RESEARCH HIGHLIGHT

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ENERGY AND WATER CONSUMPTION LOAD PROFILES IN MULTI-UNIT RESIDENTIAL BUILDINGS

INTRODUCTION

While research is beginning to generate an understanding of the annual energy and water consumption of multi-unit residential buildings, little information is currently available that can describe the consumption patterns of natural gas, electricity and water at any given time or over the course of a given day, week, month or season. This information is necessary for the evaluation of energy and water efficiency opportunities in multi-unit residential buildings, particularly in the application of cogeneration and load shedding technologies.

Canada Mortgage and Housing Corporation initiated a research project to access a proprietary database from Ozz Corporation of 15-minute meter readings of natural gas, electricity and water consumption data for 34 multi-unit residential buildings over a two-year period commencing May 1, 2001. Most of the buildings are located in the Greater Toronto Area of Ontario. While the database remains proprietary, information on energy and water load profiles has been generated to illustrate how energy and water are used on an hourly, daily, monthly basis and the overall magnitude of use. Not only are the load profiles of individual buildings of interest but also the variations between similarly equipped and sized buildings. This research documents the different features of the 34 buildings, characterizes the annual energy and water use, and provides insight on the 15-minute interval gas, electricity and water consumption data for a number of buildings in the sample set. In addition, a preliminary analysis of the annual load data for gas and electricity is provided.

RESEARCH PROGRAM

The natural gas consumption and electric loads in 34 multi-unit residential buildings and water consumption in 21 of these buildings were collected during a two-year period. The number of apartments in the buildings ranged from 69 to 473 units. In all of the buildings, domestic hot water is heated centrally by gas-fired boilers. Three of the buildings are heated electrically while the remaining buildings are heated by central gas-fired boilers connected to in-suite baseboard convectors or fan-coils. Most of the buildings (26 out of 34), including the three that are electrically heated, are bulk metered for electricity; eight of the buildings are electrically sub-metered but no in-suite data was collected.

The energy and water consumption data was analyzed in terms of

- total annual consumption per building
- normalized annual energy consumption per floor area
- normalized annual water consumption per suite
- daily consumption for the two-year period
- coincidental gas and electricity consumption for discrete time periods

A detailed statistical analysis of the data was undertaken to determine if there was any correlation between the characteristics of the buildings and energy or water use patterns observed and the strength of the correlations that were found to exist.

The following discussions highlight some of the findings of the study.

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FINDINGS

The total annual energy consumption ranged from 281 to 581 ekWh/m^2 for gas-heated buildings, and from 340 to 347 ekWH/m^2 for electrically heated buildings. Figure 1 details the normalized (per 1,000 m^2 floor area) annual gas and electricity consumption of each building in the study—grouped in subsets that reflect heating energy source, presence of air-conditioning (a/c) and whether or not the electrical data included the in-suite use. In all buildings, the domestic hot water was heated by natural gas. The buildings in the Group 1 sample set were heated electrically (no a/c—hence the relatively larger electrical consumption in comparison with the other buildings.) Group 2 and 3 were heated by gas and were bulk metered for electricity. However, Group 2 had central a/c systems while Group 3 did not. The buildings in Group 4 are gas heated, no central a/c and only have the electricity use for the common areas represented (that is, no in-suite use).

Annual natural gas consumption was between 18 to 43 m^3/ m^2 floor area (average 28 m^3/m^2). Annual electricity consumption within buildings with central air-conditioning systems was, on average, 116 kWh/m^2 while non air-conditioned buildings consumed 101 kWh/m^2 reflecting lower electricity use. Interestingly, electricity use when normalized *per suite* is actually less in the air-conditioned buildings. This is yet another indication of the large differences in the energy efficiency (consumption per unit area) among the buildings that are unrelated to the existing facilities or services. The relative average annual energy consumption for space heating, domestic hot water and electricity is shown here for the natural-gas heated buildings (Figure 2).

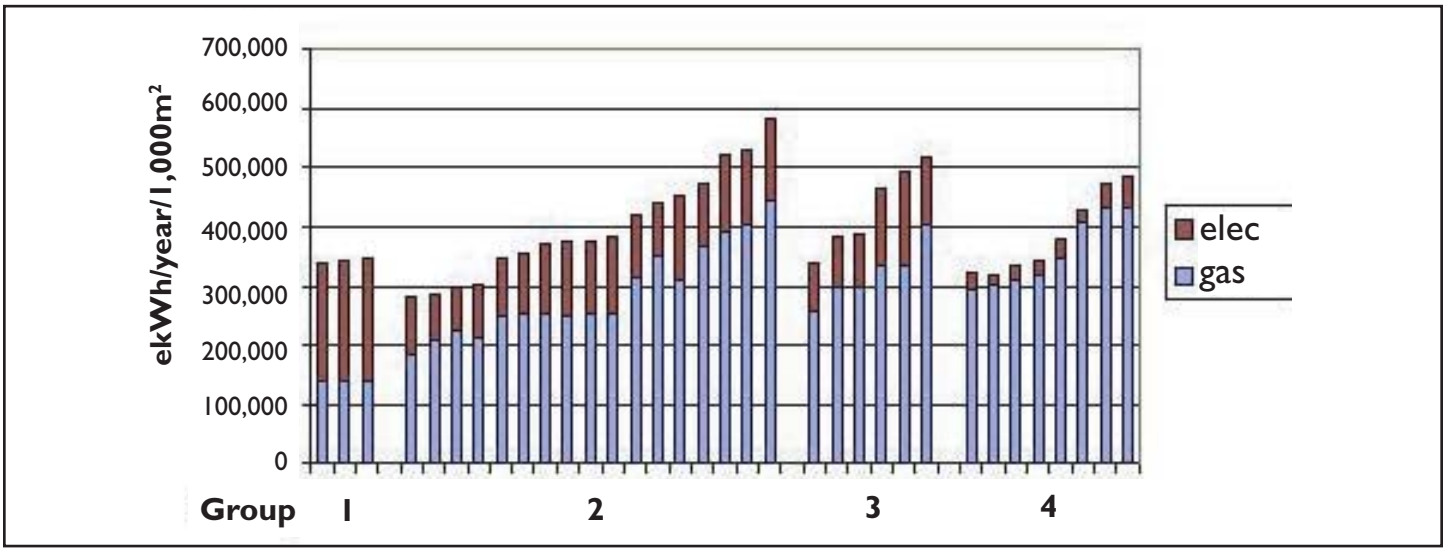

Figure 1: Annual Total Energy Consumption

In general, the research found that there were over two-fold differences in energy consumption per unit area among the 34 buildings. This applies to total energy consumption as well as to natural gas and electricity consumption separately. The differences in the usage levels could not be reliably assigned to building characteristics such as age, floor area, height or facilities such as the existence of an indoor or outdoor pool. The differences may however be attributed to variations in insulation, air leakage rates, combustion efficiencies, standby losses, controls and distribution inefficiencies of natural gas systems, or to poor energy management in general. The differences in the consumption per unit area were highly correlated with a measure of irregularities or inconsistencies in the building's gas consumption. A measure of these unexplainable irregularities was also highly correlated not only with the total gas but also total electricity consumption. It is suspected that many high-gas/electricity-use buildings have poor controls in place to regulate energy consumption.

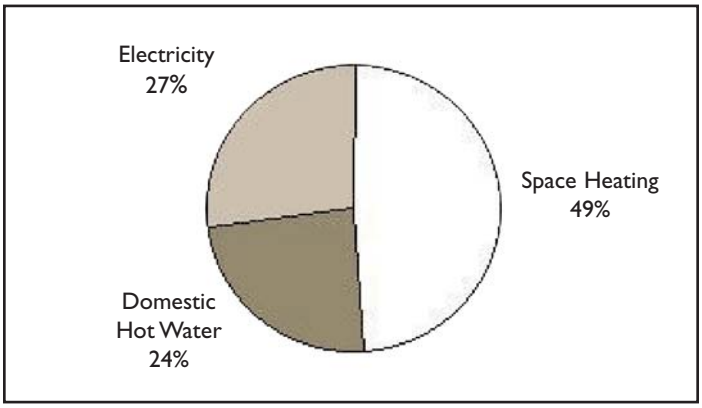

Figure 2: Annual Average Energy End-use Distribution (gas heated buildings)

Water consumption averaged 209 m^3/suite per year with a range from 92 to 313 m^3/suite per year. The consumption figures correspond to average Canadian household water use estimates that range from 192 to 313 m^3/suite per year in a 2-person suite (based on 263 to 313 Litres/person/day).

The annual natural gas consumption profile is shown in Figure 3 for selected gas heated buildings. The seasonal variation is evident and the "base" gas load for domestic hot water can be seen during the summer months. The domestic hot water load inferred by Figure 3 agreed well with the monitoring of natural gas use for domestic hot water heating in the electrically heated buildings subset.

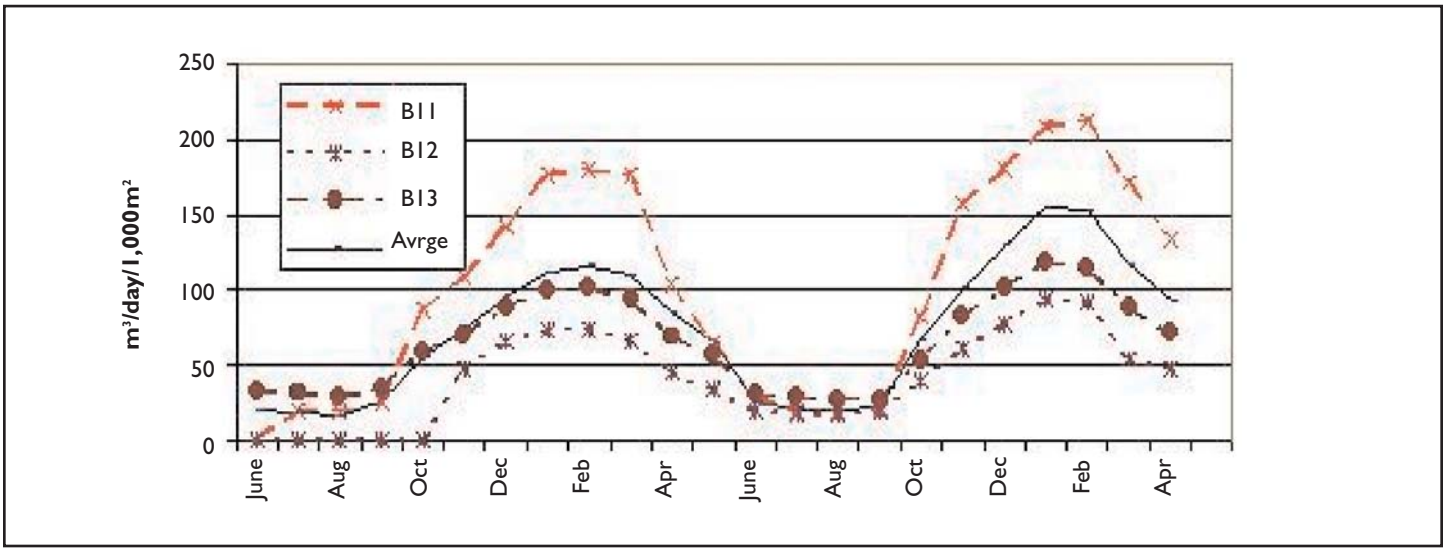

Figure 3: Annual Gas Load Profile for Selected Buildings (gas heated buildings)

Figure 4 depicts the monthly variation in electricity load for a sample of gas heated buildings with central a/c systems. The impact of the operation of the a/c system is evident in the summer months. For buildings with no central a/c (not shown), a rise in consumption during the summer was noted—this may have been due to the use of window a/c units.

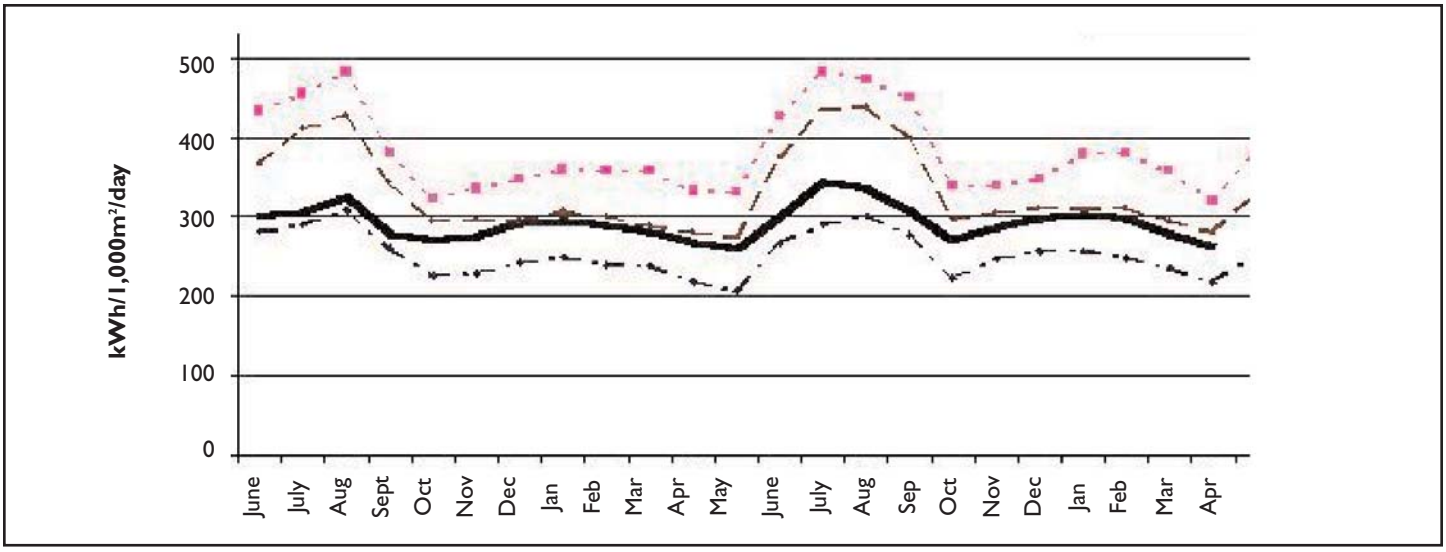

Figure 4: Annual Electricity Load Profile for Selected Buildings

The daily water consumption per unit area, summarized by months, is shown in Figure 5 for selected buildings without pools. Slight increases in water use during the summer months can likely be attributed to lawn watering and car washing (the sudden downward spike in the water consumption of one of the plots indicates a lack of readings and not a lack of usage). Perhaps one of the most striking features of the water usage graphs is the range of consumption between the buildings. The difference between the highest and lowest water consumption is much greater than that of other utilities. It was also noted that water meters are rather unreliable and routinely break down.

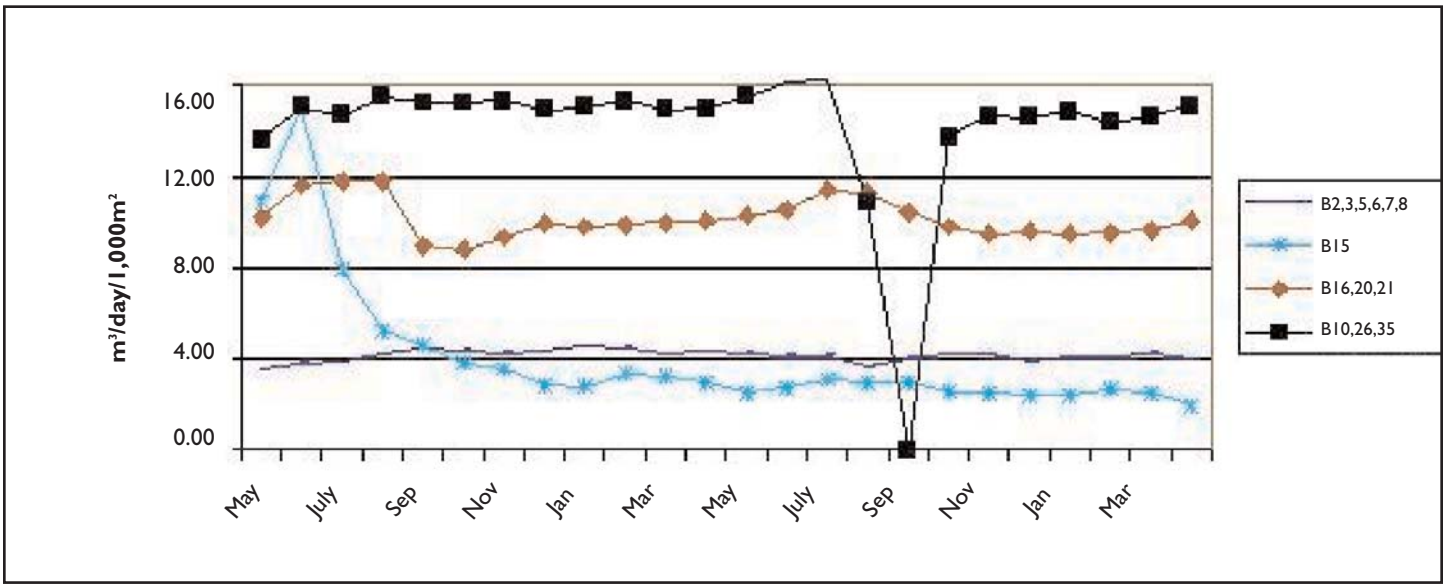

Figure 5: Annual Water Consumption Load Profile for Selected Buildings

The research also involved the compilation of simultaneous consumption data for natural gas and electricity. In peak winter demand conditions, the demand for gas was found to be approximately 2.5 to 3 times the demand for electricity in equivalent energy terms. Coincidental demand during the spring and fall were more closely matched with natural gas dominating in the spring and electricity demand dominating in the fall.

IMPLICATIONS FOR THE HOUSING INDUSTRY

The research identifies the magnitude of daily, month and annual energy and water use in a set of multi-unit residential buildings. The information is useful to show where, how much, and when, energy and water is used in buildings. This information can be useful in the assessment of the potential impacts of energy and water efficiency upgrades and the development of strategies for load shifting to take advantage of time of use energy rate schedules.

The research also shows the variability of energy and water use in multi-unit residential buildings which in turn may infer the potential reductions in energy and water use possible. The lack of a strong correlation between energy consumption and building characteristics seems to suggest that other factors, such as poor heating system control and other energy losses, are affecting the performance of the buildings.

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Research Report: Energy and Water Consumption Load Profiles in Multi-Unit Residential Buildings, June 2005, English only

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Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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