Energy Consumption and Energy Intensity in Multi-Unit Residential Buildings (MURBs) in Canada

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Executive Summary

It is estimated that approximately 31 per cent of Canadians lived in apartment buildings in 2001. Multi-Unit Residential Buildings (MURBs) are thought to account for about 24 per cent of the overall annual energy consumption within the residential sector. In this study, we use data in the HiSTAR database provided by the Canada Mortgage and Housing Corporation (CMHC) to evaluate energy consumption and energy efficiency of MURBs in Canada.

For each of the 81 buildings in the database, information is available on location, residential type, construction characteristics, mechanical system, and energy consumption. For the purposes of analysis, the buildings for each region are classified as low-rise (4-6 stories, inclusive); mid-rise (7-20 stories, inclusive); and high-rise (above 20 stories). Although these buildings are located in five different regions of the country, they are concentrated predominately in Ontario. Due to the limited number of buildings in the database and the relatively concentrated distribution, it is only possible to conduct a limited amount of analysis using this database. In addition, even the limited findings in this study may not be statistically representative of the whole MURB sector in Canada.

Our statistical analysis shows that on average, MURBs from the West Coast consumed less energy than the rest of the nation, while those from the Prairies Provinces consumed the most energy on a per square metre basis. However, this may reflect climate differences rather than the efficiency of the building itself. An interesting finding is that older buildings are less energy efficient (GJ per square metre), but on average use less energy per suite than newer buildings. Also, while energy intensity generally decreases with floor area, larger buildings tend to use more energy on a per suite basis. This has potentially important implications for overall energy consumption in the sense that energy use per person in high-rise buildings may actually be increasing even though the buildings themselves become more energy efficient in terms of energy use per square metre.

Table of Contents

List of Figures

List of Tables

1. Introduction

Multi-unit residential buildings (MURBs) play an important role in the Canadian housing sector. A study by the Canada Mortgage and Housing Corporation (CMHC) (2001a) estimates that approximately 31 per cent of Canadians lived in apartment buildings in 2001. Since the Canadian housing market has been booming for the past few years, and an apartment is relatively more affordable than a single family house, it is possible that this proportion has increased since that time.

This same study also mentions that multi-unit residential buildings account for about 24 per cent of the overall annual energy consumption within the residential sector. Based on these two numbers, it would appear that MURBs may be quite energy efficient since they use 24 per cent of the energy to support 31 per cent of the residential population, although not all apartments are in MURBs of four stories or higher, which is the focus of our analysis here. However, further research done by the CMHC shows that on a floor area basis, MURBs consume more energy than single-family dwellings even though they have a smaller exposed exterior surface. Indeed, compared to the most advanced house standards for energy consumption, MURBs consume three times the amount of energy per unit of floor area. It is also widely recognized that this sector underperforms the rest of the commercial sector in designing new buildings that attain the Commercial Building Incentive Program (CBIP) threshold of 25% better than the Model National Energy Code for Buildings (MNECB).

In this study, we will use available data to evaluate energy consumption and energy efficiency of multi-unit residential building sector in Canada. We will try to address the reasons for the relatively low energy efficiency within the sector and suggest some measures might be used to improve its energy performance.

2. Data Source

In corporation with Natural Resources Canada, the Canada Mortgage and Housing Corporation (CMHC) developed a building characteristics and utility use data collection form for multi-unit residential buildings. The data collected was subsequently used to construct a High-rise Building Statistically Representative (HiSTAR) database. The Canada Mortgage and Housing Corporation graciously provided us with access to this database in order to conduct this study.

There are 81 buildings in the HiSTAR database. For each building, information is available on its location, residential type, construction characteristics, mechanical system, and energy consumption. The buildings range from 4 to 35 stories in height and from 24,000 square feet to 463,392 square feet in size. The smallest building has 27 suites while the largest one has 510 suites. The oldest building was built in 1920 while the newest one was built in 1994.

These buildings are located in four different regions of the country: West Coast, Prairie, Central and Atlantic regions, and from 8 different provinces. However, the distribution is quite uneven and is concentrated in the Central Canada area, particularly in the province of Ontario. Almost 70% of the buildings are located in Ontario, but in contrast, there is only one building from Newfoundland and two buildings from New Brunswick. There is no building representing the province of Alberta. Detailed distributions will be presented in the next section.

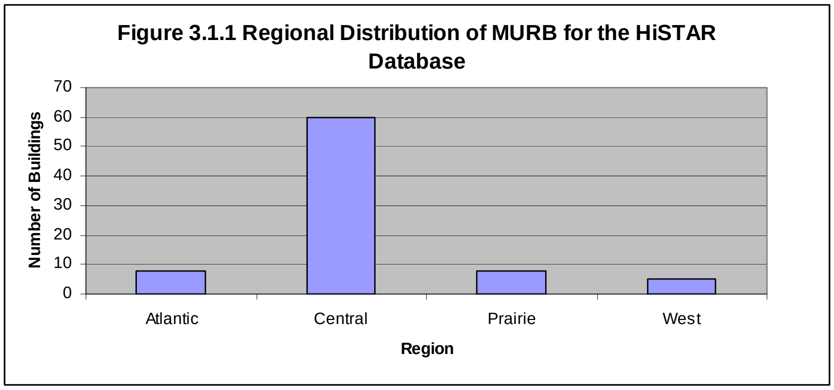
Given the limited number of buildings in the database and the relatively concentrated distribution, the database may not be statistically representative of the whole MURB sector in Canada, and hence the study results must be interpreted accordingly.

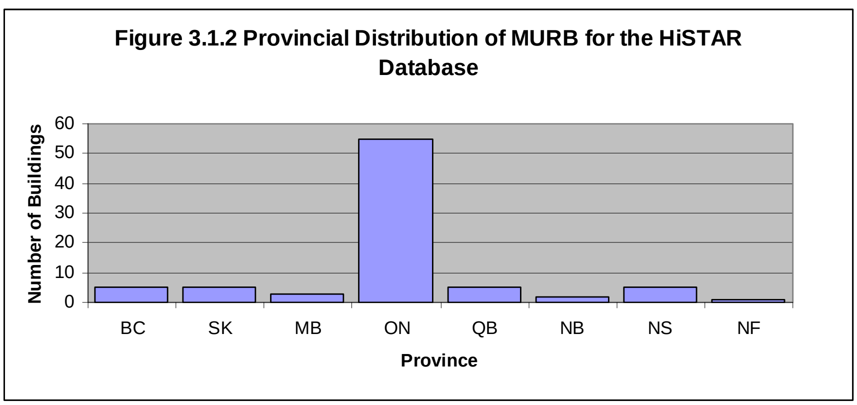
3. Statistical Results

In order to better investigate the differences in energy consumption between buildings, the buildings for each region are classified in one of three different categories: low-rise (4-6 stories, inclusive); mid-rise (7-20 stories, inclusive); and high-rise (above 20 stories).

3.1 Location

As mentioned before, of the 81 buildings in the HiSTAR database 60 are located in Central Canada, mostly in the province of Ontario. **Figure 3.1.1** shows the regional distribution and **Figure 3.1.2** shows the provincial distribution.





Because of this highly concentrated distribution of MURBs in aggregate, the distributions for different types of MURBs are also highly concentrated, as is shown in **Figures 3.1.3** to **3.1.5**. For example, 100 per cent of the high-rise MURBs are located in the Central region. As mentioned earlier, there is no claim made that this database is representative of the distribution of MURBs in total, or of different types of MURBs, across Canada. In fact, based on discussions with CMHC representatives, collection of data appears to be on a largely *ad hoc* basis, in the sense that the reason for collecting information on any particular MURB is not part of any kind of random sampling method.

Figure 3.1.3 Regional Distribution of Low-rise MURB

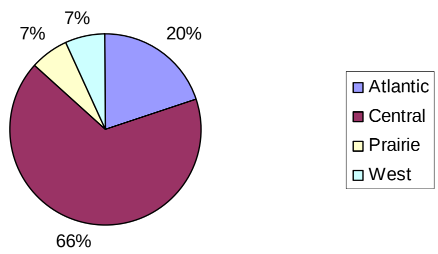


Figure 3.1.4 Regional Distribution of Mid-rise MURB

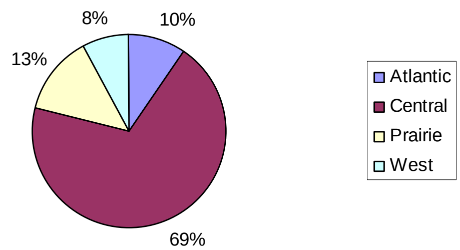


Figure 3.1. 5 Regional Distribution of High-rise MURB

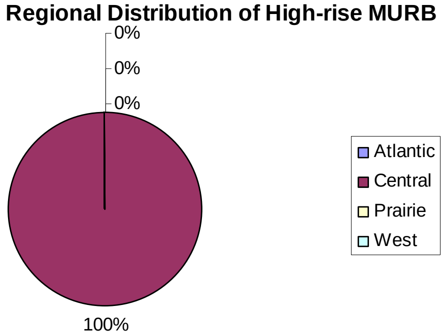


Table 3.1.1 shows the average annual energy consumption for different types of MURBs and for different regions. For Canada as a whole, on average a suite in a multi-unit residential building consumed about 88 GJ of energy annually. By region, MURBs on the West Coast consumed the least energy with only about 58 GJ/suite, while the Central and Atlantic regions both consumed about 89 GJ/suite. For different types of MURBs, the mid-rise MURB consumed about 3% less

energy per suite than the low-rise buildings and about 9% less than the high-rise buildings across Canada. However, for the Atlantic area, mid-rise buildings consumed an amazing 50% less energy per suite than low rise buildings, while in the Central region, the low-rise MURB consumed the least energy per suite.

In terms of energy intensity, the mid-rise MURB was the least energy efficient building type, with an energy intensity of 1.00 GJ/m^2 for Canada, while the low-rise buildings had the lowest intensity statistic. Again, the lowest energy intensity statistics came from the West Coast region, and the highest occurred in the Prairie Provinces. This may be due to the higher space heating demand in the Prairie area.

Table 3.1.1 Average Annual Energy Consumption for Different Regions

	Type	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Canada	Low-rise	15	96830.42	1102	111502.55	87.87	0.87
	Mid-rise	52	693940.16	8115	696890.01	85.51	1.00
	High-rise	14	350409.83	3768	374325.13	93.00	0.94
	Total	81	1141180.41	12985	1182717.69	87.88	0.96
Atlantic	Low-rise	3	25488.90	215	32508.43	118.55	0.78
	Mid-rise	5	55529.56	695	64573.44	79.90	0.86
	High-rise	0	0.00	0	0.00	N/A	N/A
	Total	8	81018.46	910	97081.87	89.03	0.83
Central	Low-rise	10	58698.79	719	65601.69	81.64	0.89
	Mid-rise	36	554389.92	6274	550157.99	88.36	1.01
	High-rise	14	350409.83	3768	374325.13	93.00	0.94
	Total	60	963498.53	10761	990084.81	89.54	0.97
Prairie	Low-rise	1	8748.93	106	7446.64	82.54	1.17
	Mid-rise	7	61286.98	746	46664.43	82.15	1.31
	High-rise	0	0.00	0	0.00	N/A	N/A
	Total	8	70035.91	852	54111.07	82.20	1.29
West	Low-rise	1	3893.80	62	5945.79	62.80	0.65
	Mid-rise	4	22733.70	400	35494.15	56.83	0.64
	High-rise	0	0.00	0	0.00	N/A	N/A
	Total	5	26627.51	462	41439.94	57.64	0.64

Average annual energy consumption also differed quite noticeably across provinces. As shown in **Table 3.1.2**, MURBs from Manitoba and British Columbia were reported consuming the least energy on a per-suite basis, which was about 70% less than the amount of energy consumed by an average suite from Saskatchewan, and 50% less than the national average. This dramatic difference between Manitoba and Saskatchewan may seem unexpected because these two provinces are quite similar in terms of climate and both have easy access to electricity and natural gas. However, the differences in energy prices may contribute to this consumption difference: the natural gas price is much lower in Saskatchewan than in Manitoba, but the electricity price is much higher in Saskatchewan. Because of this difference, people in Saskatchewan tend to use more natural gas for heating, while residents of Manitoba rely more heavily on electricity. Since electricity is more efficient than natural gas in space heating, households in Manitoba on average may consume less energy for heating than do those from Saskatchewan.

Even though Manitoba had the lowest energy/suite figure, its energy intensity statistic (GJ per square metre) almost topped the chart, only behind Saskatchewan. Again, the high energy intensity statistics for these Prairie Provinces may due to their strong energy demand for space heating. The most energy efficient building came from Newfoundland, which had an energy intensity statistic of 0.49 GJ/m^2. However, since there is only one building from this province, this result may not be representative. Buildings from British Columbia and New Brunswick also consumed considerably less energy on a per square metre basis.

Table 3.1.2 Average Annual Energy Consumption for Different Provinces

	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Canada	81	1,141,180	12,985	1,182,718	87.88	0.96
BC	5	26,628	462	41,440	57.64	0.64
MN	3	19,548	347	17,912	56.34	1.09
NB	2	22,903	236	35,298	97.05	0.65
NF	1	3,593	54	7,345	66.54	0.49
NS	5	54,522	620	54,439	87.94	1.00
ON	55	902,889	9,932	916,579	90.91	0.99
QC	5	60,609	829	73,506	73.11	0.82
SK	5	50,488	505	36,199	99.98	1.39

3.2 Building Age

Because three buildings do not have any information regarding their construction year, we will omit them in this analysis.[1] **Table 3.2.1** displays the average annual energy consumption for

[1] Sussex Place located in Lindsay, Ontario; Brooklawn and Westlake Tower, both from Peterborough, Ontario.

MURBs in different age groups in Canada, while **Tables 3.2.2** to **3.2.5** present the same information for the four different regions.

The perception is the older the building, the less energy efficient it would be. For all the buildings from the HiSTAR database, this perception seems to hold because as the building's age increase, the energy intensity statistic becomes larger as well (0.97 GJ/m^2 across Canada for MURBS built since 1960 compared to 1.02 GJ/m^2 for those built earlier). However, newer buildings consumed about 35% more energy per suite than older buildings. The picture is quite different for different types of buildings as well. For low-rise buildings, those from the 1961-1985 age group were the most energy efficient (0.76 GJ/m^2), but all three age groups had a similar energy consumption level per suite. In contrast, for mid-rise buildings, the 1961-1985 age group was the least efficient and they also consumed considerably more energy per suite than did buildings from the other two age groups. In terms of high-rise buildings, none in the database were built before 1960. Somewhat surprisingly, the newer the high-rise building, the less energy efficient it was. A suite from a new high-rise building on average consumed almost twice as much energy as one from an older building, and its energy intensity (GJ per square foot) was on average almost 20% higher.

The energy efficiency of MURBs for different age groups were quite different for different regions as well. In the Atlantic area, the older the buildings were, the smaller the energy intensity statistics. Energy consumption per suite also decreased as the building aged. The picture in Central Canada is very similar to the one for Canada as a whole. This is not surprising because the highly concentrated distribution biases the Canadian results toward the Central region. Because of data limitations, comparisons for the Prairie region are not feasible. Finally, older buildings in the West Coast did consume more energy per square metre, but average energy consumption per suite was quite similar across the three age groups. Again, the buildings from the West Coast consumed considerably less energy per square metre and per suite, while buildings from Central Canada used energy more intensively on average.

Table 3.2.1 Average Annual Energy Consumption For Different Aged Buildings - Canada

	Type	Construction Year	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Canada	Total	Before 1960	6	47,993	650	46,903	73.83	1.02
		1961-1985	51	778,805	8,973	803,198	86.79	0.97
		1986 - Present	21	303,870	3,070	312,852	98.98	0.97
		Total	78	1,130,668	12,693	1,162,954	89.08	0.97
	Low-rise	Before 1960	3	13,505	150	9,929	90.03	1.36
		1961-1985	6	45,236	492	59,510	91.94	0.76
		1986 - Present	5	35,188	393	38,132	89.54	0.92
		Total	14	93,929	1,035	107,571	90.75	0.87
	Mid-rise	Before 1960	3	34,487	500	36,974	68.97	0.93
		1961-1985	35	510,177	5,594	489,592	91.20	1.04
		1986 - Present	12	141,665	1,796	154,491	78.88	0.92
		Total	50	686,329	7,890	681,057	86.99	1.01
	High-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	10	223,393	2,887	254,096	77.38	0.88
		1986 - Present	4	127,017	881	120,229	144.17	1.06
		Total	14	350,410	3,768	374,325	93.00	0.94

Table 3.2.2 Average Annual Energy Consumption For Different Aged Buildings - Atlantic Region

	Type	Construction Year	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Atlantic	Total	Before 1960	1	6,052	112	11,037	54.04	0.55
		1961-1985	6	66,585	734	80,027	90.71	0.83
		1986 - Present	1	8,381	64	6,018	130.96	1.39
		Total	8	81,018	910	97,082	89.03	0.83
	Low-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	2	17,108	151	26,490	113.30	0.65
		1986 - Present	1	8,381	64	6,018	130.96	1.39
		Total	3	25,489	215	32,508	118.55	0.78
	Mid-rise	Before 1960	1	6,052	112	11,037	54.04	0.55
		1961-1985	4	49,477	583	53,536	84.87	0.92
		1986 - Present	0	0	0	0	N/A	N/A
		Total	5	55,530	695	64,573	79.90	0.86
	High-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	0	0	0	0	N/A	N/A
		1986 - Present	0	0	0	0	N/A	N/A
		Total	0	0	0	0	N/A	N/A

Table 3.2.3 Average Annual Energy Consumption For Different Aged Buildings - Central Region

	Type	Construction Year	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Central	Total	Before 1960	4	36,291	22,936	29,920	81.01	1.21
		1961-1985	37	642,185	7,387	669,060	86.93	0.96
		1986 - Present	16	274,510	2,634	271,340	104.22	1.01
		Total	57	952,986	10,469	970,321	91.03	0.98
	Low-rise	Before 1960	3	13,505	150	9,929	90.03	1.36
		1961-1985	3	19,379	235	25,573	82.46	0.76
		1986 - Present	3	22,913	267	26,168	85.82	0.88
		Total	9	55,797	652	61,670	85.58	0.90
	Mid-rise	Before 1960	1	22,786	298	19,991	76.46	1.14
		1961-1985	24	399,412	4,265	389,391	93.65	1.03
		1986 - Present	9	124,581	1,486	124,943	83.84	1.00
		Total	34	546,779	6,049	534,325	90.39	1.02
	High-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	10	223,393	2,887	254,096	77.38	0.88
		1986 - Present	4	127,017	881	120,229	144.17	1.06
		Total	14	350,410	3,768	374,325	93.00	0.94

Table 3.2.4 Average Annual Energy Consumption For Different Aged Buildings - Prairie Region

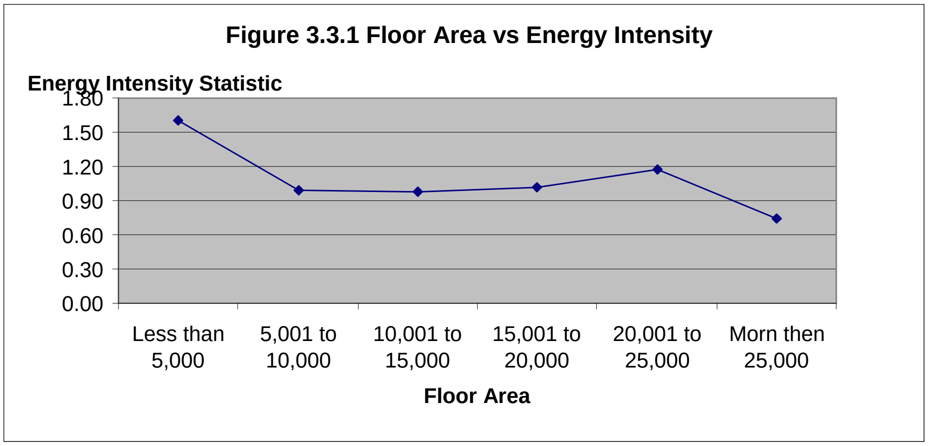
	Type	Construction Year	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Prairie	Total	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	8	70,036	852	54,111	82.20	1.29
		1986 - Present	0	0	0	0	N/A	N/A
		Total	8	70,036	852	54,111	82.20	1.29
	Low-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	1	8,749	106	7,447	82.54	1.17
		1986 - Present	0	0	0	0	N/A	N/A
		Total	1	8,749	106	7,447	82.54	1.17
	Mid-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	7	61,287	746	46,664	82.15	1.31
		1986 - Present	0	0	0	0	N/A	N/A
		Total	7	61,287	746	46,664	82.15	1.31
	High-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	0	0	0	0	N/A	N/A
		1986 - Present	0	0	0	0	N/A	N/A
		Total	0	0	0	0	N/A	N/A

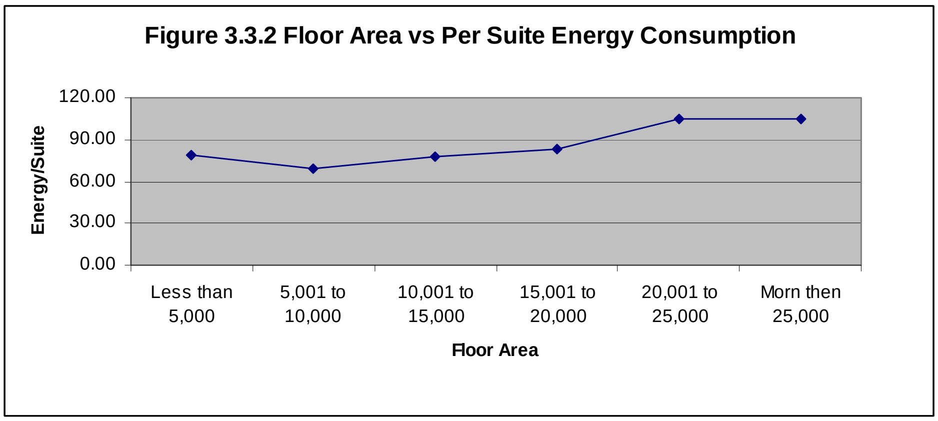
Table 3.2.5 Average Annual Energy Consumption For Different Aged Buildings - West Coast Region

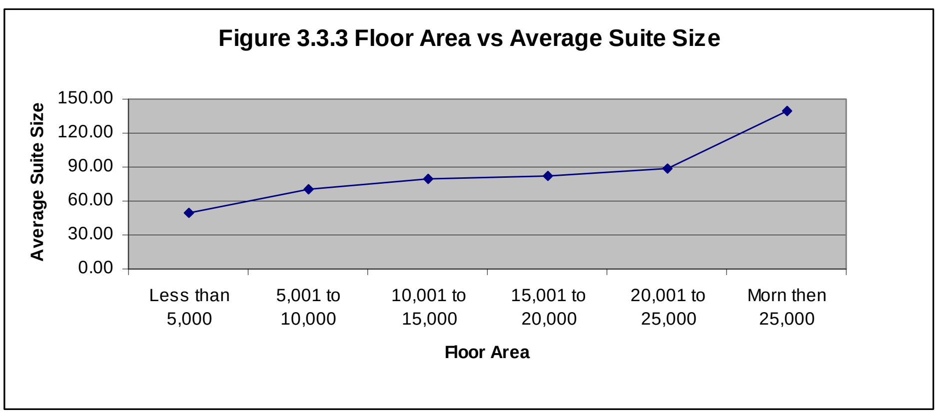
	Type	Construction Year	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
West	Total	Before 1960	1	5,649	90	5,946	62.77	0.95
		1961-1985	3	17,084	310	29,548	55.11	0.58
		1986 - Present	1	3,894	62	5,946	62.80	0.65
		Total	5	26,628	462	41,440	57.64	0.64
	Low-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	0	0	0	0	N/A	N/A
		1986 - Present	1	3,894	62	5,946	62.80	0.65
		Total	1	3,894	62	5,946	62.80	0.65
	Mid-rise	Before 1960	1	5,649	90	5,946	62.77	0.95
		1961-1985	3	17,084	310	29,548	55.11	0.58
		1986 - Present	0	0	0	0	N/A	N/A
		Total	4	22,734	400	35,494	56.83	0.64
	High-rise	Before 1960	0	0	0	0	N/A	N/A
		1961-1985	0	0	0	0	N/A	N/A
		1986 - Present	0	0	0	0	N/A	N/A
		Total	0	0	0	0	N/A	N/A

3.3 Floor Area

Figure 3.3.1 shows the generally negative relationship between the total floor area of a building and its energy intensity measure. However, **Figure 3.3.2** indicates that larger buildings used more energy on a per suite basis. This is because larger size buildings also tended to have larger suites, as shown in **Figure 3.3.3**. For instance, an average suite from a 30,000 square metre MURB was almost three times as large as an average suite from a 5,000 square metre building. Therefore, while the low energy intensity statistic for large buildings indicates that they are more energy efficient overall (on a per square metre basis), on a per-suite basis they are using considerably more energy on average. If this cannot be attributed to larger household sizes (information that is not available), then it suggests that in a broader sense they might be regarded as being less energy efficient.







Tables 3.3.1 to **3.3.5** show detailed average annual energy consumption calculated according to floor area for Canada and the four different regions. Except for one building from the Atlantic region which had abnormally low per-suite energy consumption and energy intensity statistic, all

the data from different regions are fairly consistent with the patterns described in the previous three figures.

Table 3.3.1 Average Annual Energy Consumption According to Floor Area - Canada

	Floor Area	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Canada	Less than 5,000	12	71,041	904	44,456	78.58	1.60
	5,001 to 10,000	18	132,811	1,905	134,841	69.72	0.98
	10,001 to 15,000	19	221,564	2,854	226,173	77.63	0.98
	15,001 to 20,000	11	190,424	2,300	188,111	82.79	1.01
	20,001 to 25,000	9	235,623	2,245	199,961	104.95	1.18
	More then 25,000	12	289,718	2,777	389,175	104.33	0.74
	Total	81	1,141,180	12,985	1,182,718	87.88	0.96

Table 3.3.2 Average Annual Energy Consumption According to Floor Area - Atlantic Region

	Floor Area	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Atlantic	Less than 5,000	1	257	27	2,230	9.50	0.12
	5,001 to 10,000	3	19,922	198	21,037	100.62	0.95
	10,001 to 15,000	2	20,546	329	23,826	62.45	0.86
	15,001 to 20,000	0	0	0	0	N/A	N/A
	20,001 to 25,000	1	16,851	124	24,261	135.89	0.69
	More then 25,000	1	23,443	232	25,728	101.05	0.91
	Total	8	81,018	910	97,082	89.03	0.83

Table 3.3.3 Average Annual Energy Consumption According to Floor Area - Central Region

	Floor Area	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Central	Less than 5,000	9	54,630	695	33,577	78.60	1.63
	5,001 to 10,000	7	56,194	925	60,123	60.75	0.93
	10,001 to 15,000	14	177,203	2,175	169,126	81.47	1.05
	15,001 to 20,000	11	190,424	2,300	188,111	82.79	1.01
	20,001 to 25,000	8	218,772	2,121	175,700	103.15	1.25
	More then 25,000	11	266,276	2,545	363,447	104.63	0.73
	Total	60	963,499	10,761	990,085	89.54	0.97

Table 3.3.4 Average Annual Energy Consumption According to Floor Area - Prairie Region

	Floor Area	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Prairie	Less than 5,000	2	16,154	182	8,649	88.76	1.87
	5,001 to 10,000	5	40,479	520	33,985	77.84	1.19
	10,001 to 15,000	1	13,403	150	11,476	89.35	1.17
	15,001 to 20,000	0	0	0	0	N/A	N/A
	20,001 to 25,000	0	0	0	0	N/A	N/A
	More then 25,000	0	0	0	0	N/A	N/A
	Total	8	70,036	852	54,111	82.20	1.29

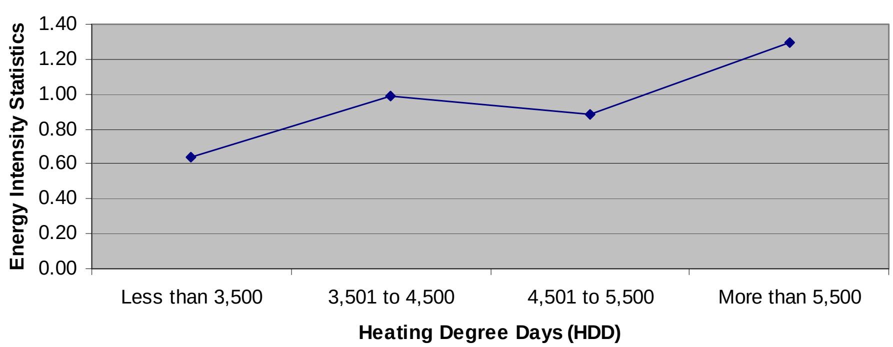
Table 3.3.5 Average Annual Energy Consumption According to Floor Area - West Region

	Floor Area	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
West	Less than 5,000	0	0	0	0	N/A	N/A
	5,001 to 10,000	3	16,216	262	19,695	61.89	0.82
	10,001 to 15,000	2	10,411	200	21,745	52.06	0.48
	15,001 to 20,000	0	0	0	0	N/A	N/A
	20,001 to 25,000	0	0	0	0	N/A	N/A
	More then 25,000	0	0	0	0	N/A	N/A
	Total	5	26,628	462	41,440	57.64	0.64

3.4 Heating-Degree-Days (HDD)

Intuitively, we expect that energy consumption will increase as the number of heating-degree-days (HDD) increases because of the higher energy demand for space heating purposes. The data generally confirm our expectation, with the positive relationship between HDD and the energy intensity statistic displayed in **Figure 3.4.1.**

Figure 3.4.1 Energy Intensity vs HDD



Regionally, the Prairie Provinces had the highest heating-degree-days and the highest energy intensity statistics (**Tables 3.4.1** to **3.4.5**). This does not necessarily indicate that the Prairie MURBs were less energy efficient than those in the rest of the nation. Rather, it may reflect the fact that this region normally has a colder and longer heating season compared to other areas in Canada. In contrast, British Columbia had the lowest number of heating degree days and one of the lowest energy intensity statistics. The lowest energy intensity of 0.62 GJ/m^2 came from the Atlantic Provinces, even though they had relatively high HDD.

Table 3.4.1 Average Annual Energy Consumption According to HDD - Canada

	HDD	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Canada	Less than 3,500	5	26,628	462	41,440	57.64	0.64
	3,501 to 4,500	56	880,342	9,929	890,014	88.66	0.99
	4,501 to 5,500	15	197,203	2,091	222,599	94.31	0.89
	More than 5,500	5	37,008	503	28,664	73.57	1.29
	Total	81	1,141,180	12,985	1,182,718	87.88	0.96

Table 3.4.2 Average Annual Energy Consumption According to HDD - Atlantic Region

	HDD	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Atlantic	Less than 3,500	0	0	0	0	N/A	N/A
	3,501 to 4,500	5	54,522	620	54,439	87.94	1.00
	4,501 to 5,500	3	26,497	290	42,643	91.37	0.62
	More than 5,500	0	0	0	0	N/A	N/A
	Total	8	81,018	910	97,082	89.03	0.83

Table 3.4.3 Average Annual Energy Consumption According to HDD - Central Region

	HDD	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Central	Less than 3,500	0	0	0	0	N/A	N/A
	3,501 to 4,500	51	825,821	9,309	835,576	88.71	0.99
	4,501 to 5,500	9	137,678	1,452	154,509	94.82	0.89
	More than 5,500	0	0	0	0	N/A	N/A
	Total	60	963,499	10,761	990,085	89.54	0.97

Table 3.4.4 Average Annual Energy Consumption According to HDD - Prairie Region

	HDD	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
Prairie	Less than 3,500	0	0	0	0	N/A	N/A
	3,501 to 4,500	0	0	0	0	N/A	N/A
	4,501 to 5,500	3	33,028	349	25,447	94.64	1.30
	More than 5,500	5	37,008	503	28,664	N/A	N/A
	Total	8	70,036	852	54,111	82.20	1.29

Table 3.4.5 Average Annual Energy Consumption According to HDD - West Region

	HDD	Number of Buildings	Total Energy Consumption (GJ)	Total Number of Suites	Total Floor Area (m2)	Energy / Suite (GJ/Suite)	Energy Intensity (GJ/m2)
West	Less than 3,500	5	26,628	462	41,440	57.64	0.64
	3,501 to 4,500	0	0	0	0	N/A	N/A
	4,501 to 5,500	0	0	0	0	N/A	N/A
	More than 5,500	0	0	0	0	N/A	N/A
	Total	5	26,628	462	41,440	57.64	0.64

3.5 Comparison with Other Sectors

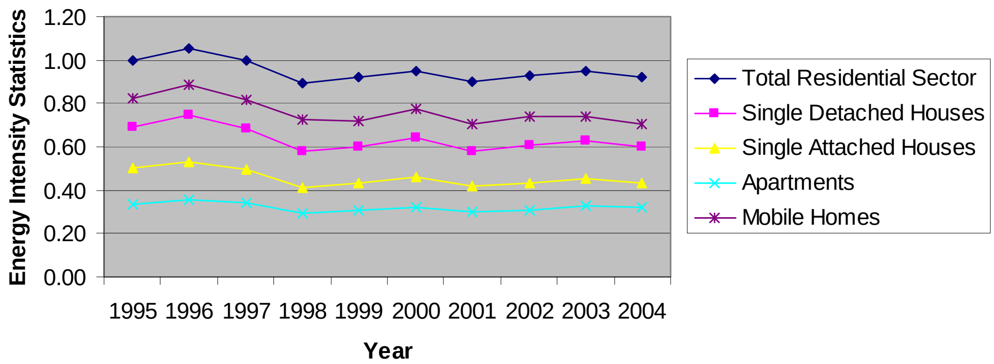
The data for the following comparisons come from the Energy Efficiency Trends Analysis Tables obtained from the Natural Resource Canada website. The most recent 10 years (1995-2004) has been chosen as a comparison period.

Table 3.5.1 presents the energy efficiency indicator for the residential sector as well for different types of residential houses. Overall the residential sector has become slightly more energy efficient over the years, as shown in **Figure 3.5.1**. Interestingly, the residential sector as a whole was significantly less efficient than any individual type of housing, which means that the inefficient segments of the sector are not separately displayed. Of the four housing types that are separately identified, mobile homes were the least efficient in terms of energy consumption per square metre. This might be expected because the living area (the denominator of the energy intensity statistics) of a typical mobile home is relatively small and its envelope is relatively inefficient. Surprisingly, apartments were the most efficient housing type, although it is not known if MURBs over 4 stories are included in this total. The average energy intensity statistics for apartments were only one third of the level for the whole residential sector. However, based on this can we conclude that multi-unit residential buildings (apartment buildings) are more energy efficient? The answer is not necessarily because based on the statistics we have for the 81 MURBs from the HiSTAR database, their energy intensity statistics ranged from 0.87 GJ/m^2 for the low-rise buildings to 1.00 GJ/m^2 for the mid-rise buildings. Therefore, at best we can only say that MURBs (4 stories or higher) are in line with the residential sector average.

Table 3.5.1 Energy Efficiency for the Residential Sector (1995-2004)

	Energy Intensity Statistics									
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Total Residential Sector	1.00	1.05	0.99	0.89	0.92	0.95	0.90	0.93	0.95	0.92
Single Detached Houses	0.69	0.75	0.68	0.58	0.60	0.64	0.58	0.61	0.63	0.60
Single Attached Houses	0.50	0.53	0.50	0.41	0.43	0.46	0.42	0.43	0.45	0.43
Apartments	0.34	0.36	0.34	0.29	0.31	0.32	0.30	0.31	0.33	0.32
Mobile Homes	0.82	0.89	0.82	0.72	0.72	0.77	0.71	0.74	0.74	0.70

Figure 3.5.1 Energy Intensity Statistics Movements for the Residential Sector (1995-2004)



Generally, it is recognized that the residential high-rise buildings underperform the rest of the commercial sector, so do the data speak for themselves? **Table 3.5.2** compares the energy efficiency for the residential and commercial sectors. Based on these data, from 1995 to 2004, the residential sector has significantly outperformed the commercial/institutional sectors, with the residential sector on average consuming 50% less energy per square metre than the commercial/institutional sector. Within the commercial sector, differences in energy consumption efficiency were quite significant across buildings devoted to different activities. For instance, the health care and social assistance segment consumed twice as much energy per square metre than did office buildings.

If we put the HiSTAR MURBs's energy intensity statistics (ranging from 0.87 GJ/m^2 for low-rise buildings to 1.00 GJ/m^2 for mid-rise buildings) into the picture, we can see the MURBs actually outperformed commercial buildings as a whole. However, given the limitations on the data we have from HiSTAR, we cannot conclude that high-rise MURBs are more energy efficient than buildings in the commercial sector. Further investigation is warranted in the future.

Table 3.5.2 Energy Efficiency Comparison bwteen the Residential and Commercial Sectors (1995-2004)

	Energy Intensity Statistics									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Residential Sector	1.00	1.05	0.99	0.89	0.92	0.95	0.90	0.93	0.95	0.92
Commercial/Institutional	1.87	1.90	1.90	1.77	1.81	1.96	1.91	2.01	2.05	2.01
Wholesale Trade	1.72	1.74	1.75	1.63	1.66	1.80	1.76	1.85	1.87	1.84
Retail Trade	1.83	1.85	1.86	1.73	1.77	1.91	1.87	1.96	1.99	1.95
Transportation and Warehousing	1.61	1.64	1.62	1.48	1.52	1.64	1.57	1.67	1.68	1.64
Information and Cultural Industries	2.68	2.72	2.74	2.54	2.60	2.82	2.76	2.89	2.96	2.91
Office *	1.49	1.51	1.51	1.42	1.45	1.57	1.53	1.60	1.62	1.59
Educational Services	1.91	1.94	1.95	1.81	1.85	2.01	1.97	2.08	2.13	2.09
Health Care and Social Assistance	3.21	3.24	3.25	3.04	3.10	3.35	3.27	3.45	3.50	3.44
Arts, Entertainment and Recreation	2.29	2.31	2.31	2.15	2.19	2.38	2.31	2.44	2.49	2.43
Accommodation and Food Services	2.97	3.00	3.02	2.82	2.88	3.11	3.04	3.19	3.25	3.19
Other Services	1.68	1.71	1.72	1.59	1.63	1.78	1.73	1.80	1.85	1.84

* "Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional; scientific and technical services; and public administration.

4. Measures to Improve High-Rise Energy Efficiency

Given the importance of high-rise MURBs in the Canadian housing market and the fact that they have not kept pace with the recent technological advanced in building design to improve energy efficiency, it is of benefit to learn what action could be taken to change this picture. Specifically, why are high-rise MURBs apparently less energy friendly than the other types of residential housing or even the rest of the commercial buildings? According to studies conducted by the Canadian Mortgage and Housing Corporation (2001), some of the common inadequacies are:

Poor Building Envelope

- High window to wall ratio and/or low performance windows.
- High air leakage.
- Inadequate insulation.
- Poor thermal bridging design.

Poor Space Heating and Air Conditioning Control

- Related to the building envelope.
- Poor heating and cooling distribution.
- Poor heating and cooling temperature control within suites.
- Poor heating and cooling system.

Poor Lighting and Appliances

- Poorly-designed lighting lay-out.
- Using less efficient lighting equipment and appliances.

Therefore, higher energy consumption in high-rise MURBs likely reflects the fact that their envelopes are not thermally efficient. Because of this, air leakage is a common problem for high-rise buildings and it also results in higher energy consumption for space heating and cooling purposes. To improve the energy efficiency of high-rise buildings, we have to focus on these areas. Possible actions that might be considered include:

Improved Building Envelope

- Upgrade to high performance windows.
- Insulate and air seal interior and exterior walls.
- Seal windows and doors to prevent air leakage.

Optimize Space Heating and Cooling System

- Replace existing equipment with higher efficiency equipment.
- Switch system or fuel. For instance, a heat pump is more efficient than an electric resistance heating system, and an electricity heating system is more efficient than a natural gas system.
- Insulate boilers and hot water piping to reduce heat losses.

Employ More Efficient Lighting and Appliances

- Replace incandescent bulbs with more efficient compact fluorescent bulbs.
- Reduce common area lighting levels if possible.
- Replace laundry appliances with more energy friendly models

The measures specified above are more relevant to improving the energy efficiency of existing high-rise buildings than they are to new construction. For potential new building developers, it is important to ensure that they have available all relevant information that would allow them to utilize available advanced technologies – at least to the extent that they are cost efficient – to design and build the next generation of energy-efficient high-rise buildings.

5. Conclusions

Using the HiSTAR data, we have studied the energy efficiency for the MURBs with 4 stories or more. Our statistical analysis shows that on average, MURBs from the West Coast consumed less energy than the rest of the nation, while those from the Prairies Provinces consumed the most energy on a per square metre basis. However, this may reflect more the climate difference rather than the efficiency of the building itself. Furthermore, the data do not confirm the hypothesis that residential high-rise buildings are less energy efficient than commercial buildings. However, because of limitations with the data, we cannot reject this hypothesis either. More data and further investigation is required.

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