13.4	42.1	39.1
Housing-Type Effect	0.02	1.8	0.7	-0.1	1.5	-2.2
Square Foot per Household	17.0	4.4	5.3	5.6	14.5	16.5
Intensity	-54.3	-28.9	-32.1	-25.4	-28.5	-30.9
Weather	1.7	2.9	2.9	3.9	2.5	1.0

Source: Computed from NRCan 2011, national and regional Table 1.

Decomposition of effects for total energy 1990-2001 and 2001-2009

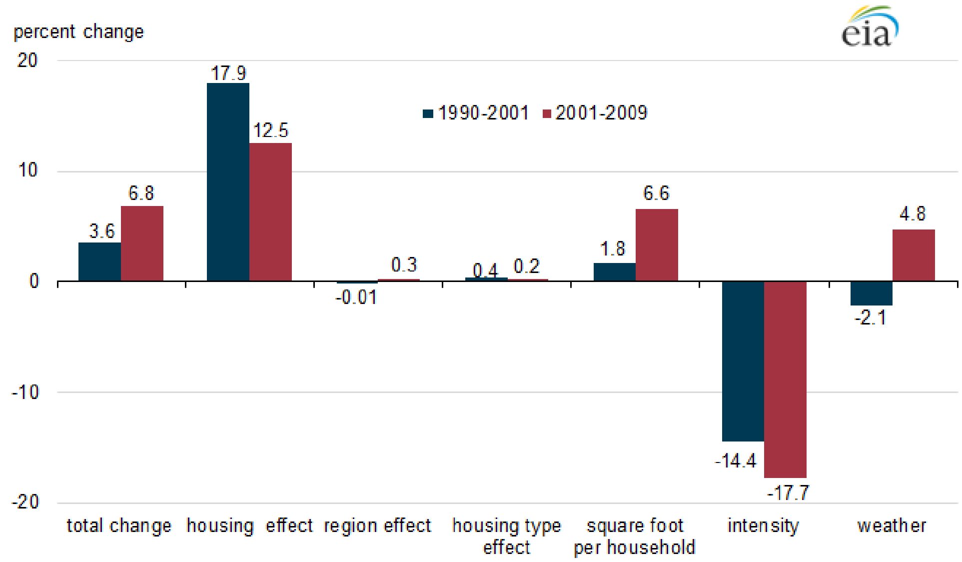
National

To understand the changes in energy consumption over the 19-year period, the 1990-2001 and 2001-2009 sub-periods were examined separately. The year 2001 was primarily selected because ENERGY STAR appliances were first introduced into the Canadian market during this time. Figure 12 summarizes the decomposition of effects at the national level for the two sub-periods. Growth in energy consumption was significantly different between the two periods (Figure 12). The increase in energy consumption for 2001-2009 was 6.8%, nearly twice the change for 1990-2001. From 2001 to 2009, although energy intensity was even lower than the previous sub-period, the average size of a home grew at more than three times the rate of the 1990-2001 period. However, the increase in energy consumption from housing units, the average size of a home, housing-type mix, region, and weather effects were more than offset by the decline in energy intensity.[9]

The year 2001 was warm relative to 1990 and 2009. Comparing 1990 with 2001, the weather effect offset energy consumption growth. Comparing 2001 with 2009, the weather effect was positive because space heating requires more energy than cooling.

[9] The change in intensity during the two sub-periods could have also been affected by energy prices. Retail indices of natural gas prices increased by more than 130% during 1990-2001 and declined by 3.9% during 2001-2009. While retail indices of electricity prices increased by 35.2% and 24.0%, respectively (computed from International Energy Agency 2011, Table 4).

Figure 12. Decomposition of total energy consumption, 1990-2001 and 2001-2009



Source: Computed from Natural Resources Canada 2011, national and regional Table 1.

Regional

Growth in consumption was significantly different between the two periods across the regions (Table 4). With the exception of Quebec and Manitoba and Saskatchewan, the decline in percentage change in intensity was faster during the latter sub-period than during the prior sub-period. The Atlantic region had the highest intensity effect during both periods, with declines of 24.8% and 29.5%, respectively.

Weather effects were in the same direction in all regions during both sub-periods, but the effects were substantially stronger in Alberta and in Manitoba and Saskatchewan during 2001-2009. There were also variations across regions and sub-periods with respect to the number of housing and average size effects. The effect of change in the mix of housing types in the 1990-2001 sub-period was about twice that in the 2001-2009 sub-period for British Columbia and Territories, Quebec, Ontario, and Alberta.

Table 4. Decomposition of total energy by regions, 1990-2001 and 2001-2009

	Atlantic		Quebec		Ontario		Manitoba and Saskatchewan		Alberta		British Columbia and Territories	
	percent change											
	1990-2001	2001-2009	1990-2001	2001-2009	1990-2001	2001-2009	1990-2001	2001-2009	1990-2001	2001-2009	1990-2001	2001-2009
Total Change	-8.4	-6.1	-1.2	9.7	5.0	2.7	-8.3	5.8	13.4	18.7	14.4	9.1
Housing Effect	13.1	8.0	16.9	11.4	18.6	12.4	5.1	8.4	22.0	20.1	25.0	14.1
Housing Type Effect	0.0	0.02	1.2	0.6	0.4	0.2	-0.1	-.02	1.0	0.5	-1.5	-0.7
Square Foot per Household	4.1	12.8	-1.4	5.8	1.8	3.6	2.2	3.4	2.9	11.5	5.1	11.4
Intensity	-24.8	-29.5	-15.6	-13.3	-13.8	-18.3	-13.2	-12.2	-8.5	-20.0	-13.2	-17.7
Weather	-0.8	2.5	-2.3	5.2	-1.9	4.8	-2.4	6.3	-4.0	6.6	-1.0	2.0

Source: Computed from Natural Resources Canada 2011, national and regional Table 1.

Conclusion

Buildings accounted for 30.5% of total energy use in Canada in 2009, with the residential sector responsible for more than 54.5% of buildings energy consumption. Natural gas followed by electricity were the main sources of energy consumption over the period of study; natural gas remained the main household energy source. The increasing importance of natural gas and electricity in residential energy consumption is mainly a reflection of the increase in the use of natural gas for appliances (water heating, space heating) and new uses for electricity, especially household electronics.

Providing a better understanding of how structural, activity, weather, and intensity factors have impacted Canadian residential energy consumption yields insight into how this significant portion of Canada's total energy use has changed and may change in the future.

The national and regional results indicated that the increase in the number of households was the main cause of increase in energy consumption, followed by growth in the average size of buildings.[10] The results further illustrated that over the total interval and for the 2001-2009 sub-period, the combined effect of housing type, region, and weather led to increases in the amount of decomposed intensity change relative to what would have been estimated based on energy intensity calculated at the aggregate level. Also, the change in intensity was the dominant reducing effect for energy consumption. The reduction in national energy consumption accounted for by improvement in energy intensity was more than the 2009 household energy consumption in the Quebec and Manitoba and Saskatchewan regions.

The national level analysis of sub-periods 1990-2001 and 2001-2009 indicated that the latter sub-period illustrated greater intensity decline. This could be the impact of improvements in energy efficiency standards and the introduction of new programs such as the ENERGY STAR program. The Atlantic, Ontario, Alberta, and British Columbia and Territories followed the same trend, where the declines in energy intensities in these regions were higher in the post-2001 period.

The regional analysis of sub-periods also showed that the change in housing type mix was almost twice as high during the 1990-2001 sub-period as in the 2001-2009 sub-period in Quebec, Ontario, and British Columbia.

[10] Except for Quebec during the 1990-2001 sub-period, where the growth in average floorspace was a decline of 1.4 percent.

References

Ang, B.W., Liu, F. L., Chew E. P. 2003. Perfect Decomposition Techniques in Energy and Environmental Analysis. Energy Policy 31(14), 1561-1566.

Ang, B. W., Choi, K., 1997. Decomposition of Aggregate Energy and Gas Emission Intensities for Industry: A Refined Divisia Index Method. The Energy Journal 18(3) 59-74.

Ang, B. W., 2005. The LMDI Approach to Decomposition Analysis: A Practical Guide. Energy Policy 33(7), 867-871.

Boyd, G. A., Roop, J. M., 2004. A Note on the Fisher Ideal Index Decomposition for Structural Change in Energy Intensity. The Energy Journal, 5(1), 87-101.

Hojjati, B., Wade, S.H., 2012. U.S. Household Energy Consumption and Intensity Trends: A Decomposition Approach. Energy Policy (2012), doi: 10.1016/j.enpol.2012.05.024.

International Energy Agency, 2011. Energy Prices and Taxes, Quarterly Statistics, 4th Quarter, Table 4, page 96.

International Energy Agency, 2009, Gadgets and Gigawatts : Policies for Energy Efficient Electronics

Natural Resources Canada 2011, Comprehensive Energy Use Database, 1990 to 2009 (accessed March 2012)., available online: http://oee.rncan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/list.cfm?attr=0

National Resources Canada, 2012. Energy Use Data Handbook 1990-2009, available online: https://oee.nrcan.gc.ca/publications/statistics/handbook11/pdf/handbook11.pdf

National Resources Canada, 2012.ABOUT ENERGY STAR; available online: http://www.nrcan.gc.ca/energy/products/energystar/about/12529

Schipper L., Howarth, R. B., Geller, H., 1990. United States Energy Use from 1973 to 1987: The Impacts of Improved Efficiency. Annual Review of Energy 15(1), 455-504.

Shui, B., Evans, M., 2009. Country Report on Building Energy Codes in Canada. Pacific Northwest National Laboratory, prepared for U.S. Department of Energy under Contract DE-AC05-76RL01830.

Appendix A. Additional Decomposition Results and Comparison of Aggregate and Decomposed Intensity

Table A1. Preliminary analysis of decomposition of total electricity consumption without type effect

	Total Change	Housing Effect	Region Effect	Square Foot per Household	Intensity	Weather
			percent change			
1990-2001	7.7	17.9	-0.3	1.5	-11.3	-0.1
2001-2009	13.3	12.5	-0.5	6.8	-6.6	1.2
1990-2009	21.1	30.4	-0.8	8.3	-18.0	1.1

Source: Computed from Natural Resources Canada 2011.

Note: All households are assumed to use electricity. Thus, the housing effect is similar to the national analysis of total site energy consumption.

Table A2. Comparison of decomposed and aggregate intensity

		1990-2001		2001-2009		1990-2009
			percent change			
	Aggregate Intensity	Decomposed Intensity	Aggregate Intensity	Decomposed Intensity	Aggregate Intensity	Decomposed Intensity
Atlantic	-25.4	-24.8	-26.9	-29.5	-52.4	-54.3
Quebec	-17.7	-15.6	-8.0	-13.3	-25.7	-28.9
Ontario	-15.4	-13.8	-13.2	-18.3	-28.6	-32.1
Manitoba and Saskatchewan	-15.6	-13.2	-6.1	-12.2	-21.7	-25.4
Alberta	-11.8	-8.5	-13.5	-20.0	-25.3	-28.5
British Columbia Territories	-14.3	-13.2	-15.9	--17.7	-30.2	-30.9
Canada	-16.4	-14.4	-12.6	-17.7	-28.9	-32.1

Source: Computed from Natural Resources Canada 2011.

Note: [a]percentage changes are logarithmic.

Appendix B. Decomposition Methodology

The decomposition method used in this study is based on Hojjati and Wade (2012). They distinguished among four main factors affecting household energy use within each region: activity, structure, energy intensity, and seasonal variations in weather. Their decomposition analyses follow a well-known method introduced by Ang & Choi (1997) known as the log mean Divisia method (LMDI-II).

Accordingly, the change in total energy consumption for a decomposition including four types of homes for each region can be expressed as follows: [11]

$$\ln\left(\frac{E_t}{E_0}\right) = \sum_{i=1}^{4} z_i \ln\left(\frac{H_t}{H_0}\right)$$ number of households effect[12]

$$+\sum_{i=1}^{4} z_i \ln\left(\frac{S_{it}}{S_{i0}}\right)$$ housing type effect

$$+\sum_{i=1}^{4} z_i \ln\left(\frac{F_{it}}{F_{i0}}\right)$$ size effect (square foot per household)

$$+\sum_{i=1}^{4} z_i \ln\left(\frac{W_{it}}{W_{i0}}\right)$$ weather effect

$$+\sum_{i=1}^{4} z_i \ln\left(\frac{I_{it}}{I_{i0}}\right)$$ intensity effect (energy consumption per square foot)

Where

E_t = total energy consumption at year *t*;

E_0 = total site energy consumption at year *0*;

i = represents the 4 types of housing;

[11] The national results are obtained using an LMDI-II analysis that combines four regions.

[12] At the national level, the region effect is the difference between the growth in the aggregate number of buildings and the decomposed number of buildings effect from the 2-stage LMDI-II analysis for combined regions.

z_i = the log-mean weight[13] for the i^{th} housing type;

H_t = total number of households at year t;

H_0 = total number of households at year 0;

S_{it} = share of housing type *i* at year *t*;

S_{i0} = share of housing type *i* at year *0*;

F_{it} = average floorspace of housing type *i* at year *t*;

F_{i0} = average floorspace of housing type *i* at year *0*;

W_{it} = the ratio of energy use to weather-adjusted energy use of housing type *i* at year*;*

W_{i0} = the ratio of energy use to weather-adjusted energy use of housing type *i* at year *0*;

I_{it} = average energy per square foot of housing type *i* at year *t*;

I_{i0} = average energy per square foot of housing type *i* at year *0*.

---

[13] It is specified as $$z_i = L(e_{i0}, e_{it}) = \frac{(e_{it} - e_{i0})}{\ln\left(\frac{e_{it}}{e_{i0}}\right)},$$

Where

e_{it} = represents the share of energy in the i^{th} housing type at year *t;*

e_{i0} = represents the share of energy in the i^{th} housing type at year *0;*

$L(e_{i0}, e_{it})$ = the log-mean weight function .

The final weights (z_i^*) are normalized to sum to one

$$z_i^* = \frac{L(e_{i0}, e_{it})}{\sum_{i=1}^{4} L(e_{i0}, e_{it})}.$$