Number 12

BUILDER INSIGHT

BC HOUSING
RESEARCH CENTRE

Energy Use in Mid to High-Rise Multi-Unit Residential Buildings

Overview

Mid to high-rise multi-unit residential buildings (MURBs) consume a significant amount of energy. Understanding how MURBs use this energy is essential to reducing energy use and cost to building owners and occupants.

In Vancouver, approximately 32% of residential gas and 50% of residential electricity is used in mid and high-rise multi-unit buildings. To better understand energy use in MURBs, energy consumption data from more than 60 mid to high-rise condominium buildings was collected and studied.

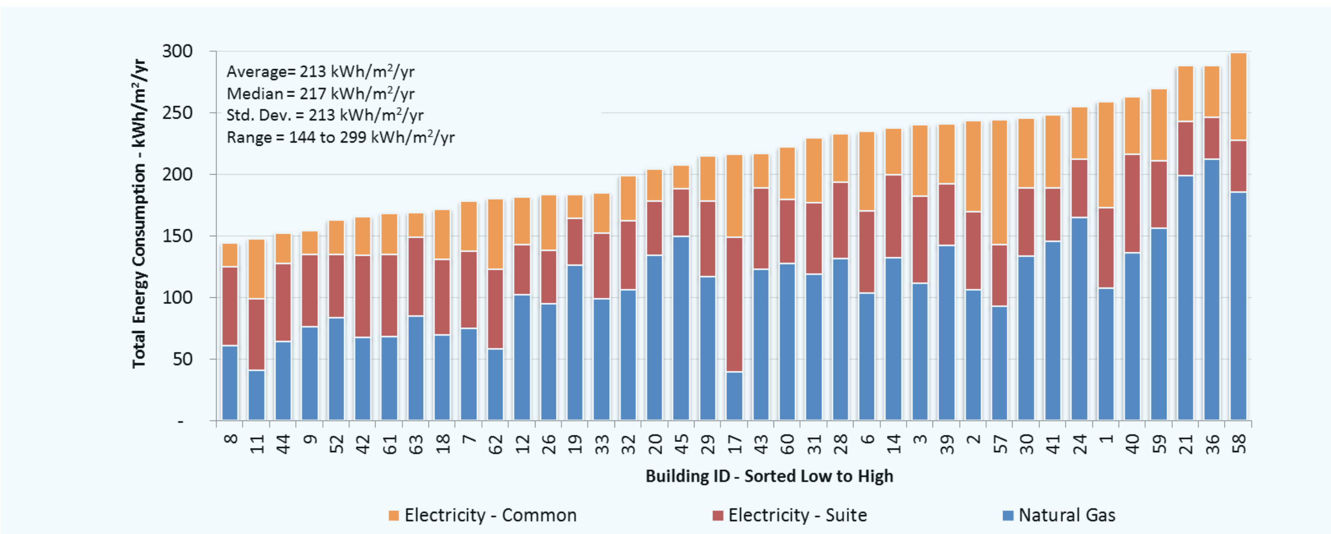
Information in this bulletin is based on the results of a study in buildings located on the south coast of British Columbia, primarily in Metro Vancouver and Victoria. While many general conclusions can be drawn from the results of the study, they do not necessarily apply to all MURBs. Each building has unique features and location, and therefore its energy use characteristics are also unique.

Builder Insight is a series of bulletins and companion videos designed to provide practical information about new and emerging technologies, best practices and current issues in residential construction to Licensed Residential Builders and others in the industry. Produced by BC Housing, this bulletin was prepared based on research conducted by RDH Building Engineering in collaboration with Canada Mortgage and Housing Corporation, BC Hydro, Fortis BC and the City of Vancouver.

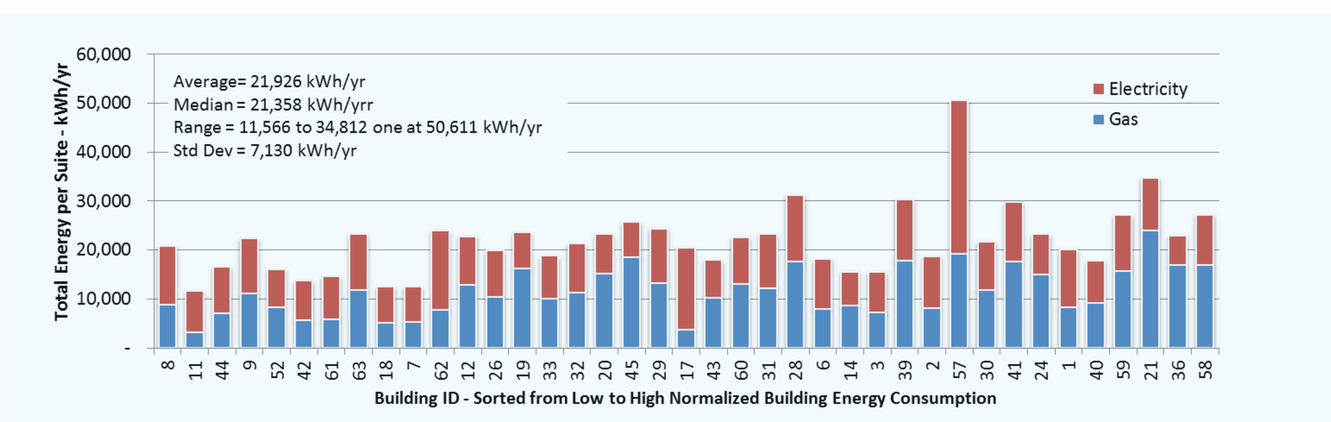
Overall Energy Use

Of the initial 64 study buildings, detailed energy consumption data was analyzed for 39 (34 in Metro Vancouver and five in Victoria). The average energy use intensity for the MURBs study was 213 kWh/m²/yr, with a fairly even distribution between 144 to 299 kWh/m²/yr. On average, 51% of this energy is attributable to the burning of natural gas (make-up air units, hot water and gas fireplaces), 28% to electricity used in individual suites (electric heat, lighting, appliances, outlets, etc.) and 21% to electricity supplied to common areas (lighting, elevators, fans, pumps, common space heating, etc.). Total energy consumption is normalized by suite.

It is interesting to look at the annual energy consumption on a per suite basis. Buildings with larger suites can have a higher total energy consumption that is not as apparent when looking at it on a per floor area basis. Although building 57 is within the middle group by floor area, it has the highest energy consumption by far when looking at it on a per suite basis. Its high energy consumption is attributed to the fact that this building is a high-end condominium with suites in the 2,000+ ft² range with full amenities, including air conditioning, in-suite fireplaces, and common area recreation centre and pool.



Total normalized energy consumption by floor area

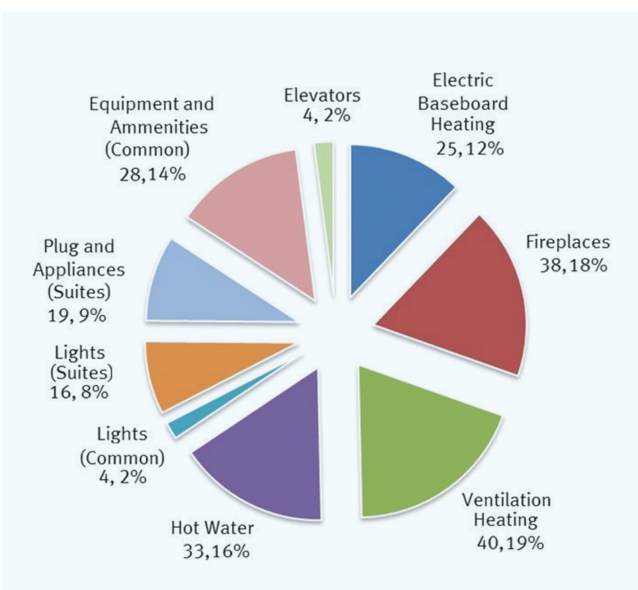


Total energy consumption normalized by suite

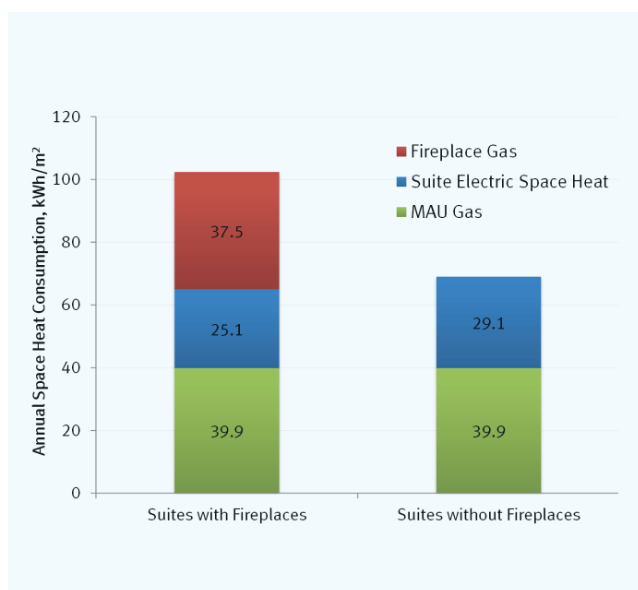
The figure below shows how energy is typically consumed in a MURB. Building simulations were used to determine the typical contribution of space heating energy of fireplaces. When no fireplace is present, in-suite electrical space heating energy consumption is approximately 16% higher. However, total in-suite space heating energy, including electricity and natural gas, can more than double with the presence of a fireplace as shown in the bar chart below. Decorative fireplaces are generally installed in MURBs and are placed in locations that tend to enhance aesthetic value. The performance of fireplaces could be improved with more efficient fireplaces installed in locations that maximize space heating potential.

Newer buildings (built after about 1990) typically use more energy than older buildings (built in the 1970s and 80s). This is due, in part, to increased ventilation requirements for new buildings that result in more outdoor air that is heated as it is brought into the building. Additionally, newer buildings typically have more amenities such as pools, saunas and exercise rooms. Gas fireplaces that are relatively inefficient at space heating are also more common in newer buildings.

The overall thermal performance of newer MURBs appears to have decreased slightly relative to older MURBs, and the heat loss through the building enclosure remains significant. Several newer buildings in the study had overall effective enclosure R-values in the range of R-2.0 hr·ft^2•°F/Btu, due to higher glazing percentages (window to wall ratio) and large thermal bridges (exposed slab edges, balconies, steel framing, etc.). The study found that buildings constructed before the year 2000 had average pre-rehabilitation R-values of R-2.5 effective.



Distribution of annual energy consumption in a typical MURB. Units shown in kWh/m^2/yr and as percentage of total consumption.



Comparison of annual space heat consumption for buildings with and without fireplaces.

Energy Costs

The average energy cost per suite is roughly $1,200 ($1.10/sq ft) per year, 39% paid by the owner or occupant, and 61% is paid by the strata corporation. These costs assume utility rates of 8¢/kwh for electricity and $9/GJ for natural gas. In buildings with fireplaces, an average of $160/year is added to the per suite total natural gas costs paid by the strata.

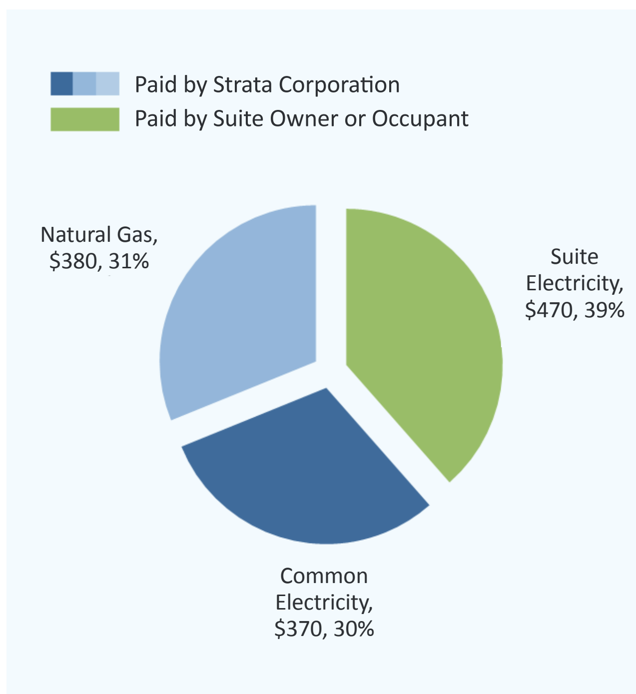
Energy Use Trends

Make-up Air Units (MAUs)

- The gas used to heat ventilation air by MAUs is often the largest single component of energy use within MURBs. This is particularly true for those constructed in the past decade which have higher design ventilation rates. While space heating in most buildings is intended to be primarily provided by electric baseboard heaters, in many cases a large portion of the space heating energy in the building is provided within the ventilation air heated by the MAU. On average, 69% of the total space heating energy is consumed by the MAU.
- Typically, the set point temperature for air delivered to the building from the MAU is set higher than 20°C (68°F). Corridor temperatures do not need to be maintained that warm. A temperature of 16°C to 18°C (60°F to 64°F) would significantly reduce energy consumption. Building simulations performed for the study found that reducing the temperature from 20°C to 16°C (68°F to 60°F) can reduce MAU gas consumption by approximately 21%. The lower air temperature would, in turn, increase in-suite electrical heating energy by around 15%, for a total building space heating savings of roughly 12%.
- While ventilation air is intended to be delivered to suites by the MAU through the pressurized corridor, much of the air this unit provides is lost to the outdoors through stairwells, elevator shafts, etc., before it reaches the suites. Door threshold sweeps are often installed by occupants to reduce noise, odours, or light from the corridors, but they also block the entry of make-up air. The MAU system is a supply only system. This means that no provisions are in place for continuous exhaust of stale air from the suites to allow air from the MAU to readily enter the suite.

In new MURB construction and major building rehabilitation projects, moving away from the traditional pressurized corridor approach to a compartmentalized suite approach where each suite has its own heating and ventilation system has many benefits:

- The amount of outdoor air to the suites is better regulated.
- The suite owners can be billed for their individual space heating and ventilation needs.
- Preheated outdoor air lost through the building is reduced.
- It allows for the implementation of heat recovery ventilators (HRV). By recovering heat from the exhaust air before it is exhausted outside, average space heating savings of approximately 34% can be achieved with an 80% efficient in-suite HRV.



Natural Gas Fireplaces

- While electric baseboard heaters are usually the intended primary source of space heating, fireplaces are frequently used. Some occupants prefer to use fireplaces for personal reasons and aesthetics. There is also an incentive to heat with fireplaces as the utility bill is paid by the strata corporation as opposed to electrical space heating that is paid directly by the suite owners. In the end, suite owners pay more as their monthly condo fees are increased by an amount higher than their electricity savings.
- Traditional decorative gas fireplaces are inefficient at space heating and can consume approximately 18% of the energy in a MURB. Pilot lights can consume up to 50% of the fireplace energy consumption. Strata or owner groups may wish to consider a building-wide pilot light shut-off for the summer months. Turning the pilot lights off for six months of the year can reduce fireplace gas consumption by up to 25%. It can also reduce cooling costs, where cooling is present, and improve thermal comfort during the summer. It is a good idea to install fireplace timers as these are relatively inexpensive, easy to install, and are good at reducing gas consumption.

Electric Baseboard Heating

- For the 39 study buildings, on average, 69% of the purchased energy for space heating is for gas (through the MAU, ventilation system), with a range from 40% to 97%. The remaining 31% of the space heating is used by electric baseboard heaters (the primary heating system) with a range from 3% to 60%. This electrical space heating accounts for 38% of the suite electricity consumption (range of 6% to 61%). It is also typical for some owners to purchase small electric space heaters to supplement baseboard heaters, particularly for unheated rooms such as enclosed balconies.

Domestic Hot Water

- With the exception of one study building that had in-suite electric Domestic Hot Water (DHW) tanks, DHW was provided to units from a central natural gas boiler. There was a big range of DHW energy consumption values from one building to another going from a low of 14 kWh/m^2/yr and 9% of the building energy consumption, to a high of 77 kWh/m^2/yr and 35% of building energy consumption. There was only a slight correlation in total building DHW consumption and the number of suites in the building, with much of the energy use being inconsistent.

Elevators

- A number of MURBs constructed in the 1980s to 1990s had AC-DC elevator motor convertors that ran continuously (timers with broken or not installed), resulting in a significant amount of wasted energy.

Lighting

- Lighting energy on average consumed 10% of the building's energy use, of which 20% was for common area lighting/parking garages, and 80% for in-suite lighting. There are opportunities to save energy in common areas through the use of occupancy and/or daylight sensors, as they are typically on 24 hours a day, seven days a week. Lights and fixtures can also be replaced with compact fluorescents and more energy efficient light bulbs and ballasts at a relatively low cost and acceptable payback. Lighting upgrades within suites are also possible (for example, to CFLs or LEDs), yet these are generally upgraded by the suite occupants.

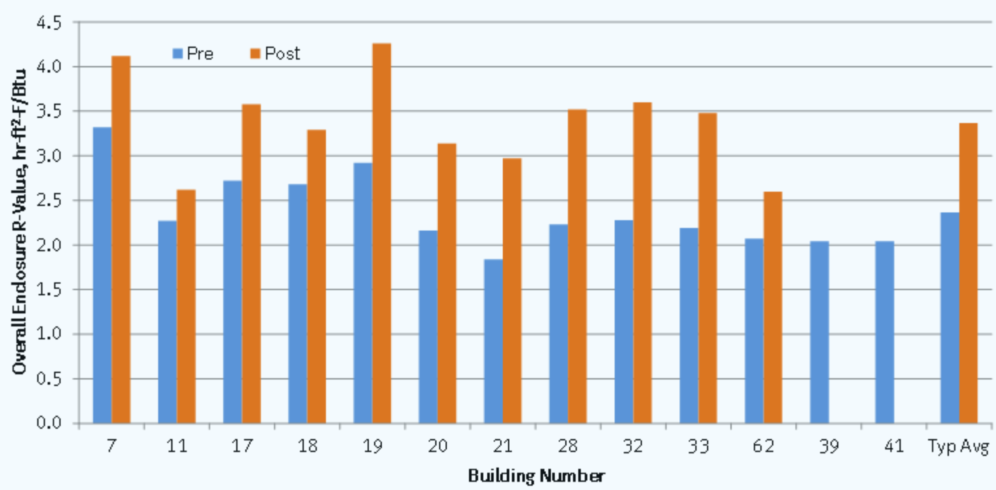
Building Enclosure Air Leakage

- There is limited data on overall MURB airtightness as it is more complex to measure building enclosure air leakage of a MURB compared to a house. The use of operable windows (particularly in temperate climates) further invalidates most estimates of operating building pressures, building enclosure airtightness, and suite ventilation/heating distribution. Simulations were conducted to determine the impact of the airtightness of the building enclosure on energy consumption. The baseline simulations assumed an average airtightness of 0.15 cfm/ft^2 at normal operating pressures. A series of air leakage rates was simulated, ranging from very tight, to average, to very leaky, to determine the energy impact of varying the air leakage rate. Reducing the air leakage rate to 0.02 cfm/ft^2 decreased energy use by 8.5%, whereas increasing the rate to 0.4 cfm/ft^2 increased consumption by 8.6%. When increasing the airtightess of a building, it is important to ensure that there is adequate outdoor air provided to all of the suites.

Building Enclosure Rehabilitation and Renewals Projects

Many multi-unit residential buildings in British Columbia and other parts of North America have or are undergoing comprehensive building enclosure rehabilitation, largely to remedy moisture-related problems. In other instances, MURBs need to undergo renewals of building enclosure assemblies as part of the facility upkeep. Unfortunately, for reasons primarily related to short-term costs, little or no attention is typically directed at energy conservation when implementing these projects. The study found that, even without energy efficiency in mind, important energy savings are being realized by improved enclosure assemblies and details (for example, energy efficient windows, reduced thermal bridging and improved airtightness). Even more significant savings can be achieved if energy efficiency is given more consideration.

Energy use was analyzed in 13 study buildings that underwent a full (walls, windows, roof) building enclosure rehabilitation to address moisture damage. As part of this analysis, detailed enclosure thermal



Summary of calculated overall effective enclosure R-values (pre and post rehabilitation).

performance characteristics were determined. The overall R-value of rehabilitated buildings improved from an average of R-2.4 hr·ft²·°F/Btu (pre-rehabilitation) to R-3.4 (post rehabilitation). These results were achieved even though the rehabilitation work focused on the correction of water ingress problems, rather than improving the heat transfer characteristics of these buildings.

For the 13 buildings analyzed in greater detail, the average energy consumption was 203 kWh/m²/year pre-rehabilitation. On average, the building enclosure rehabilitations resulted in space-heat energy savings in the order of 14%, and total energy savings of approximately 8%. This was substantial given that energy efficiency was not a primary design concern for the rehabilitations. Energy use was reduced during these rehabilitations primarily because of the improved thermal efficiency (exterior insulation and reduced thermal bridging effects), and improved airtightness (full exterior air barrier and more airtight windows/doors).

Recommendations for the MURB Construction Industry

A number of recommendations were developed based on the results of the study. These recommendations can be used to guide changes in new building design and construction practices. They also present opportunities to improve the performance of existing building stock:

- Reduce the heating and cooling loads by improving the thermal performance of the building enclosure. Design new buildings and retrofits with more insulation, better windows, lower window to wall area ratios, enclosures with less thermal bridging, and therefore improved overall effective R-values.
- Control airflow within MURBs through airtight enclosures, compartmentalization of floors and suites, and more efficient ventilation systems. Enable outdoor air to be provided directly to the suites. This will help to minimize air leakage and make it easier to install heat recovery ventilators to recover heat from the exhaust air.

- Engage and educate building developers, owners and occupants to enhance understanding of where and how energy is used within their building.
- Address the disconnect between energy use and payment for consumption through individual suite energy metering.

Energy Saving Opportunities for Owners and Managers

A wide range of measures exist to help save energy in MURBs. They vary significantly in scale and cost. Some smaller scale strategies to reduce energy consumption include:

- Tune-up existing systems including the make-up air units.
- Lower the make-up air temperature set-point and adjust flow rates to required levels.
- Reduce the use of gas fireplaces as a source of heat. Implement building-wide shut-off of pilot lights for half the year when fireplaces are not in use.
- Educate building occupants about their building's energy consumption.

Larger projects, such as improving the insulation levels of a building or installing more thermally efficient windows, may prove too expensive for many owner groups when simple payback periods alone are considered. However, when energy conservation measures are integrated with building maintenance and renewals activities, significant cost effective opportunities exist to reduce consumption.

Key Points

- ❑ Energy consumption was analyzed in 39 Lower Mainland mid to high-rise MURBs.
- ❑ Average energy consumption is roughly half natural gas and half electricity.
- ❑ The most energy is used to heat outdoor air for ventilation. Significant savings can be achieved by simply lowering the temperature set-point used in the make-up air unit.
- ❑ Significant savings can be achieved by simply turning off fireplace pilot lights during summer months throughout the building.
- ❑ In general, energy consumption was not found to be lower in newer buildings due to a variety of combined factors.
- ❑ Roughly two-thirds of the energy is paid indirectly by suite owners through strata fees.
- ❑ Great opportunities exist to reduce energy consumption during building rehabilitations and renewals. Study buildings that were fully retrofitted achieved 14% space heating savings even though energy efficiency was not a primary design consideration.

More Information

- › Energy Consumption and Conservation Mid- and High-Rise Residential Buildings in British Columbia
- › Maintenance Matters No. 12: Reducing Energy Use in Multi-Unit Residential Buildings
- › Maintenance Matters No. 7: Building Envelope Maintenance and Renewals Planning

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