ENERGY CONSUMPTION IN LOW-RISE WOOD-FRAME MULTI-UNIT RESIDENTIAL BUILDINGS

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ABSTRACT

A study was performed to understand the energy consumption in low-rise wood-frame multi-unit residential buildings (MURBs) and townhouse buildings in south-west British Columbia. Low-rise MURBs are an important building type as they make up a growing proportion of housing stock in cities across North America.

Through this study, energy data was collected from electricity and gas utilities for 20 low-rise buildings (four storeys and less) and three townhouse complexes. This data was calendarized and weather normalized to determine average annual and monthly energy consumption for analysis and comparison.

Two buildings were chosen from the data set for detailed analysis, one low-rise (four-storey) and one townhouse complex. The buildings were selected based on characteristics typical of low-rise MURBs in south-west BC. The purpose of the detailed analysis was to assess opportunities to improve the energy efficiency and reduce carbon emissions in existing low-rise MURBs using whole building energy modelling.

This paper details the energy consumption trends observed through the data analysis, and the energy modelling results of the buildings chosen for detailed study. These results are also compared to results from a similar study which evaluated the energy use in mid- to high-rise non-combustible MURBs. The work presented here will improve our understanding of energy consumption in low-rise MURBs, and characterize opportunities for energy savings in these buildings.

INTRODUCTION

The energy consumption characteristics of wood-frame MURBs are not well understood by the building industry. MURBs are an important building type for energy consumption and greenhouse gas emissions (GHGs), particularly in large cities where they often comprise a significant proportion of the housing stock. There is a lack of data documenting measured energy consumption in low-rise MURBs, and a lack of feedback to designers, builders, and owners on how their buildings are performing in service. Occupants are often unaware of their total energy consumption and costs since common area energy accounts are separated from the individual account holders, and there is usually no metering of gas for individual units.

Many MURBs in British Columbia and other parts of North America have completed or are undergoing comprehensive building enclosure retrofits either to remedy moisture-related issues, or simply to renew aging components. For reasons primarily related to short term cost, historically very little attention has been directed towards energy conservation strategies or GHG emission reduction in these buildings. However, the retrofit, renewal, or rehabilitation of aging buildings presents a unique opportunity to significantly reduce a building's energy consumption and associated GHG emissions.

This research study was undertaken as a follow up to the study *Energy Consumption and Conservation in Mid and High-Rise Residential Buildings in British Columbia* (RDH, 2012). The current study compliments the previous high-rise study by estimating the impacts of building enclosure renewals on the measured energy consumption of low-rise (two- to four-storey) wood-frame MURBs, including townhouse developments and multifamily buildings. The study findings will be used to assess the benefits of better building enclosure design strategies to reduce energy consumption and associated GHG emissions. The study focuses primarily on condominium-owned MURBs, though five market rental buildings were also included in the study.

OBJECTIVES

The three primary objectives of this research study are as follows:

1) Characterize end-use energy consumption of low-rise wood-frame MURBs (two- to four-storeys) in the Lower Mainland of British Columbia. Building types include townhouse developments plus three- to four-storey wood-frame MURBs constructed from the 1970s through 2000s.

2) Compare the energy use of low-rise wood-frame MURBs to mid- to high-rise non-combustible MURBs and identify similarities, differences, and trends.

3) Identify opportunities for low-rise MURBs of different types to reduce energy use and associated GHG emissions in existing MURBs.

METHODOLOGY

Building Selection

Fifty-seven MURBs of four-storeys and less were initially considered for analysis as part of this study. Candidate buildings were obtained from previous RDH projects as well as volunteers interested in participating in the study. They included projects that have had depreciation reports, condition assessments, and in some cases, building enclosure renewal projects, as well as buildings with no previous RDH involvement. All buildings are located in either Metro Vancouver or Victoria. The buildings were selected to be representative of typical low-rise MURBs in south-west BC.

Data from 23 of the buildings are covered in this report. The data from the remaining buildings was deemed unsuitable for this study for several reasons, including missing or erroneous energy data, building enclosure construction that remains outside of the scope of this project (i.e. steel stud framing or solid masonry), metering issues (i.e. single gas or electricity meters for several buildings grouped in complexes), or lack of available data on the buildings. All of the buildings in this study use a combination of natural gas and electricity. For confidentiality reasons, buildings are referenced in this study using numbers 1 through 23.

Energy Consumption Data Analysis

A minimum of three years of gas and electrical billing data was collected for each of the study buildings. Electricity and gas consumption data for each building was provided by the utilities, BC Hydro and FortisBC, with permission from the building owners.

Following the review of the total monthly energy data for each building, the data was weather normalized to determine the building's average annual energy consumption for a typical weather year. The monthly energy consumption was plotted versus the actual monthly heating degree days (HDD) obtained from Environment Canada. The resulting trend was used to calculate average monthly weather normalized consumption. Further details on this process are explained in the full research report (RDH, 2017).

The weather normalized average monthly consumption was analyzed to estimate the amount of heating and non-heating (baseline) energy consumption. This is done by assuming heating is not used in July and August, and these months' consumption reflect typical base loads for end-uses such as lighting, appliances, and domestic hot water (DHW). This analysis assumes there are no other significant seasonal trends, such as seasonal variations in lighting or domestic hot water. This analysis, referred to as a "top-down" approach, gives an approximate breakdown of heating versus baseline energy use at the building. More detailed analysis requires whole building energy modelling and/or sub-metering.

Calibrated Modelling

In contrast to the top-down data analysis approach presented above using utility billing data, a bottom-up approach uses whole building energy modelling to estimate energy consumption by end-use. In this analysis, energy models are calibrated to align with metered energy consumption so that the model results better reflect the building's consumption.

Of the initial 23 case study buildings, two were selected for calibrated energy modelling: one townhouse (constructed in 1983) and one four-storey MURB (constructed in 2008); these two buildings were selected because they had complete data and are representative of low-rise MURBs in south-west BC. Modelling was performed to better understand how energy is consumed in low-rise townhouse and multi-storey wood-frame MURBs, and to assess the impacts of potential energy conservation measures (ECMs) in these buildings. The buildings were modelled using DesignBuilder, which is an interface that uses the US DOE-sponsored EnergyPlus™ engine to simulate annual energy consumption on an hourly basis.

The energy model uses regional weather data for a typical year as well as inputs that describe the enclosure parameters, mechanical systems, electrical systems, and operational characteristics to simulate the building's annual energy consumption. Most inputs were determined from architectural, mechanical, and electrical plans for each building, as well as site visits. Other inputs such as airtightness and plug loads were unknown and thus estimated based on published standards and previous research. These unknown inputs were manually adjusted during the model calibration process until the model output aligned with the metered data.

Mechanical parameters that were varied to calibrate the model included make-up air set point temperature, DHW flow rate, and baseboard output capacity. Electrical parameters that were varied to calibrate the model included suite lighting power density, appliance and plug loads, and miscellaneous common area loads.

To assess the quality of the model calibration, ASHRAE Guideline 14 (ASHRAE, 2002) describes statistical methods to quantify modelling uncertainty for calibration to monthly utility bills. This involves calculating the Coefficient of Variation of the Root Mean Square Error (CVRMSE) and the Normalized Mean Bias Error (NMBE). The CVRMSE must be less than 15%, and the NMBE less than 5%.

The calibrated energy models were used to analyze the impact of various ECMs on building energy consumption by modelling ECMs that could be implemented at the time of an enclosure retrofit. Three tiers of bundles were modelled: (1) a better enclosure, (2) a "best" enclosure, and (3) the addition of mechanical and lighting upgrades to the best enclosure case. The bundles were modelled to determine the resulting energy use intensity (EUI, kWh/m²/yr), total energy savings (%), and heating energy savings (%). The results of the ECM analysis are presented in the Calibrated Energy Modelling section of this paper.

Archetypical Building Modelling

Following the calibrated modelling and ECM analysis for the two case study buildings, information collected from the larger study sample was used to develop two models representative of older archetypical buildings. These models are intended to represent typical existing buildings, constructed in the 1970s, which have not undergone enclosure or energy-related retrofits to date. The two models were adjusted to reflect typical building methods of that era, such as single-pane, aluminum-frame windows and 2x4 wood framing with fibreglass batt insulation. The building characteristics were selected by gathering data from the oldest buildings in the larger study sample as well as previous project experience.

The same ECM bundles were that were modelled for the townhouse and low-rise calibrated models were also modelled for the archetypical older building models.

LOW RISE ENERGY CONSUMPTION DATA ANALYSIS

The total energy consumption for 23 MURBs is presented in this section. Figure 1 displays the total EUI for all the buildings, sorted from low to high energy consumption.

The average EUI for the 23 low-rise MURBs in the study is 171 kWh/m^2/yr. The EUIs ranged from 95 to 279 kWh/m^2/yr, with a median EUI of 160 kWh/m^2/year. Based on this small sample set, the building type (MURB vs townhouse) does not appear to influence the total EUI as two of the three townhouse buildings are at the low end of the data set, and the remaining townhouse is at the high end of the data set.

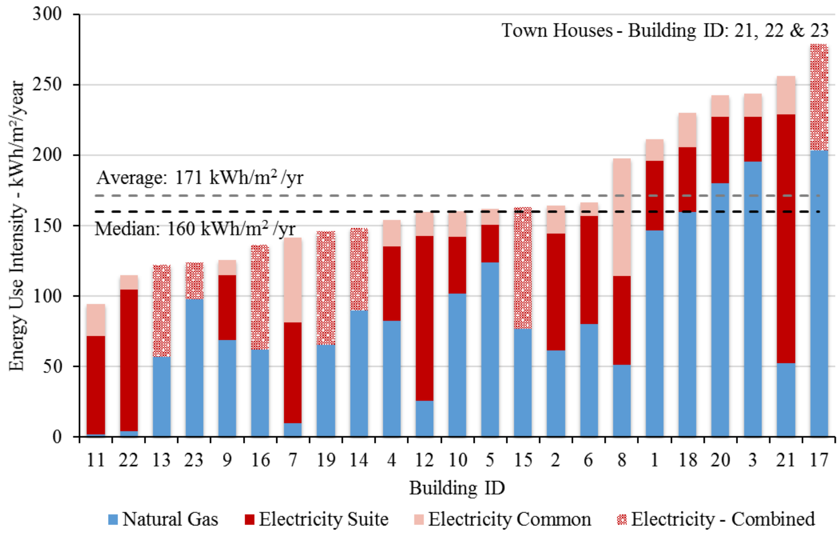

Figure 1: Total EUI sorted low to high, split by electricity (common and suite) and gas.

LOW-RISE VS. MID- AND HIGH-RISE MURBS

RDH previously collected and analyzed in detail the energy consumption of mid- and high-rise residential buildings (RDH, 2012). The data collected in this study compared to the mid- and high-rise study findings. Figure 2 presents the energy use, normalized per suite, sorted from low to high, with the overall gas and electricity portions indicated for low- and high-rise MURBs.

The energy use per suite is on average 22,000 kWh/yr for high-rise MURBs, 16% higher than the average suite consumption in a low-rise MURB, which is 18,500 kWh/yr. High-rise Building 57 (Figure 3) with the highest suite consumption of 50,600 kWh/yr, is a luxury condominium building with individual suites over 2,000 ft^2. This building has full amenities that typical low-rise MURBs do not include such as air conditioning, a common area pool, and a recreation centre.

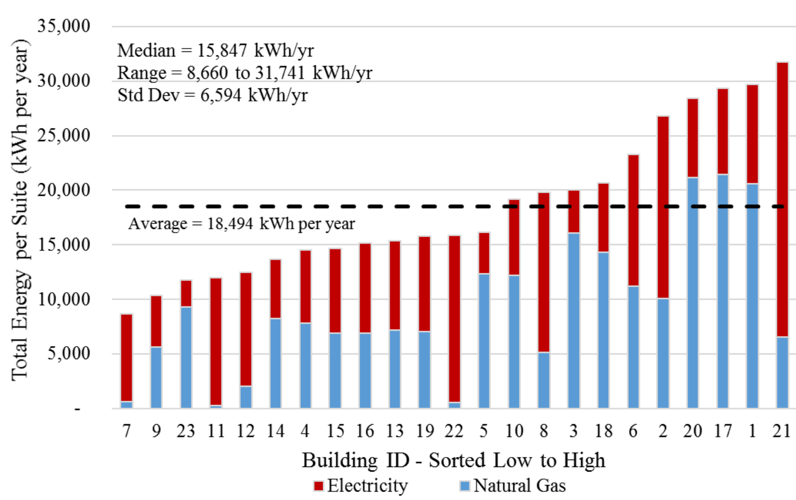

Figure 2: Low-rise MURB total energy consumption normalized by suite, divided between natural gas and electricity, sorted low to high.

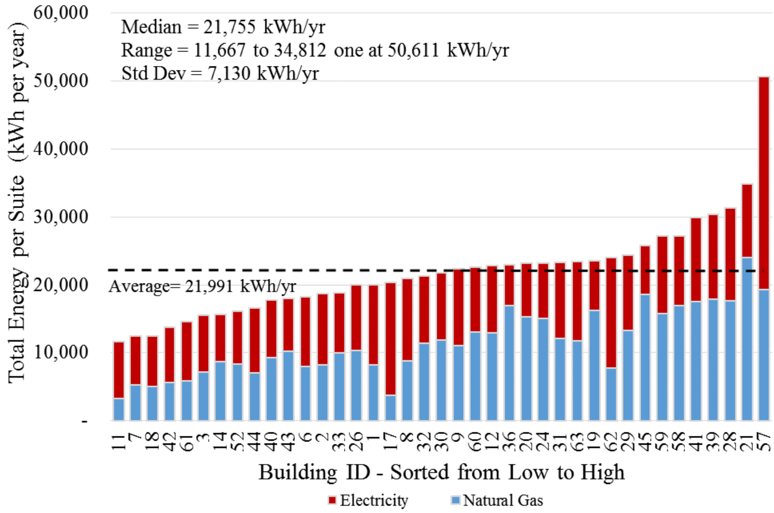

Figure 3: High-rise MURB total energy consumption normalized by suite, divided between natural gas and electricity, sorted low to high (RDH, 2012).

Energy Consumption and Year of Construction

Figure 4 and Figure 5 show the total EUI for each of the buildings versus the year of construction for low- and high-rise MURBs, respectively. The total energy used for space heating per floor area is also shown. The years of construction range from 1974 to 2010.

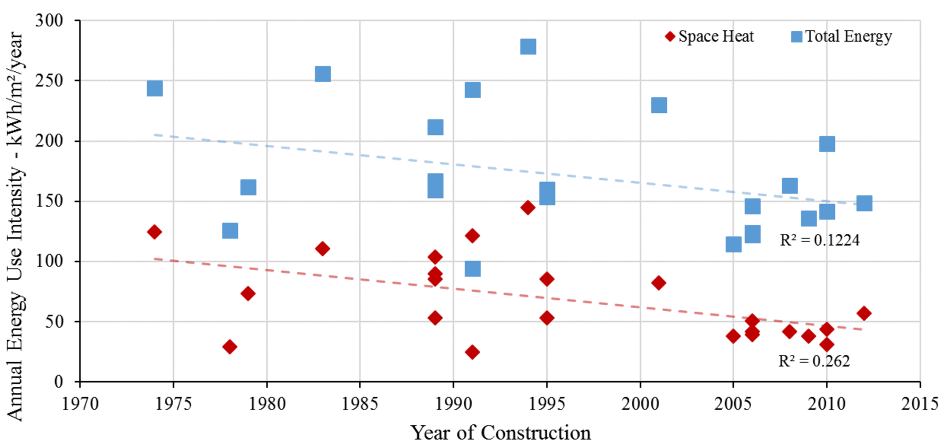

Figure 4: Total building EUI and space heating energy versus year of construction for low-rise MURBs.

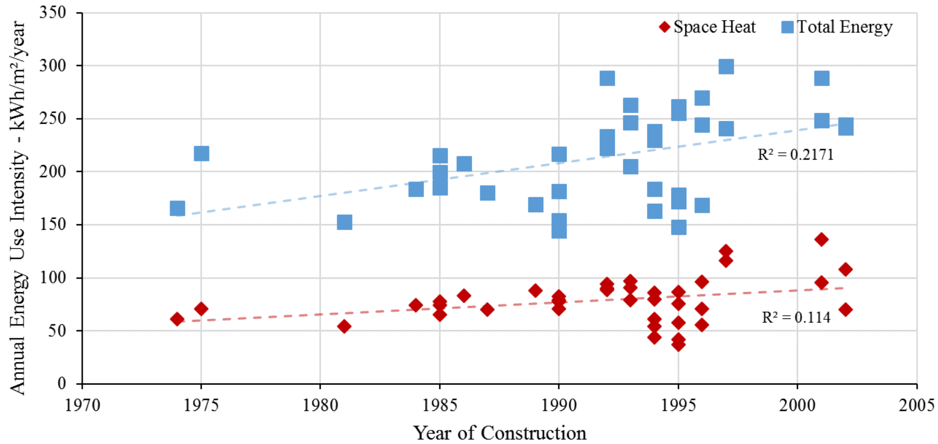

Figure 5: Total building EUI and space heating energy versus year of construction for high-rise MURBs (RDH, 2012).

The low-rise plot shows the total and heating EUIs gradually decreasing for newer buildings. Reasons for the decrease in total energy and space heating energy could include the use of more efficient mechanical systems, lighting, and appliances, as well as improved performance of the building enclosures.

This decreasing trend is in contrast to Figure 5, which shows an increase in both space heat and total energy for newer high-rise buildings, particularly in buildings constructed between 1990 and 2000. The reason for the increase is likely due to a combination of factors, including more amenities (pools, hot tubs, etc.), more complex building form, higher ventilation rates, and higher glazing areas in newer high-rise MURBs.

Energy Consumption and Window-to-Wall Ratio

The EUI (total and heating) versus window to wall ratio for each of the buildings is presented in Figure 6 and Figure 7 for low- and high-rise MURBs, respectively.

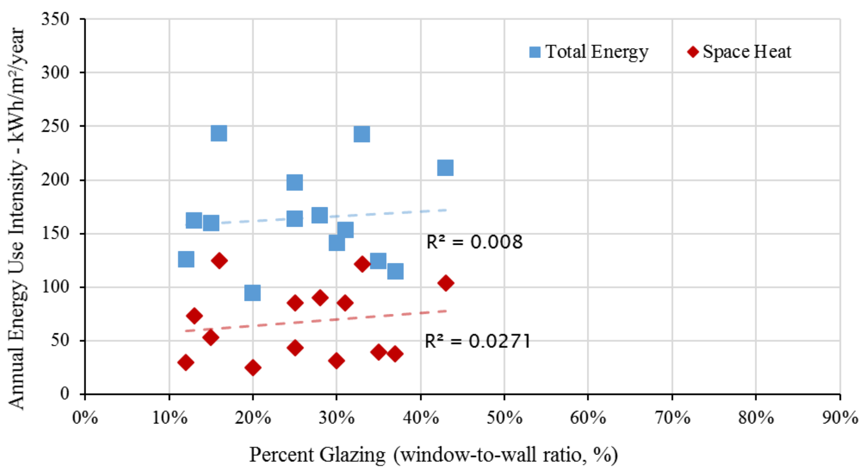

Figure 6: Total EUI and space heat energy versus the window to wall ratio for low-rise MURBs.

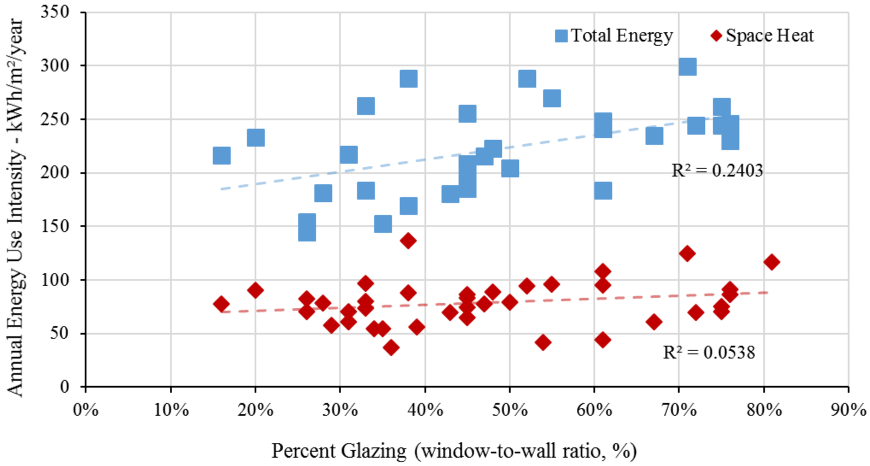

Figure 7: Total EUI and space heat energy versus the window to wall ratio for high-rise MURBs.

The low-rise plot (Figure 6) shows a slight increase in both total and space heating EUI as window to wall ratio increases, however the correlation is weak. The window to wall ratio was only available for 14 buildings in the data set. By comparison, the high-rise plot (Figure 7) shows a slight correlation between total energy and window to wall ratio. Since the trend is stronger for total EUI than heating, it is more likely due to buildings with more amenities tending to have higher window to wall ratios.

Percentage of Heating Energy

The buildings in both studies have similar mechanical systems, with the majority of buildings providing space heat with electric baseboards and gas-heated make-up air to pressurize corridors (some buildings provide untempered make-up air). Six buildings have supplementary heat provided by in-suite gas fireplaces. Two buildings have hydronic baseboard heaters instead of electric baseboards.

Figure 8 shows the average distribution of baseline energy consumption and space heating energy, normalized by floor area for both low- and high-rise MURBs.

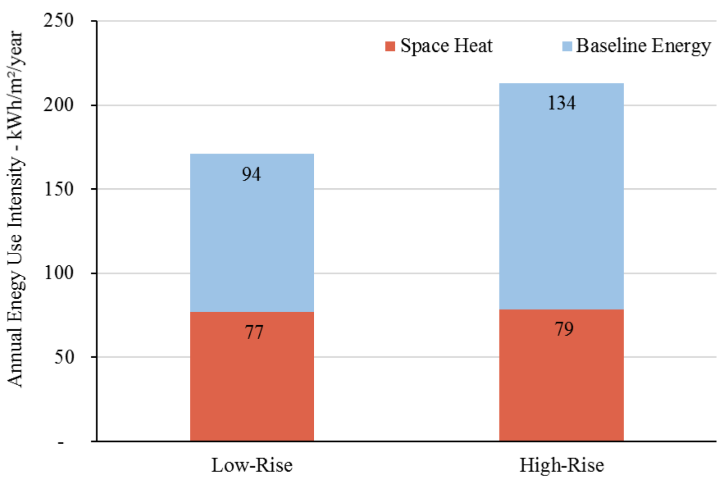

Figure 8: Average low and high-rise MURB energy consumption, kWh/m^2/yr.

The study results indicated that low-rise buildings have 2% lower space heating compared to high-rise buildings, and 25% less total energy consumption. In other words, the two building types were found to have similar heating energy intensities, but high-rise MURBs had greater baseline energy consumption, likely due to an increase in building amenities, such as pools, gyms, etc.

CALIBRATED ENERGY MODELLING

ECMs were modelled using the calibrated energy models for the two case study buildings, a four-storey MURB (Building 15, built in 2008) and a townhouse complex (Building 21, built in 1983 with enclosure retrofit in 2000). The ECMs were chosen to reflect feasible changes that would impart significant energy savings to each building.

Building 15: Four-Storey MURB

ECMs were first modelled independently and then in three tiers of bundles for Building 15 reflecting (1) a better enclosure, (2) a "best" enclosure, and (3) the addition of mechanical upgrades to the best enclosure case. GHG emissions were calculated for each of the buildings using British Columbia emission factors (Ministry of Environment, 2016).

The energy and GHG savings for each bundle are shown in Table 1 and Figure 9. In the analysis for Building 15, Bundles 2 and 3 show the greatest heating savings. While Bundle 3 with DHW and lighting ECMs has the greatest total energy savings. Only moderate increases in savings are seen by adding the MUA measures in Bundle 3 because the MUA outdoor flow rate was already reduced by adding in-suite HRVs in Bundle 2.

Table 1: Building 15 (MURB) ECM Bundles.

Description	Total EUI ($kWh/m^2/yr$)	Heating EUI ($kWh/m^2/yr$)	Total Energy Savings (%)	Heating Savings (%)	GHG Savings (%)
Baseline	**181**	**57**	—	—	—
Bundle 1 – Better Enclosure Add R-5 to walls (R-21 total) Add R-10 to roof (R-48 total) Double glazed windows (U-0.28) Air tightness to 0.10 cfm/ft^2 (@4 Pa)	172	48	5 %	16 %	1 %
Bundle 2 – Best Enclosure Add R-10 to walls (R-26 total) Add R-10 to roof (R-48 total) Triple glazed windows (U-0.17) Air tightness to 0.04 cfm/ft^2 (@4 Pa) 85% efficient HRVs in suites	142	5	22 %	91 %	36 %
Bundle 3 – Best Enclosure plus Mechanical and Lighting Bundle 2, plus: High efficiency MUA (93%) MUA set point lowered to 17°C Low-flow in-suite fixtures High efficiency boiler (93%) Occupancy sensors , LED lighting	106	5	41 %	91 %	55 %

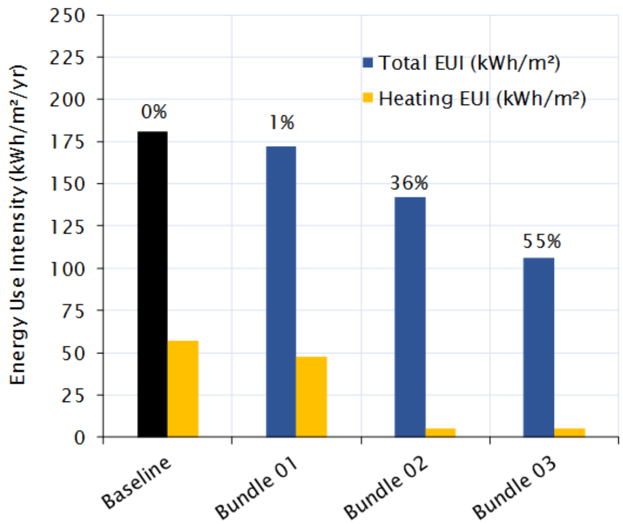

Figure 9: The total EUI, heating EUI, and percentage reductions for the Building 15 baseline and ECM bundles.

Building 21: Townhouse

Three tiers of ECM bundles were assembled for Building 21, reflecting (1) a better enclosure, (2) a "best" enclosure, and (3) the addition of mechanical upgrades to the best enclosure case. The energy savings for each bundle are shown in Table 2 and Figure 10.

ECM bundle energy savings for Building 21 (townhouse) are not as high as for Building 15 (MURB). This is partly due to the fact that Building 21 does not have a MUA unit and thus less savings are seen by adding HRVs (there is no MUA energy that would be decreased by adding HRV ventilation) and HRVs add electrical fan energy to the overall consumption.

Less heating savings can also be attributed to the gas fireplaces in Building 21. These are modelled as static, occupant-controlled loads to the suites, so a reduction in fireplace energy was not modelled with the improved enclosure, assuming occupants use their fireplaces for ambiance and not only for heat. The true impact on the change in occupant fireplace use with a significantly improved enclosure requires further study. Since the fireplace consumption remains unchanged, the observed heating savings are lower than Building 15.

Table 2: Building 21 (Townhouse) ECM Bundles.

Description	**Total EUI ($kWh/m^2/yr$)**	**Heating EUI ($kWh/m^2/yr$)**	**Total Energy Savings (%)**	**Heating Savings (%)**	**GHG Savings (%)**
Baseline	**277**	**128**	—	—	—
Bundle 1 – Better Enclosure Add R-5 to walls (R-16 total) Add R-10 to roof (R-28 total) Double glazed windows (U-0.28 Air tightness to 0.10 cfm/ft2 (@4 Pa)	243	95	12 %	26 %	4 %

Bundle 2 – Best Enclosure Add R-10 to walls (R-21 total) Add R-20 to roof (R-38 total) Triple glazed windows (U-0.17) Air tightness to 0.04 cfm/ft2 (@4 Pa) 85% efficient HRVs in suites	189	32	32 %	75 %	10 %
Bundle 3 – Best Enclosure plus Mechanical and Electrical Bundle 2, plus: Low-flow in-suite fixtures High efficiency boiler (93%) Occupancy sensors, LED lighting	164	33	41 %	74 %	32 %

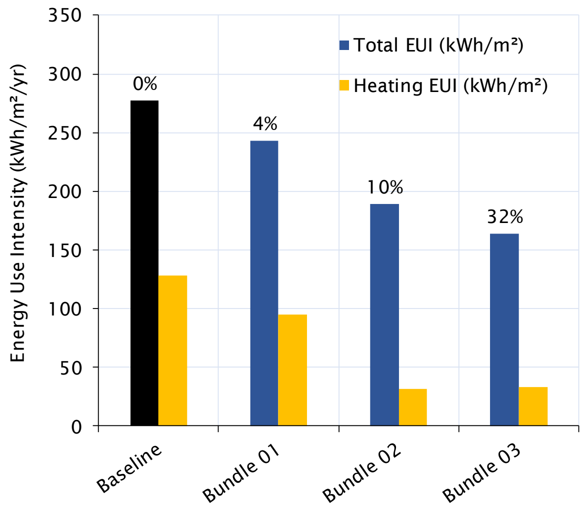

Figure 10: The total EUI, heating EUI, and percentage reductions for Building 21 baseline and ECM bundles.

ARCHETYPICAL PRE-RETROFIT BUILDING MODELS

The calibrated models of the four-storey MURB (Building 15) and the townhouse (Building 21) were adjusted to reflect more typical construction practices and materials/equipment from the 1970's era. This cohort of wood-frame MURBs is currently over 40 years old, and many of these buildings are in need of significant renewals to address ageing enclosures and to replace existing equipment. The same ECM bundles simulated for the case study were also simulated for the archetypical older buildings.

Archetypical Low-Rise MURB

The savings for the archetypical older low-rise building are greater than for Building 15 because the baseline was altered to reflect the lower energy performance of an older building type, including single glazed windows, less insulated walls/roof, and higher air leakage. The archetypical older low-rise MURB baseline EUI is 214 kWh/m²/yr, compared to 181 kWh/m² for Building 15. The energy savings for each bundle are shown in Table 3 and Figure 11.

Table 3: Archetypical low-rise MURB ECM bundles.

Description	Total EUI ($kWh/m^2/yr$)	Heating EUI ($kWh/m^2/yr$)	Total Energy Savings (%)	Heating Savings (%)	GHG Savings (%)
Baseline	**214**	**90**	—	—	—
Bundle 1 – Better Enclosure Add R-5 to walls (R-16) Add R10 to attic roof (R-30) Double glazed windows ,(U-0.28) Air tightness to 0.10 cfm/ft² (@4 Pa)	189	65	12 %	28 %	2 %
Bundle 2 – Best Enclosure Add R-10 to walls (R-21) Add R-20 to attic roof (R-40) Triple glazed windows (U-0.17) Air tightness to 0.04 cfm/ft² (@4 Pa) 85% efficient HRVs in suites	144	7	33 %	92 %	44 %
Bundle 3 – Best Enclosure plus Mechanical and Electrical Bundle 2, plus: High efficiency MUA (93%) MUA set point lowered to 17°C Low-flow DHW fixtures, High efficiency boiler (93%) Occupancy sensors, LED lighting	108	7	49 %	92 %	61 %

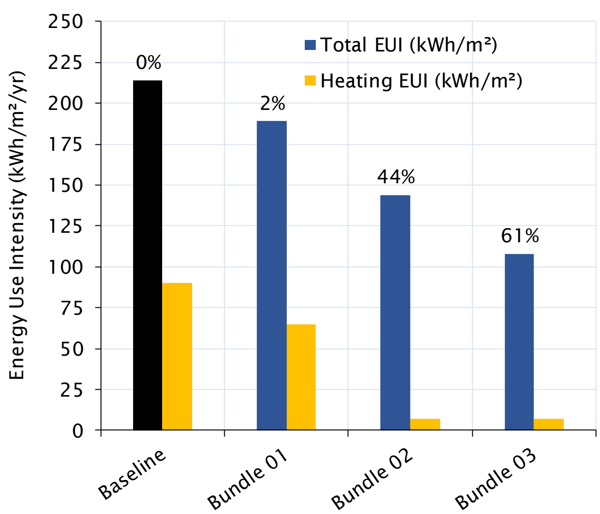

Figure 11: The total EUI, heating EUI, and percent reductions for the archetypical, pre-retrofit 1970s low-rise baseline and ECMs.

As with the calibrated model, the energy conservation bundles in Table 3 result in extremely low heating EUI's (as low as 6 $kWh/m^2/yr$). Occupant behavior would likely have a greater effect on heating consumption than was captured here. For example, occupants may still open their windows even with efficient HRV systems. Factors such as this are difficult to predict and may result in a higher heating energy consumption. Another factor may be the impact of thermal bridging at details such as window installation, corners, and interfaces; this was not captured in detail in the energy modelling for this study, but can have a significant impact once higher insulation and window performance values are reached.

Archetypical Townhouse

Building 21 was altered to reflect the lower energy performance of an archetypical older townhouse. The archetypical townhouse baseline EUI is 316 kWh/m²/yr, compared to 277 kWh/m²/yr for Building 21. The energy savings for each bundle are shown in Table 4 and Figure 12. Compared to Building 15 and Building 21, the energy savings potential is higher for the archetypical, older building models for low-rise and townhouse archetypes. These energy savings could be extrapolated to low-rise MURBs that are scheduled to undergo enclosure retrofits in south-west BC.

Table 4: Archetypical Townhouse - ECM Bundles.

Description	Total EUI (kWh/m²/yr)	Heating EUI (kWh/m²/yr)	Total Energy Savings (%)	Heating Savings (%)	GHG Savings (%)
Baseline	**316**	**166**	—	—	—
Bundle 1 – Better Enclosure Add R-5 to walls (R-16 total) Add R-10 to roof (R-28 total) Double glazed windows (U-0.28 Air tightness to 0.10 cfm/ft² (@4 Pa)	243	95	23 %	43 %	8 %
Bundle 2 – Best Enclosure Add R-10 to walls (R-21 total) Add R-20 to roof (R-38 total) Triple glazed windows (U-0.17) Air tightness to 0.04 cfm/ft2 (@4 Pa) 85% efficient HRVs in suites	189	32	40 %	81 %	13 %
Bundle 3 – Best Enclosure plus Mechanical and Electrical Bundle 2, plus: Low-flow in-suite fixtures High efficiency boiler (93%) Occupancy sensors, LED lighting	164	33	48 %	80 %	35 %

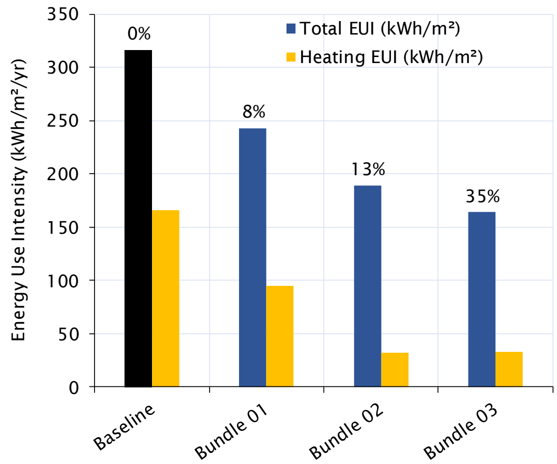

Figure 12: The total EUI, heating EUI, and percent reductions for the archetypical, pre-retrofit townhouse baseline and ECMs.

CONCLUSIONS

Characterizing Energy Consumption

Measured energy consumption data was analyzed for 23 MURBs in south-west British Columbia. These included MURBS with 14 to 267 residential units, with construction dates ranging from 1974 to 2012. Many have electric baseboards as their primary space heating source, and two have gas hydronic heating.

The median energy consumption of the data set is 160 kWh/m^2/yr. The average is higher (at 171 kWh/m^2/yr) due to much higher energy consumption in buildings with natural gas space heating and/or fireplaces. The range in energy consumption was a maximum of 280 kWh/m^2/yr to a minimum of 95 kWh/m^2/yr.

Energy consumption per suite varied from 8,660 to 31,740 kWh per year, for all electricity and natural gas. The median was 15,800 kWh and average was 18,500 kWh.

The buildings showed a trend toward lower energy consumption per unit floor area for newer buildings, both in terms of space heating and total energy use. No clear trend was found between window to wall ratio and heating or total energy use in the low-rise buildings.

Comparison with High-Rise MURBs

Table 5 summarizes the results of the current study compared to a similar high-rise study (RDH, 2012). The results showed higher EUI in high-rise buildings: 35% comparing the median, and 25% comparing the averages. This difference was primarily in baseline (non-heating) energy consumption, and so is likely due mainly to more amenities typically found in high-rise buildings compared to low-rise buildings.

Table 5: Comparison of low- and high-rise study results.

Variable	Low-Rise	Mid- and High-Rise (% difference to low-rise)
Median EUI	160 kWh/m^2/yr	217 kWh/m^2/yr (35%)
Average EUI	171 kWh/m^2/yr	213 kWh/m^2/yr (25%)
Maximum EUI	279 kWh/m^2/yr	299 kWh/m^2/yr (7%)
Minimum EUI	95 kWh/m^2/yr	144 kWh/m^2/yr (52%)
Average Energy per Suite	18.5 MWh/suite/yr	21.9 MWh/suite/yr (18%)
Median Energy per Suite	15.8 MWh/suite/yr	21.3 MWh/suite/yr (25%)
Average window-to-wall ratio	26% Glazing	47% Glazing (80%)
Average space heating % (including fireplaces)	45% Space Heating	37% Space Heating (-18%)

Energy and GHG Reduction Opportunities

Energy savings opportunities for the two case study buildings varied from 12% to 49%. The bundled energy savings are outlined in Table 6.

Table 6: Summary of ECM bundle energy savings for calibrated energy models.

ECM Bundle	4-storey MURB (Building 15) EUI, kWh/m^2/yr (% reduction)	Townhouse (Building 21) EUI, kWh/m^2/yr (% reduction)
Baseline	181	277
Bundle 1 – Better Enclosure	172 (5%)	243 (12%)
Bundle 2 – Best Enclosure	142 (22%)	189 (32%)
Bundle 3 – Best Enclosure plus Mechanical, DHW, and Lighting	106 (41%)	164 (41%)

The ECM Bundle 3 (Best Enclosure plus Mechanical, DHW, and Lighting) has the greatest total energy savings for both the 4-storey MURB (Building 15) and the townhouse (Building 21), both 41% savings. This type of energy retrofit also results in 74-90% heating energy savings.

Archetypical Building Models

The two case study building models were modified to reflect archetypical older MURBs with no previous upgrades. Table 7 summarizes the modelled energy savings from ECM bundles for these older archetypes.

Table 7: Summary of ECM bundle energy savings for archetypical older MURBs.

ECM Bundle	4-storey MURB (archetypical) EUI, kWh/m^2/yr (% reduction)	Townhouse (archetypical) EUI, kWh/m^2/yr (% reduction)
Baseline	214	316
Bundle 1 – Better Enclosure	189 (12%)	243 (23%)
Bundle 2 – Best Enclosure	144 (33%)	189 (40%)
Bundle 3 – Best Enclosure plus Mechanical, DHW, and Lighting	108 (49%)	164 (48%)

The ECM Bundle 3 (Best Enclosure plus Mechanical, DHW, and Lighting) has the greatest total energy savings for both the archetypical 4-storey MURB and the archetypical townhouse, 49% and 48%, respectively. Energy savings from the townhouse archetype can be interpreted as typical for low-rise MURBs that do not have MUA ventilation. This type of energy retrofit also results in 80–90% heating energy savings.

The retrofit bundles described here can help to bring existing low-rise MURBs into compliance with future Thermal Energy Demand Intensity (TEDI) limits that have been established in some codes for new buildings (e.g. the BC Energy Step Code).

In typical low-rise MURBs with gas-fired MUA units, retrofits that include installing electrically-powered in-suite HRVs can reduce greenhouse gas emissions by up to 61%. When the energy upgrades modelled in this study are implemented in existing building retrofits, coupled with near net-zero emission new construction, can help to achieve near-decarbonization of buildings in British Columbia by 2050.

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