FINAL REPORT

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Energy Consumption in Low-Rise Multi-Family Residential Buildings in British Columbia

RDH BUILDING SCIENCE

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Executive Summary

Many multi-unit residential buildings (MURBs) in British Columbia and other parts of North America have completed or are undergoing comprehensive building enclosure retrofits either to remedy moisture-related problems or to renew aging components. Low-rise buildings account for the majority of this multi-unit residential building stock: 99% of MURBs in the Pacific Northwest are six storeys or less[1]. For reasons primarily related to short-term cost, historically very little attention has been directed at energy conservation strategies or greenhouse gas (GHG) emissions in most developments. However, the retrofit, renewal, or rehabilitation of aging building enclosures presents a unique opportunity to significantly reduce a building's energy consumption and associated greenhouse gas (GHG) emissions.

This research study was undertaken as a follow-up to the Energy Consumption and Conservation in Mid- and High-Rise Residential Buildings in British Columbia report that was published in 2012.[2] The current study complements the aforementioned report by assessing the impacts of building enclosure rehabilitations on the measured energy consumption of low-rise (two- to four-storey) wood-frame multi-unit residential buildings, including townhouse developments and multifamily buildings.

This study's principal objectives are to review and assess the actual energy consumption of low-rise residential buildings, as well as the impacts of building enclosure retrofit- or rehabilitation-related improvements on the overall energy consumption of these buildings. These findings are used to assess the benefits of better building enclosure design strategies to reduce energy consumption and associated GHG emissions for both new and existing buildings.

Local gas and electric utility suppliers provided detailed energy consumption data for 23 buildings constructed over the past 40 years, all wood-frame construction, including townhouse and multifamily buildings. The majority of the buildings are strata titled, however, five market rental buildings were also included. Consumption data from these buildings, 22 of which are located in the Lower Mainland of B.C. and one in Victoria, was analyzed to benchmark the energy use of low-rise MURBs. The contribution of gas and electricity to overall energy consumption and to space heat were examined in great detail.

These 23 low-rise MURBs had an Energy Use Intensity (EUI) range of 95 to 279 kWh/m²/yr. The average EUI for the 23 buildings was found to be 171 kWh/m²/yr, with a median of 160 kWh/m²/yr. For comparison, the 2011 study found an average EUI of 213 kWh/m²/yr for mid- and high-rise MURBs (greater than six storeys, non-combustible construction). In general, higher energy consumption in mid- and high-rise MURBs compared with low-rise MURBs can be explained by higher window-to-wall ratios (WWR) or significant make-up air (MUA) heating, whereas low-rise MURBs often have unheated MUA and sometimes none at all. The enclosures of the low-rise MURBs studied are all wood-frame, which has more capacity for insulation and low-conductivity frame windows. High-rise buildings are typically

[1] Residential Building Stock Assessment: Multifamily Characteristics and Energy Use, Northwest Energy Efficiency Alliance (NEEA), 2013. Available online: http://neea.org

[2] Available online: https://www.bchousing.org/research-centre/library/building-science-reports

concrete or steel stud with more thermal bridging. High-rise MURBs also tend to have more amenities, such as pools and exercise rooms.

This study assessed differences in energy use trends between low-rise and mid- to high-rise MURBs. Energy use per suite was found to be 16% higher in mid- and high-rise MURBs than in low-rise MURBs. Space heating is a higher fraction of the overall energy use in low-rise MURBs (45%, compared with 37% for mid- and high-rises). Over the past few decades, space heating and overall energy consumption has decreased in newer low-rise MURBs, particularly after the year 2000. This contrasts the results of the previous study, which found that newer mid- and high-rise MURBs often consume more energy than older buildings (1970s and 1980s), despite more stringent building code requirements from the 1990s to present.

Once the baseline energy consumption for all 23 low-rise buildings was analyzed, two buildings were selected for further analysis. One four-storey MURB (Building 15) and one townhouse development (Building 21) (both wood-frame) were selected for their availability and completeness of building information, and representation of low-rise wood-frame MURBs in B.C. Calibrated energy modelling was performed on these two typical buildings to further understand how energy is consumed in low-rise MURBs and to assess the impacts of potential energy conservation measures (ECMs).

The ECMs with the largest savings were heat recovery ventilation (up to 13% total energy savings, 64% heating savings), and improving whole building air tightness (up to 11%total energy savings, 24% heating savings). Installing triple-glazed low-conductivity frame windows also resulted in significant savings of 4-5% of total energy, 10-14% heating savings.

The study modelled bundles of ECMs that could be implemented as a package at the time of an enclosure retrofit. With these bundles, it was possible to achieve up to 40% total energy reduction and up to 90% heating energy reduction. The same bundles of ECMs were also applied to “typical” older building models. These typical building models were created by adjusting the calibrated building models to reflect typical construction of older low-rise residential buildings: 2x4 framing with fibreglass batt insulation, single-glazed aluminum frame windows, and higher air leakage. The ECM bundles showed even greater potential energy savings for the typical building models, resulting in total energy savings of up to 50% and heating savings up to 90%.

The ECM retrofit bundles studied here can help bring existing low-rise MURBs into compliance with future Thermal Energy Demand Intensity (TEDI) limits that could be implemented in renovation retrofit codes by provincial and municipal governments. These ECM bundles can also help achieve GHG emission reduction targets. For example, 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 over 60%. These energy upgrades to existing buildings can achieve a significant step towards decarbonisation of buildings in B.C.

Contents

Appendices

1 Introduction

Multi-unit residential buildings (MURBs) are an important building sector for energy consumption and greenhouse gas (GHG) emissions, particularly in large cities where they make up the majority of the local housing stock. However, the building industry does not generally understand the energy consumption characteristics of wood-frame multi-unit residential buildings (MURBs). There is a lack of data that demonstrates actual energy consumption in MURBs and gives feedback to designers, builders, or owners on how their buildings are performing in service. Occupants are also generally unaware of their total energy consumption and costs as common area spaces have separate energy accounts than unit holders, and there is usually no metering of gas for individual units.

RDH's 2012 study for BC Housing and other partners looked at the energy consumption of non-combustible strata mid- to high-rise residential buildings in the Lower Mainland of B.C. This study found a range of energy consumption in this housing type ranged from a low of 149 $kWh/m^2/yr$ to a high 299 $kWh/m^2/yr$ (average of 212 $kWh/m^2/yr$). Despite recent building code changes and construction practices that target improved energy performance, the study found that newer MURBs (constructed in the 1990s to mid-2000s) typically use more space-heating and total energy than older MURBs. This is partially due to higher window-to-wall ratios and higher ventilation rates in newer style buildings. Smaller suite sizes in newer buildings also increase the energy intensity of amenities, such as dishwashers, televisions, and drying machines, per total building floor area. There is also a tendency for newer buildings to have more shared amenity spaces (e.g. fitness rooms).

When compared to single family dwellings, mid- and high-rise MURBs use considerably more energy per household, even when accounting for higher occupant and space densities. This recent study identified several contributing factors that result in higher than expected energy consumption, including building enclosure performance (i.e. effective R-values and air-leakage), energy code compliance/enforcement (i.e. NECB and ASHRAE 90.1), heating and ventilation system design (i.e. pressurized corridor), decorative gas fireplaces, and occupant behaviour.

There remain significant opportunities and local interest to expand the scope of this mid- and high-rise MURB research study to specifically look at the energy consumption of low-rise wood-frame MURB buildings. Together, with the data from the previous study, this work identifies opportunities for improvements in the energy efficiency of wood-frame MURBs. This study focuses primarily on strata-titled MURBs; 5 market rental buildings were also included in the study.

1.1 Objective

The primary objectives of this research study are:

1. Benchmark and characterize end-use energy consumption of low- to mid-rise wood-frame MURBs (two- to six-storeys in height) in the Lower Mainland of B.C. Building types include townhouse developments, plus three- to six-storey wood-frame multifamily buildings constructed from the 1970s through 2000s.

2. Compare the energy characterization of low- to mid-rise wood-frame MURBs to mid- to high-rise non-combustible MURBs (from previous RDH study) and identify similarities, differences, and trends.
3. Identify opportunities for different types of low-rise MURBs to improve energy efficiency (i.e. building enclosure, HVAC systems, equipment, operations, etc.) and to reduce energy use and associated GHG emissions in both new and existing MURBs.

1.2 Scope

This research study benchmarks and assesses the energy consumption in low-rise wood-frame MURBs, including townhouses. Its' general purpose is to quantify how energy is used in this type of building stock and identify opportunities to improve the energy efficiency and reduce energy related operating costs in both new and existing buildings. This information will also be combined with the previous high-rise MURB energy study performed by RDH Building Science Inc. (RDH) to assess and evaluate the energy efficiency and market opportunities for alternate building enclosure designs, space heating, and domestic hot water strategies for MURBs.

Building types included in this study are townhouse developments and three- to six-storey wood-frame MURBs constructed from the 1970s through to the present in southwest B.C.

Data was collected for 23 buildings. Of this data set, two representative buildings were selected for calibrated energy modelling: one three-storey building and one townhouse development. The calibrated models were further modified to represent archetypical existing low-rise MURBs that had not undergone any renewals.

1.3 Literature Review

In addition to RDH's previous work on energy consumption and conservation in mid- and high-rise MURBs, three benchmarking studies were reviewed:

→ New York City Local Law 84 Benchmarking Report (PlaNYC, 2012)[3]

→ Seattle Building Energy Benchmarking Analysis Report 2013 (Seattle Office of Sustainability and Environment)[4]

→ Residential Buildings Stock Assessment: Multifamily Characteristics and Energy Use (David Baylon, et. al., 2013)[5]

Appendix A contains a summary of these studies. Each of these studies reported benchmarked Energy Use Intensity (EUI) for low- to high-rise MURBs. Overall, the studies showed large amount of variation in benchmarked EUIs, from 417 kWh/m^2 in New York City (including both low- and high-rise buildings) to a low of less than 100 kWh/m^2 in the Seattle study (low-rise buildings only). Comparing the EUIs from these studies to the current low-rise study is of limited value due to the different methodologies and different climate zones.

3 http://www.nyc.gov
4 http://www.seattle.gov
5 http://neea.org

2 Methodology

2.1 Building Selection

Fifty-seven MURBS of four storeys or less were initially considered for analysis as part of this study. Buildings were chosen from RDH's project portfolio, and included projects that have had depreciation reports, condition assessments, and, in some cases, building enclosure renewals projects. Five- and six-storey wood-frame MURBs constructed in B.C. as of 2009 were not included, due to insufficient occupied energy data at the start of this study. All of the buildings are located in either Metro Vancouver or Victoria. The buildings were selected to be representative of typical low-rise MURB housing stock and contain buildings of forms common to other low-rise residential buildings throughout the province of B.C. and elsewhere in Canada and the US.

Data from 23 of these buildings are covered in this report. The data from the remaining buildings was deemed unsuitable for this study for a number of 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.

All of the buildings use a combination of natural gas and electricity. A summary of the study buildings is provided in Appendix C. For confidentiality purposes, buildings are referenced in this study using numbers 1 through 23.

2.2 Energy Consumption Data Analysis

Historical gas and electrical billing data was collected for each of the buildings. The objective of analysing the historical data was to gain an understanding of how the climate affects the consumption of energy used for space heating.

Building characteristics such as age, enclosure details, building layout, mechanical systems, and fuel type were also collected to help analyze the energy data. Table 2.1 provides a characteristics summary of the 23 buildings for reference. The data represents an approximate total of 1,740 residential suites with 175,000 ft² of gross floor area.

TABLE 2.1 BUILDING CHARACTERISTICS

ID	Year Built	Number of Storeys	Number of Suites	Primary Space Heating	Secondary Space Heating	Mechanical Ventilation	DHW System
1	1989	4 (MS)*	78	Electric baseboards	Electric fireplaces (some suites)	Gas-heated make-up air	Central gas water heater
2	1989	3 (MS)	51	Electric baseboards	Electric fireplaces (some suites)	No make-up air	Central electric water heater
3	1974	3 (MS)	33	Hydronic baseboards		No make-up air	Central electric water heater

TABLE 2.1 BUILDING CHARACTERISTICS							
4	1995	4 (MS)	167	Electric baseboards		Untempered make-up air	Central gas water heater
5	1979	4 (MS)	40	Hydronic baseboards	Electric fireplaces (some suites)	Untempered make-up air	Central gas water heater
6	1989	3 (MS)	46	Electric baseboards		Untempered make-up air	Central electric water heater
7	2010	4 (MS)	267	Electric baseboards		Gas-heated make-up air	Central gas water heater
8	2010	3 (MS)	190	Electric baseboards		Gas-heated make-up air	Central gas water heater
9	1978	3 (MS)	27	Electric baseboards		Untempered make-up air	Central gas water heater
10	1995	3 (MS)	40	Electric baseboards		Gas-heated make-up air	Central gas water heater
11	1991	4 (MS)	14	Electric baseboards		No make-up air	Electric in-suite water heaters
12	1989	4 (MS)	8	Electric baseboards	Gas fireplaces	No make-up air	Electric in-suite water heaters
13	2006	4 (MS)	55	Electric baseboards		Gas-heated make-up air	Central gas water heater
14	2012	4 (MS)	107	Electric baseboards		Gas-heated make-up air	Central gas water heater
15	2008	4 (MS)	60	Electric baseboards		Gas-heated make-up air	Central gas water heater
16	2009	4 (MS)	46	Electric baseboards		Gas-heated make-up air	Central gas water heater
17	1994	4 (MS)	142	Electric baseboards		Gas-heated make-up air	Central gas water heater
18	2001	4 (MS)	78	Electric baseboards		Gas-heated make-up air	Central gas water heater
19	2006	4 (MS)	71	Electric baseboards		Gas-heated make-up air	Central gas water heater
20	1991	3 (MS)	120	Electric baseboards	Gas fireplaces	Gas-heated make-up air	Central gas water heater
21	1983	3 (TH)	32	Electric baseboards	Solid fuel fireplaces	No make-up air	Central gas water heater
22	2005	3 (TH)	24	Electric baseboards	Electric fireplaces	No make-up air	Electric in-suite water heaters
23	2006	3 (TH)	44	Electric baseboards	Gas Fireplaces	No make-up air	Central gas water heater

*Multi-storey (MS) and townhouse (TH)

Electricity and gas consumption data for each building was provided by BCHydro and FortisBC, with permission from the owners.

BCHydro provided electricity data separated into two categories: suite electricity (a consolidation of all individual suite electric meters for privacy) and common electricity (a meter for common or shared space, such as corridors, elevators, amenity rooms, and parking areas).

Natural gas is typically measured on a single meter for the entire building, therefore, it is not divided into common and individual suite consumption. This means that all gas appliances and heating devices (if any) are included in the single reading.

Figure 2.1 shows an example of the monthly metered electricity and gas consumption obtained for one building.

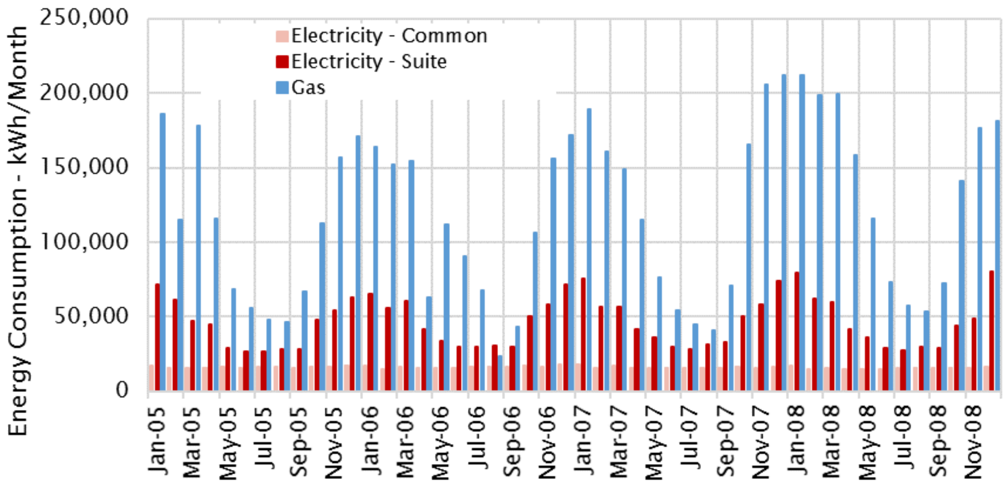


Figure 2.1 Example of monthly total energy consumption from 2005 through 2008.

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 in a typical (weather) year. The monthly energy consumption was plotted versus the actual monthly heating degree days (HDD) provided by Environment Canada. Where a suitable relationship existed, it was used to calculate average monthly weather normalized consumption. Additional details on the weather normalization process are in the report *Energy Consumption and Conservation in Mid- and High-Rise MURBs*[6] (RDH, 2012).

Figure 2.2 shows an example of monthly electricity and gas consumption plotted against HDDs to determine a suitable relationship, while Figure 2.3 shows the resulting monthly energy consumption. Common electricity is typically not weather normalized due to a weak seasonal correlation, with monthly use being relatively flat.

[6] Available online: https://www.bchousing.org/research-centre/library/building-science-reports

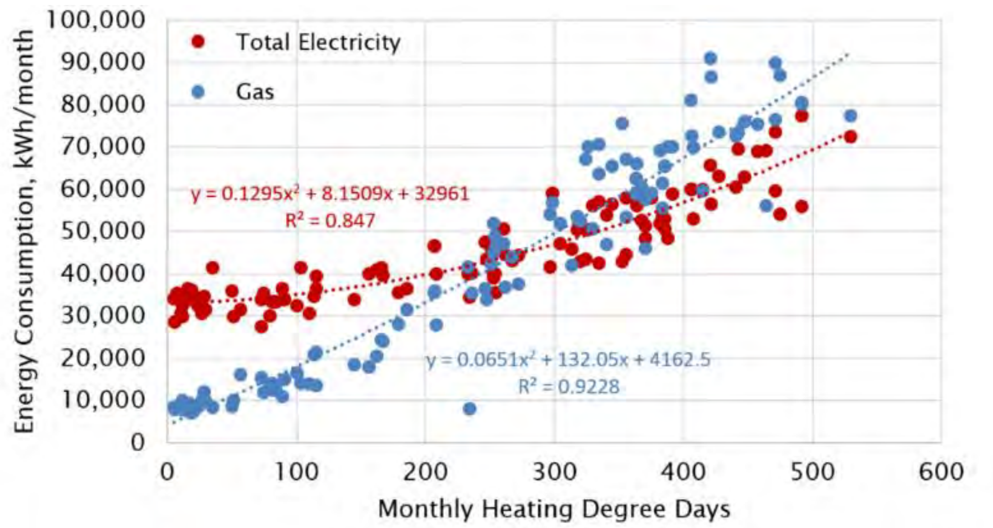


Figure 2.2 Example monthly energy consumption versus heating degree days.

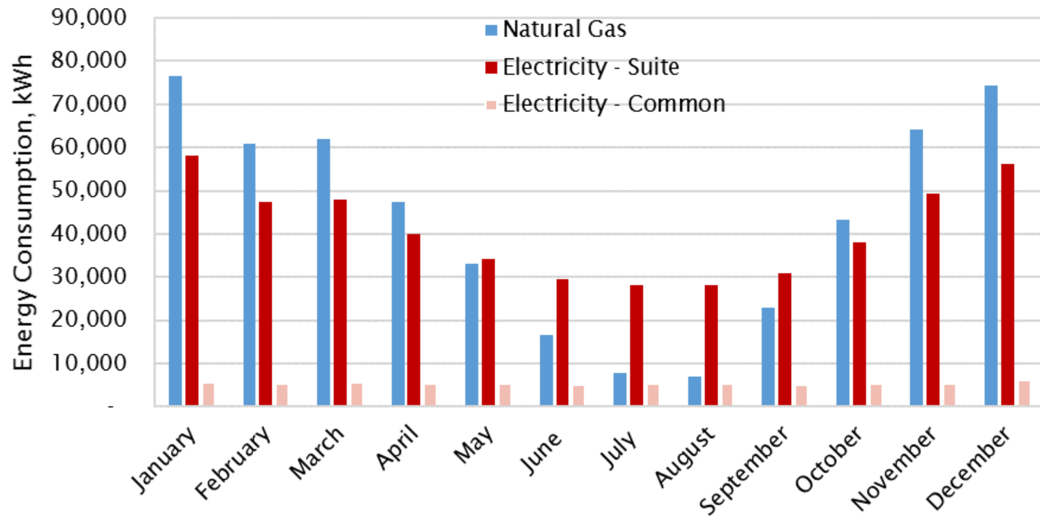


Figure 2.3 Example weather normalized monthly energy consumption.

This weather-normalized average monthly consumption can be further 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 that these months' consumption reflect typical base loads for end-uses such as lighting, appliances, and domestic hot water (DHW). The analysis also assumes there are no other significant seasonal trends, such as air conditioning or seasonal variations in lighting. This analysis, commonly referred to as a "top-down" approach, gives an approximate breakdown of heating versus baseline energy use of a building, but more detailed analysis requires whole building energy modelling.

Figure 2.4 shows an example of the heating versus baseline gas and electricity consumption for one of the buildings. In this example, more than half of annual consumption is seasonal gas and electricity.

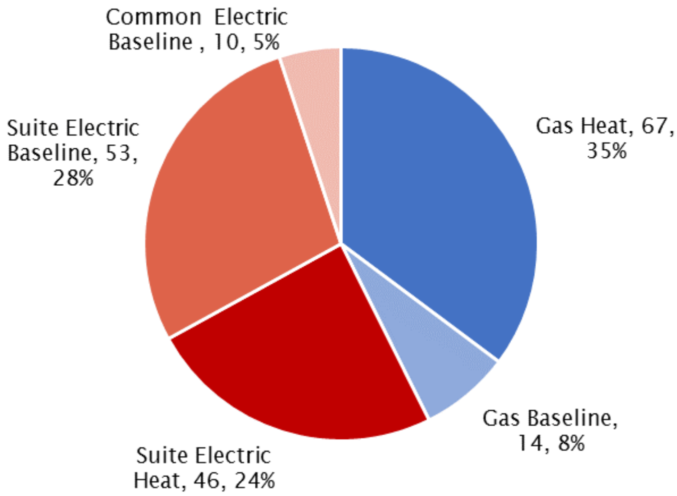


Figure 2.4 Example top-down analysis of annual energy consumption by end-use (kWh/m², % of total).

Section 3 presents the results of the energy consumption data analysis completed for the 23 study buildings, including average results and trends.

2.3 Calibrated Energy Modelling

In contrast to the top-down data analysis approach presented above, 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 models' results better reflect the building's consumption. The calibrated modelling process can also provide insight into some operating characteristics of the building, but accuracy is limited without significant sub-metering of end uses.

Calibrated energy modelling was performed to further understand how energy is consumed within low-rise townhouses and multi-storey wood-frame MURBs, and to assess the impacts of potential energy conservation measures (ECMs) in these buildings. Of the initial 23 case study buildings, two were selected for calibrated energy modelling: one townhouse and one four-storey MURB. These buildings were selected because they had sufficient, clean data and are representative of low-rise MURBs in the Lower Mainland. A separate energy model was created for each of the two selected buildings using DesignBuilder, an interface that uses the US DOE-sponsored EnergyPlus™ software to simulate annual energy consumption on an hourly basis.

To start the model, a geometrical representation of each building is constructed within DesignBuilder using architectural plans. The program 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 calculate the building's annual energy consumption.

Most inputs were found in architectural, mechanical, and electrical plans for each building, as well as during RDH site visits. Other initial inputs, such as airtightness and plug loads, were unknown and could only be estimated based on published standards and previous research. These unknown inputs were adjusted during the model calibration process. Additional details on the townhouse and MURB models are provided in Section 4 and Appendix B.

The initial, uncalibrated output of each model was compared with the weather-normalized metered utility data. The estimated inputs were then varied until the model output matched the metered data. Mechanical parameters were varied to calibrate the model, including make-up air set point temperature, domestic hot water flow rate, and baseboard output capacity. Electrical parameters were also varied to calibrate the model, including lighting power density, plug load density, and miscellaneous common area loads.

This process resulted in an energy model that reflected actual energy consumption for each building, though some assumptions still required to give a calibrated model. Where required, assumptions and estimations are documented in Section 4 and Appendix B.

2.4 Analysis of Energy Conservation Measures

In addition to quantifying how energy is used in low-rise residential building stock, the main purpose of this study was to identify opportunities to improve energy efficiency, reduce GHG emissions, and reduce energy-related operating costs in existing buildings. This information can be used to prioritize alternate building enclosure designs, space heating, and domestic hot water strategies for existing MURBs.

The calibrated energy models analyzed the impact of various ECMs on building energy consumption. The list of modelled ECMs was developed to reflect typical retrofit measures that can be implemented in low-rise MURBs primarily through building enclosure renewals, though simple mechanical lighting renewals are also discussed.

ECMs were modelled using the calibrated energy models for the two case study buildings (townhouse and four-storey). The ECMs were chosen to reflect feasible changes that would impart significant energy savings to each building during their operation. All ECMs were first modelled independently to show the impact of measures individually. The ECMs were then grouped into bundles to analyze “good”, “better”, and “best” energy efficiency performance levels.

The analysis divides the ECM benefits into three categories:

1. The resulting lower EUI (kWh/m²/yr)
2. Total energy savings (%)
3. Heating energy savings (%)

Total and heating energy savings were calculated from the reduction in modelled energy use for each ECM, or bundle, compared with the baseline building.

The results of the ECM analysis for the two study buildings are presented in Section 5.

2.5 Archetypical Older Building Models

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 archetypical older building models. These models are intended to represent typical existing buildings, constructed in the 1970s, which have not undergone 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 at 16” O.C. 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 work by RDH on older low-rise MURBs that were built before or during the 1970s.

The same ECM bundles were modelled on the townhouse and low-rise archetypical older building models. As with the case study buildings, the benefits of the ECMs and bundles were divided into three categories:

1. The resulting lower EUI (kWh/m²/yr)
2. Total energy savings (%)
3. Heating energy savings (%)

Total and heating energy savings were calculated from the reduction in modelled energy use for each ECM bundle, compared with the archetypical older building baseline. This analysis allows the study results to be extrapolated to a wider range of buildings in southwest B.C.

The archetypical older building model analysis is presented in Section 6.

3 Energy Consumption Trends

3.1 Low-Rise Energy Consumption Trends

One of the goals of the study was to benchmark and characterize end-use energy consumption of low- to mid-rise wood-frame MURBs in southwest B.C. The total energy consumption for 23 MURBs is presented in this section. Figure 3.1 displays the total energy consumption for all of the buildings, normalized by gross floor area, sorted low to high.

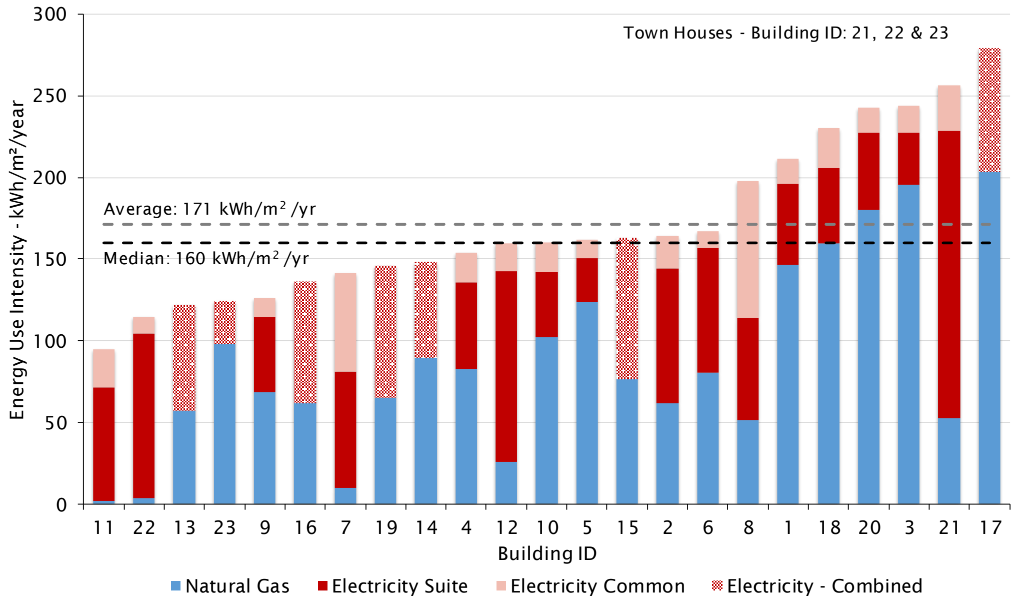


Figure 3.1 Total EUI sorted low to high, split by electricity (common and suite) and gas.

The average Energy Use Intensity (EUI) for the 23 low-rise MURBs identified in the study is 171 kWh/m²/yr. The EUIs ranged from 95 to 279 kWh/m²/year throughout the sample set with a median EUI of 160 kWh/m²/year. The majority of the buildings are located in the Lower Mainland (22 of 23) with only one building located in Victoria (Building 11). Of the 23 buildings, 15 are low-rise strata buildings, five are low-rise market rental buildings and three are townhouse complexes. The building type (multi-storey vs townhouse) does not appear to influence the total EUI, as two of the three townhouse buildings are on the low end of the spectrum and the remaining townhouse is at the high end of the data set.

Figure 3.2 below presents the energy use, normalized per suite, sorted from low to high, with the overall gas and electricity portions indicated.

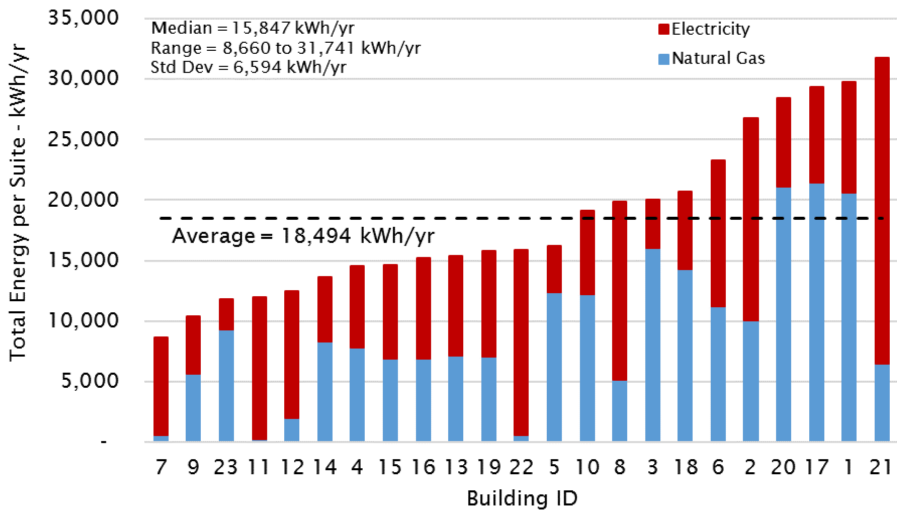


Figure 3.2 Total energy consumption normalized by suite, divided between total gas and electricity (common and suite), sorted low to high.

The average energy use per suite is 18,494 kWh/yr, with a range of 8,660 to 31,741 kWh/yr. With the exception of a few buildings, the use of gas and electricity was relatively constant throughout the data set. From the average energy use per suite, the amount of electricity used is 9,209 kWh/yr and 9,285 kWh/yr is natural gas usage.

There is no significant correlation between building types (townhouse and multi-storey) and total suite consumption. However, it is noticeable that two of the townhouses (Buildings 21 and 22), consume mostly electricity. Unlike the multi-storey buildings, there are no common areas to be served by tempered MUA units, resulting in minimal natural gas use.

These two townhouses rely primarily on electric baseboard heating as their main heat source. As an exception to this, Building 23 has a much higher natural gas consumption per suite due to the use of natural gas fireplaces as the primary heating source. Building 23 has electric baseboards for space heating, yet decorative natural gas fireplaces are used by occupants as the main source of space heating since natural gas is billed directly to the strata and not the individual occupants.

3.1.1 Energy Use Intensity versus Make-Up Air Type

The buildings in this study use a variety of ventialtion strategies, including pressurized corridors with heated or unheated make-up air (MUA), natural ventilation through operable windows, and occupant-controlled exhaust fans (without MUA air or other mechancial ventilation). Figure 3.3 presents the Energy Use Intensity, sorted by MUA type (tempered, untempered, and no MUA).

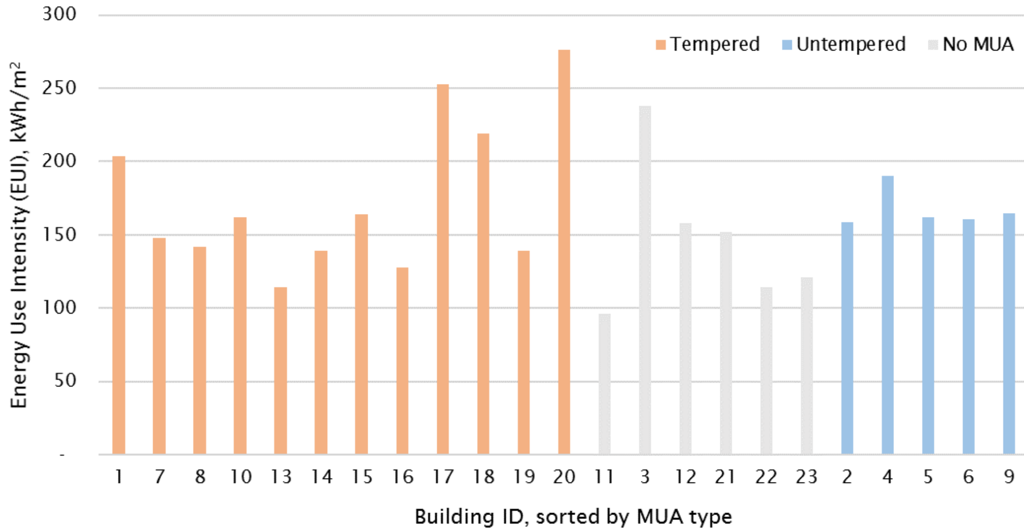


Figure 3.3 Energy Use Intensity (kWh/m²) vs. Building ID (sorted by MUA type)

There are no visible trends relating the building EUI and the type of MUA unit. Townhouse complexes most often do not have common areas. The townhouse complexes included in this study, Buildings 21, 22 and 23, are shown in the "No MUA" portion of this plot.

3.2 Low-Rise versus Mid- and High-Rise MURBs

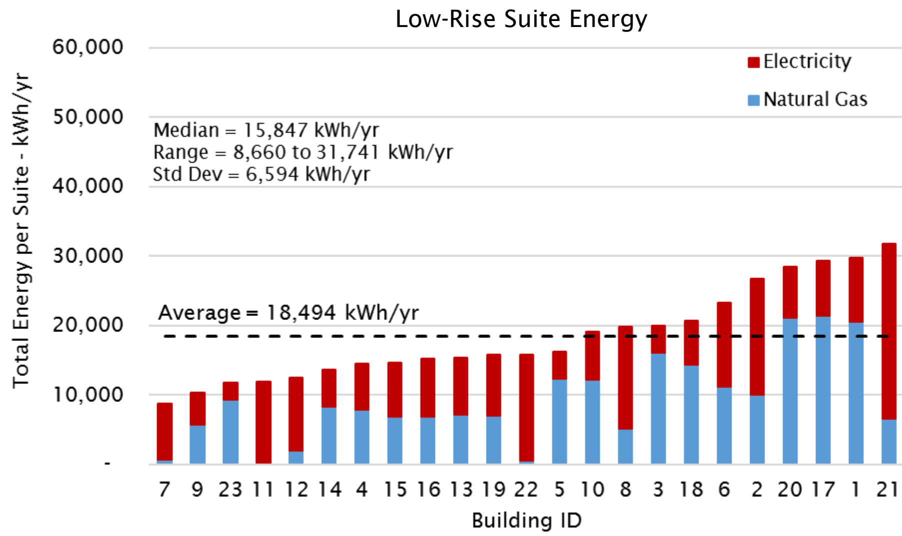
RDH previously collected and analyzed in detail the energy consumption and conservation of mid- and high-rise residential buildings[7]. Plots are produced for the current study to mirror those produced in the previous study so the data collected for both low- and high-rise building types can be compared visually.

3.2.1 Energy Consumption per Suite

Figure 3.4 presents the energy use, normalized per suite, sorted from low to high, with the overall gas and electricity portions indicated for high-rise MURBs.

The energy use per suite is on average 21,926 kWh/year, a 16% increase over the average suite consumption in a low-rise MURB at 18,494 kWh/yr. Building 57 (Figure 3.4), with the highest suite consumption at 50,611 kWh/year is a luxury condominium building with individual suites in the 2,000-plus ft² range. This building has full amenities that the typical low-rise MURB would not, including air conditioning, in-suite fireplaces, and a common-area pool and recreation centre.

[7] Energy Consumption and Conservation in Mid- and High-Rise Residential Buildings in British Columbia. Available online: https://www.bchousing.org/research-centre/library/building-science-reports



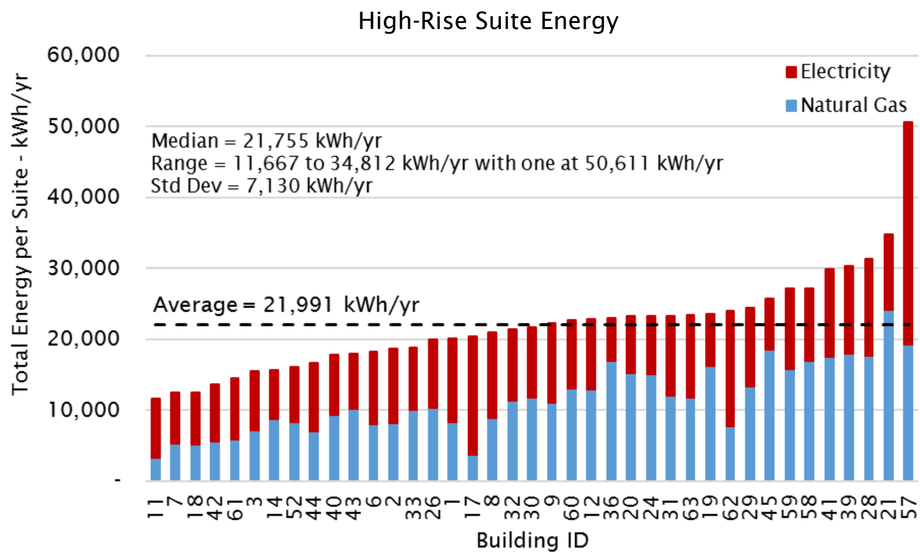


Figure 3.4 Total energy consumption normalized by suite, divided between natural gas and electricity, sorted low to high—low-rise MURBs are shown above, high-rise MURBs are shown below.

3.2.2 Total Energy Consumption and Year of Construction

The total Energy Use Intensity (EUI) for each of the buildings is plotted below versus the year of construction. Figure 3.5 and Figure 3.6 show the total energy used for space heating per gross floor area for high- and low-rise buildings. The year of construction ranges from 1974 to 2010.

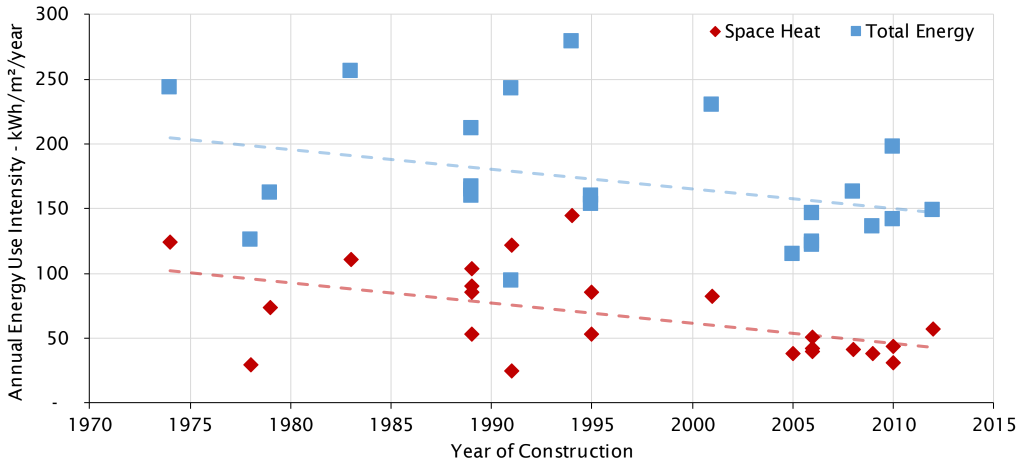


Figure 3.5 Total building EUI and space heating energy versus year of construction for low-rise MURBs.

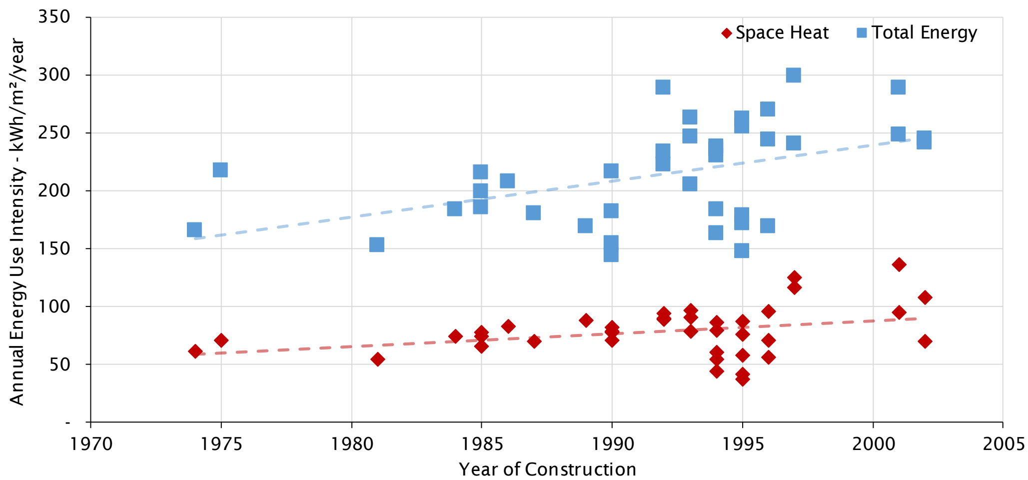


Figure 3.6 Total building EUI and space heating energy versus year of construction for high-rise MURBs.

The low-rise plot shows the total EUI (kWh/m^2/yr) along with the total heating EUI, appearing to gradually decrease over construction year. 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 a similar plot formulated in a similar study representing high-rise MURBs in southwest B.C. Figure 3.6 shows the total EUI for high-rise MURBs as well as the space heat normalized by gross floor area versus the year of construction. The plot shows a general increase in both space heat and total energy use as the year of construction increased, particularly in buildings constructed between 1990 and 2000. The reason for the increase is likely due to a combination of factors, including amenities in newer buildings, such as pools or hot tubs, more complex building form, higher ventilation rates, and higher glazing areas.

3.2.3 Energy Consumption and Window-to-Wall Ratio

The space heating and total energy consumption versus window-to-wall ratio for each of the buildings is presented in Figure 3.7 and Figure 3.8 for high- and low-rise MURBs, respectively.

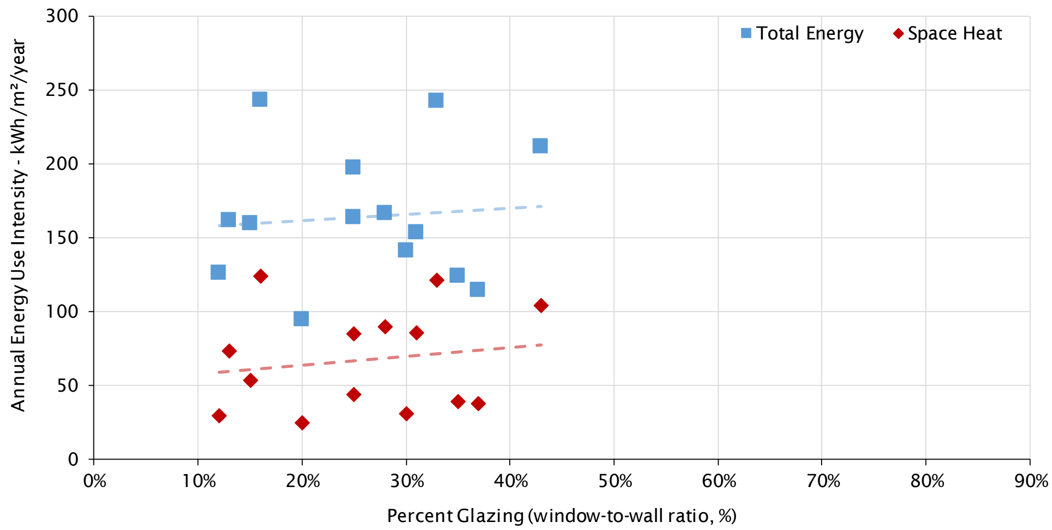


Figure 3.7 Total EUI and space heat energy versus the window to wall ratio for low-rise MURBs.

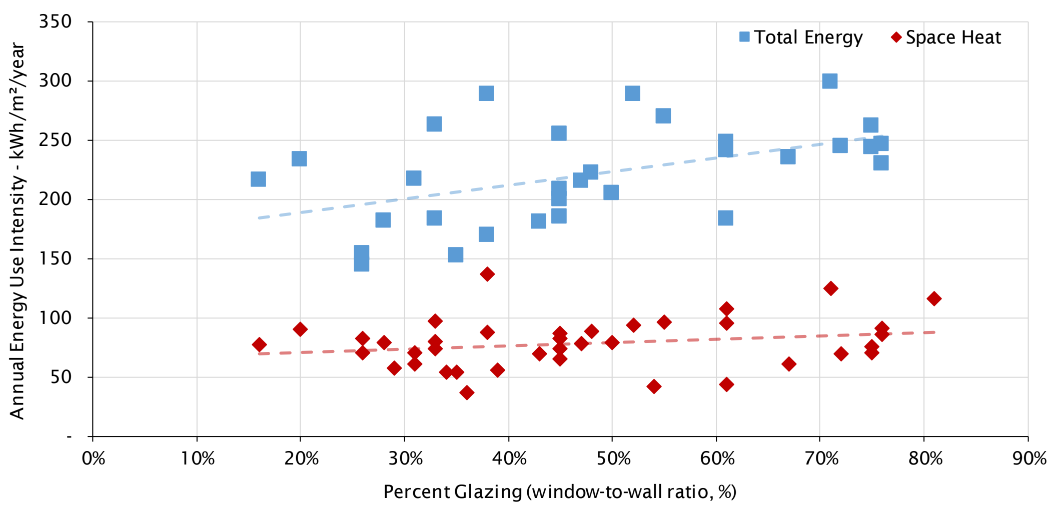


Figure 3.8 Total EUI and space heat energy versus the window to wall ratio for high-rise MURBs.

Although the low-rise plot (Figure 3.7) shows a very slight increase in both total EUI and space heat energy as the window-to-wall ratio increases, the correlation is not significant, resulting in an inconclusive analysis. The window-to-wall ratio was only available for the 14 buildings shown in this plot. The high-rise plot (Figure 3.8) shows a slightly more significant correlation between energy use and window-to-wall ratio.

Increased glazing areas have become common in newer high-rise architectural styles where glazing areas of up to 80% are present. These high glazing areas influence the total energy consumption as well as the space heat consumption for all buildings.

3.2.4 Percentage of Heating Energy

The buildings in both studies have similar mechanical systems, with the majority of buildings providing space heat with electric baseboard heaters 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. Building 5 has hydronic baseboard heaters instead of electric baseboards.

Figure 3.9 shows the average distribution of baseline energy consumption and space heating energy, normalized by floor area for both low-rise MURBs and high-rise MURBs.

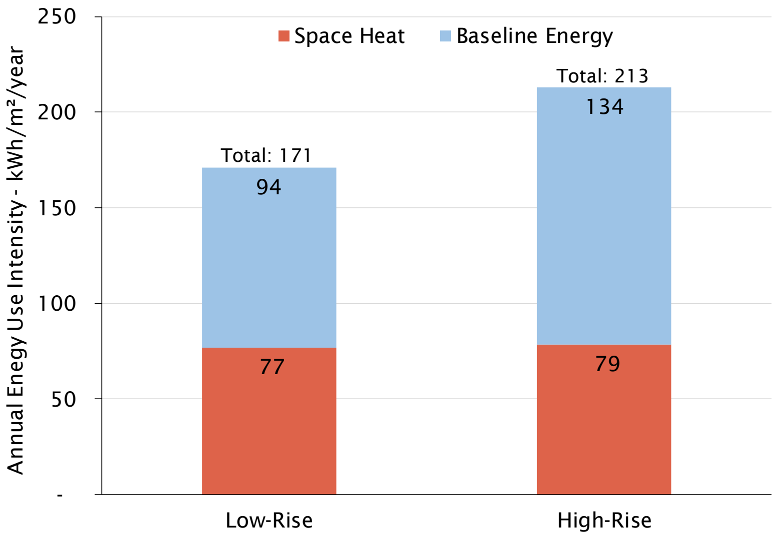


Figure 3.9 Average low- and high-rise MURB energy consumption, kWh/m²/yr.

The high- and low-rise studies found that, on average, low-rise buildings only consume approximately 2% less space heating energy than high-rise buildings. While there is a reduction in total space heating energy in the low-rise MURBs, low-rise space heat makes up 45% of the overall building energy, whereas the high-rise space heat makes up 37% of the total building energy. However, high-rise MURBs generally have higher baseline energy consumption, which is likely due to more building amenities, such as pools and gyms.

3.2.5 Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions were calculated for each of the buildings in this study using British Columbia CO_2 emission factors[8]. The buildings in this study produce 137 tons of CO_2 equivalent each year on average. The average annual GHG Intensity (GHGI) for buildings in this study is 17 kg-CO_2e/m^2. The buildings demonstrated a range of emissions, as low as 2, 4, and 6 kg-CO_2e/m^2 for the all-electric buildings (Building IDs 11, 7, and 22, respectively). Building 16 had the highest GHGI at 37 kg-CO_2e/m^2.

The buildings in the high-rise study produced an average of 234 tons of CO_2e per year, and an average annual GHGI of 21 kg-CO_2e/m^2. As expected, the high-rise emissions are higher than the low-rise due to the greater use of natural gas, particularly for ventilation heating (MUA).

[8] Emissions factors are 49.87 kg CO2e/GJ for gas and 2.964 kg CO2e/GJ for electricity per the 2016/17 BC Best Practices Methodology for Quantifying Greenhouse Gas Emissions. Available online: http://www2.gov.bc.ca

While the amount of GHGs emitted by the high-rise buildings is larger than the low-rise buildings, the distribution of GHGs between heating and baseline gas consumption is almost identical, as shown in Figure 3.10. The *Gas – Heat* portion of this chart is a combination of MUA, suite heat, and gas fireplace consumption, while *Gas – Baseline* is primarily DHW. Figure 3.11 shows the average GHG emission distribution by end use for the high-rise study.

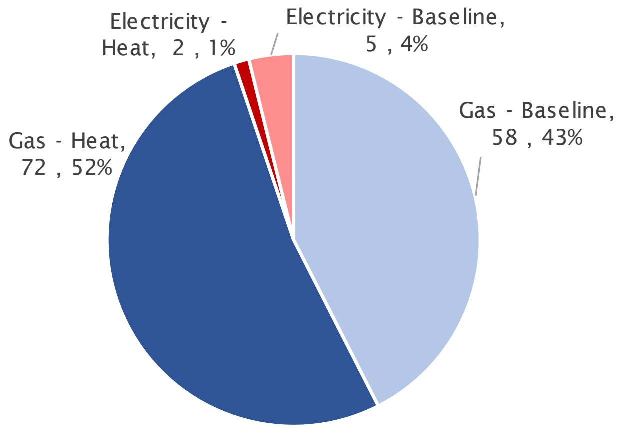


Figure 3.10 Average distribution of GHG emissions from low-rise study buildings, tCO_2e and % of total.

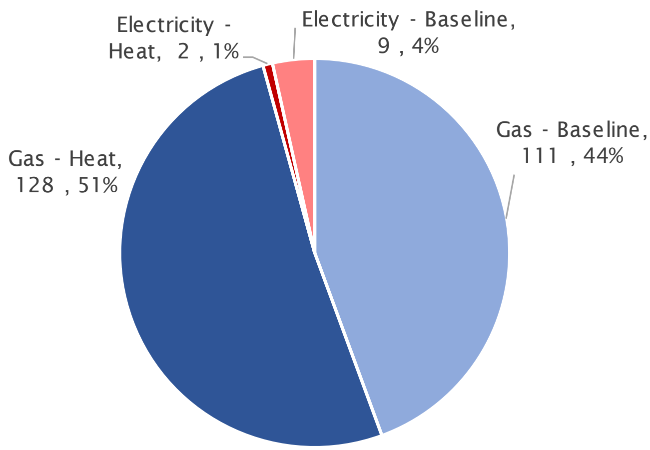


Figure 3.11 Average distribution of GHG emissions from high-rise study buildings.

4 Calibrated Energy Modelling

Energy modelling was performed to further understand how energy is consumed within low-rise MURBs and to assess the impacts of potential energy conservation measures (ECMs). A detailed description of the methodology can be found in Section 2.3. Of the initial 23 case study buildings, two were selected for calibrated energy modelling as they both had sufficient, clean data, and are representative of two different styles of low-rise MURBs, both townhouses and multi-storey wood-frame buildings in the Lower Mainland.

The calibrated energy models were used to analyze the impact of various energy conservation measures (ECMs) on building energy consumption. The ECM analysis is presented in Section 5. A more detailed description of Building 15 (four-storey MURB) and of Building 21 (townhouse) and their calibrated models is provided below.

4.1 Building 15: Four-Storey MURB

The following section provides a summary of the characteristics and calibrated energy model for Building 15. Additional details and model inputs can be found in Appendix B.

4.1.1 Description of the Building

Building 15 is located in Vancouver in a neighbourhood of similar sized buildings. The building is oriented with its entrance facing north. It is four storeys tall and contains 60 suites over an unconditioned reinforced concrete parking garage. The conditioned floor area is 4,800 m^2 (52,000 ft^2) and it has a window-to-wall ratio of 36%. Originally constructed in 2004, there have been no major retrofits to date.

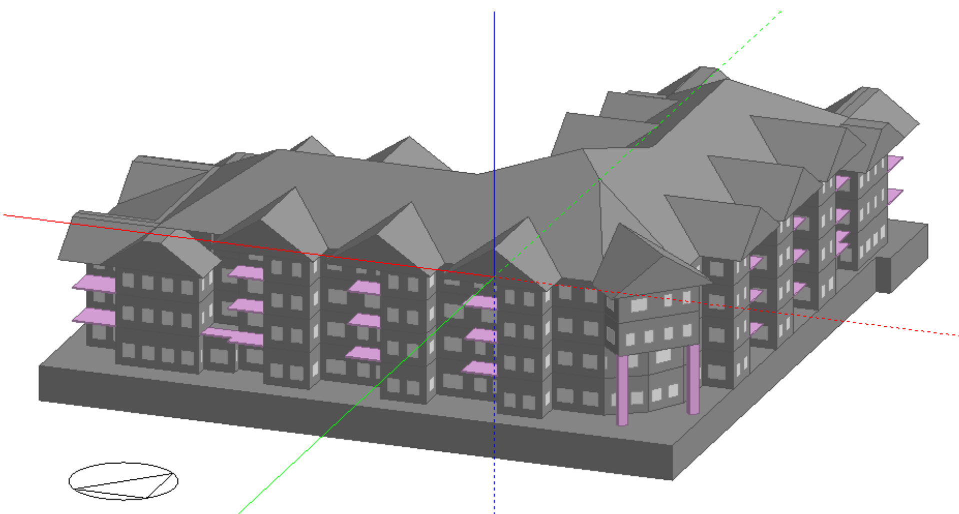


Figure 4.1 Model rendering of Building 15, four-storey MURB.

Building 15's enclosure construction is common to many wood-frame buildings in the Lower Mainland constructed in the 2000s and later: 2x6 wood studs with R-20 batt insulation for walls, R-40 batt for attic roofs, and reinforced concrete for below-grade walls and parking garage. The windows consist of vinyl frames with double-glazed insulating glazing units (IGUs). Though the specific glazing configuration could not be confirmed, it is estimated that the units have a basic low-e coating based on the building's year of construction.

The building uses a pressurized corridor approach to ventilation. A roof-top make-up air unit with natural gas heating that is rated to supply 3,300 cfm of outdoor air to the corridors (equivalent to 55 cfm/suite) with a nominal efficiency of 81%. This system is supplemented by suite bathroom and kitchen exhaust fans operated by the residents. Heating is provided by electric baseboards and electric fireplaces in each suite. Domestic hot water (DHW) is provided by a central gas-fired boiler and storage tank that has 81% nominal efficiency.

Light fixtures are a mix of recessed and surface mounted, incandescent, and fluorescent bulbs. The building manager suspects that many of the occupants have converted some of their incandescent bulbs to LEDs in their suites, however lighting power densities (LPDs) within suites could not be confirmed.

4.1.2 Utility Data Analysis

Building 15 was chosen as the multi-storey archetype for energy modelling due to its common system types and EUI close to the average of all buildings reviewed. It is a four-storey building with electric baseboard heating, gas-fired makeup air and DHW, and gas fireplaces. It has a weather normalized average EUI of 163 kWh/m^2.

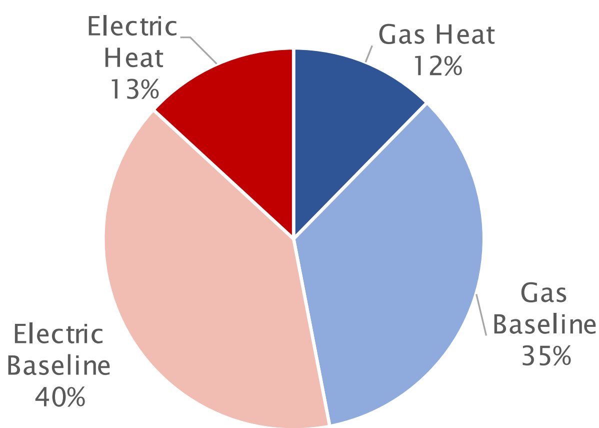


Figure 4.2 Building 15 (four-storey) energy consumption by end use (breakdown of suite and common electricity was not available for this building).

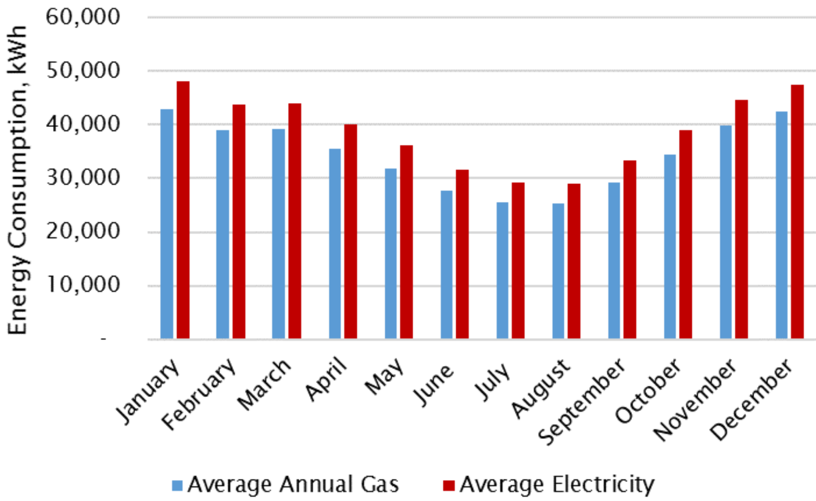


Figure 4.3 Building 15 (four-storey) weather normalized average annual energy consumption.

4.1.3 Calibrated Energy Model

The original model inputs were either taken from standard references, previous research, or from the building plans and site visit. It was anticipated that standard values would be changed during calibration to reflect the specific building. It was also anticipated that mechanical or electrical systems may not be operating at their original efficiencies.

In the case of Building 15, notable adjustments were needed to match the modelled electricity and gas outputs to the metered data, including:

→ Lowering miscellaneous electrical (plug) and lighting loads

→ Limiting electric baseboard capacity

→ Increasing DHW flow rate

→ Lowering the MUA unit nominal air flow rate

→ Increasing air infiltration rate

→ Increasing heating set point temperature

The initial uncalibrated model for Building 15 significantly over predicted both gas and electric heating. Extensive calibrations were required to align the model with metered data:

→ Seasonal gas consumption (gas heating, attributable to the MUA unit) was significantly higher in the model than metered. The reason for this difference was not known as testing was outside the scope of this study. To calibrate gas MUA heating, the outdoor air flow rate was reduced by approximately 28% versus the unit's rated flow rate. This calibration was applied as a last resort after reasonable adjustments to the temperature set point and efficiency failed to calibrate the model. Additional investigation and testing would be required to determine the reason for low metered gas consumption attributed to the MUA.

→ Seasonal electricity consumption (likely attributable to the electric baseboards) was also significantly higher in the model than metered. To calibrate electric baseboard heating, a baseboard capacity was applied to the model. This calibration was applied as a last resort after other reasonable adjustments were exhausted, such as temperature set point, infiltration, and window performance characteristics. Additional investigation and testing would be required to determine the reason for low metered electricity consumption in the winter months. However, it is noteworthy that this same calibration was required for buildings with electric baseboard heating in the high-rise study[9] (the range of capacities varied significantly in the high-rise study, but the value applied here was within the same range applied in the high-rise study).

Figure 4.4 and Figure 4.5 show the metered energy consumption compared with the final calibrated model results for electricity and gas, respectively. Percentage differences between the metered and modelled consumption are ±6% during each month, with annual consumption ±2%.

To assess the quality of the model calibration, ASHRAE Guideline 14[10] 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 Building 15 model calibration has a CVRMSE and a NMBE below 1% for gas and below 2% for electricity, both within the recommended limits.

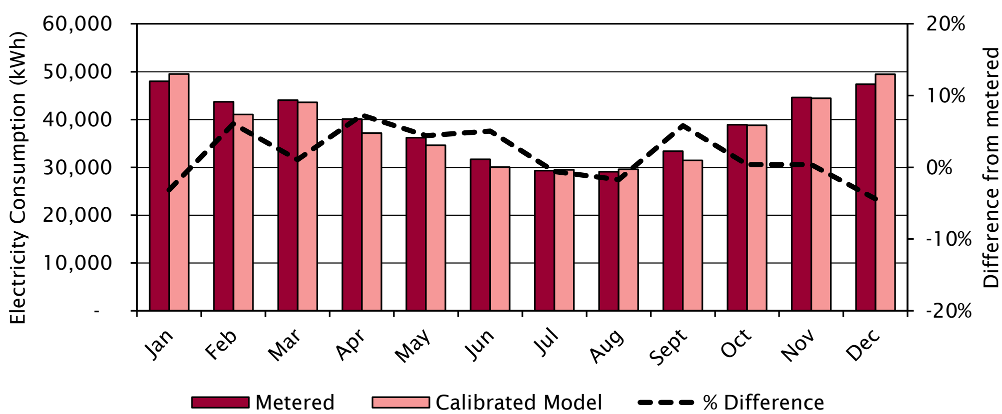


Figure 4.4 Calibration of modelled electricity consumption for Building 15, four-storey MURB.

[9] Available online (Energy Consumption and Conservation in Mid and High-Rise Residential Buildings in British Columbia): https://www.bchousing.org/research-centre/library/building-science-reports

[10] ASHRAE Guideline 14-2002 Measurement of Energy and Demand Savings

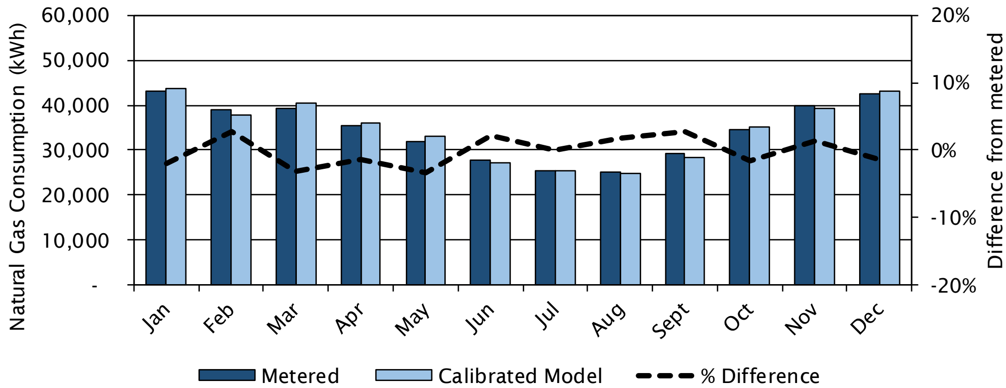


Figure 4.5 Calibration of modelled gas consumption for Building 15, four-storey MURB.

Building 15 has an Energy Use Intensity (EUI) of 181 kWh/m^2. The breakdown of annual energy consumption by end use is shown in Figure 4.6. Nearly half (47%) of the energy consumption of Building 15 is from gas heating for the make-up air handling unit and gas heating for domestic hot water. Electrical consumption including indoor lighting (23%), heating by electric baseboards and in-suite electric fireplaces (11%), and miscellaneous plug loads (16%) make up the majority of electricity consumption. The breakdown of those electricity categories varied during the calibration process and remains only an estimate. Energy use for indoor lighting is quite high in this building, largely due to inefficient corridor lighting design. The lighting power density inside the suites is unknown, so this is an uncertain category.

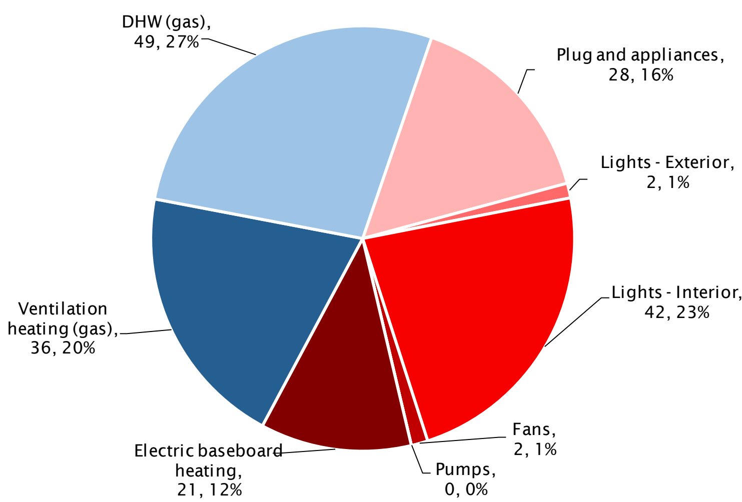


Figure 4.6 Annual energy consumption distribution (kWh/m^2 and % of total) for Building 15, four-storey MURB.

4.2 Building 21: Townhouse

The following section provides a summary of the characteristics and calibrated energy model for Building 21. Additional details and model inputs can be found in Appendix B.

4.2.1 Description of the Building

Building 21 is located in Vancouver in a neighbourhood of similar sized buildings. The building is oriented with its entrance facing north. It is two storeys tall and contains 32 townhouse units over a reinforced concrete parking garage. The units are accessed from outside, with no common corridor space between units above grade. The complex's only common space comprises the parking garage and a below-grade area with corridor and amenity space, including a lounge, sauna, fitness equipment, locker rooms, and change rooms. The conditioned floor area is 3,500 m^2 (38,000 ft^2) and has a window-to-wall ratio of approximately 23% on east, west, and north elevations (including sloped glazing), and no windows on the south elevation, which overlooks the back alley.

Since its original construction in 1982, the building has undergone several renewals projects. In 2002, the courtyard pond was removed and the following items were replaced:

- Roof membrane
- Deck, balcony, and podium membrane and pavers
- Wall cladding (replaced with a rainscreen assembly)
- Windows, skylights, and sliding doors
- Exterior wood stairs
- Exterior light fixtures

The window, skylight, and door replacement project likely would have improved the energy performance of the building by reducing heat loss and infiltration. The wall and balcony rehabilitation and roof and deck renewals would have likely helped to reduce infiltration at the building. Other items, such as the roof membrane replacement, would have had little or no impact on the energy efficiency of the building.

Between 2002 and 2014, other items were also upgraded, including hot water heaters and a recirculation pump. A spa Jacuzzi® was shown in the plans, but was either never installed or was removed soon after building construction, therefore it was not included in the model. The calibrated energy model for Building 21 used inputs that reflected the changes from retrofits to be representative of the period for which energy consumption data was obtained. It was not possible to obtain pre-retrofit energy consumption data for this building.

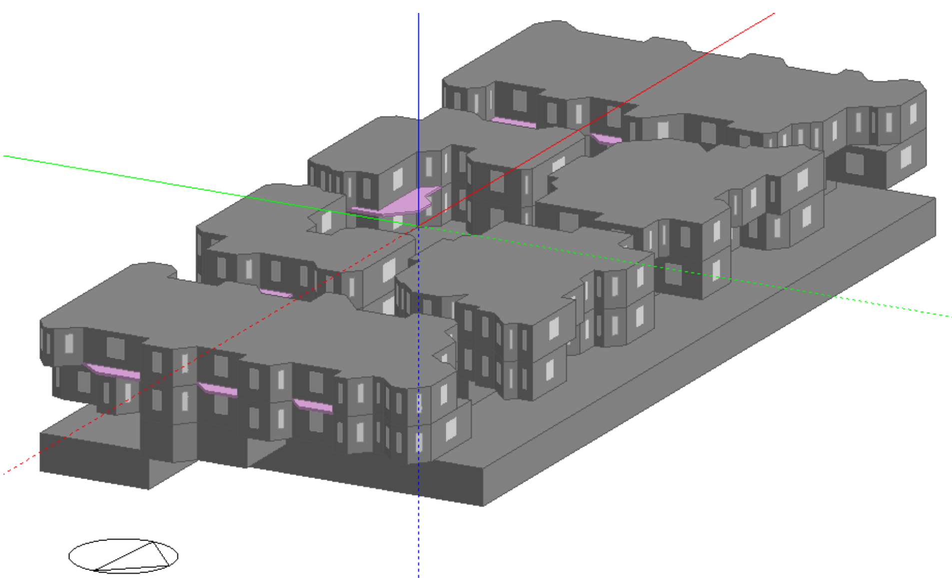


Figure 4.7 Model rendering of Building 21, townhouse complex.

Building 21 is constructed with 2x4 wood studs with R-12 batt insulation for walls, low-slope roofs with R-19 batt between joists, and uninsulated concrete below-grade walls. The enclosure details were taken from limited wall assembly drawings in the plans and where values were unknown they were approximated given the construction type and age of the building.

Electric baseboards in each suite provide heating along with wood-burning fireplaces. Some of the wood-burning fireplaces have been converted to gas fireplaces, though the number of suites with gas fireplaces could not be confirmed. Suites are ventilated through bathroom and kitchen exhaust fans operated by the occupants. There is no make-up air unit as the suites are not accessed from an interior corridor. The amenity space with a sauna is served by an air handling unit. DHW is provided by a central gas-fired boiler with a nominal efficiency of 80%.

Light fixtures are a mix of recessed and surface mounted, incandescent and fluorescent bulbs. A lighting legend was not available, so typical bulb types were assumed and verified where photos were available.

4.2.2 Utility Data Analysis

Building 21 was chosen for the second archetype. It is a three-storey townhouse development with electric baseboard heating, no make-up air, some wood fireplaces (others switched to natural gas) as a secondary heat source, and natural gas DHW. It has above average EUI compared with all buildings reviewed. The proportion of wood-burning fireplaces to natural gas fireplaces is not known, and wood-burning fireplaces are assumed to be used infrequently and for relatively short periods (as such, they are not a significant heating source). Therefore, the wood fuel and heat gain was assumed to be insignificant and not accounted for in our analysis.

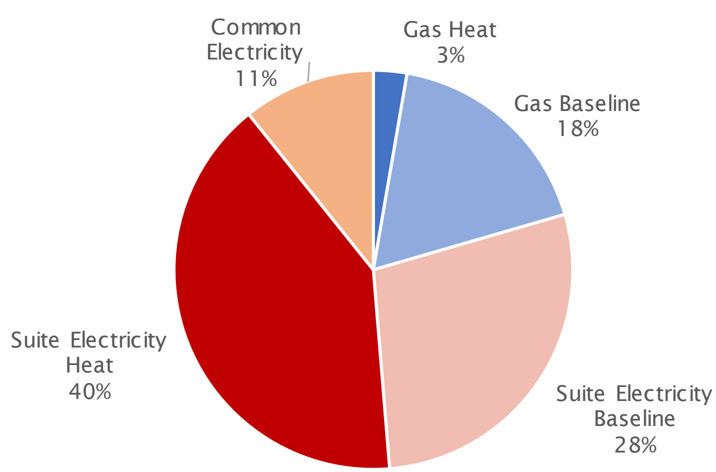


Figure 4.8 Building 21 (townhouse) energy consumption by end use.

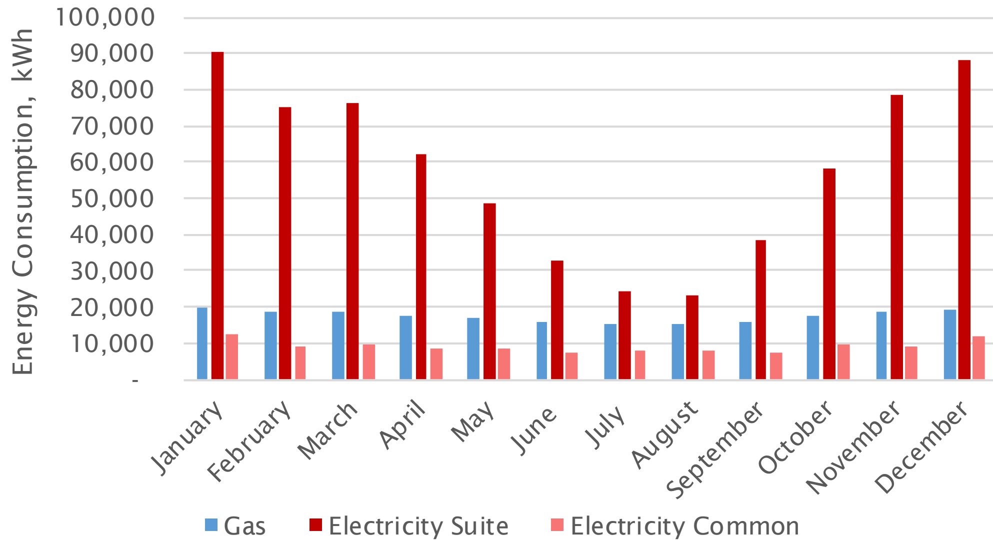


Figure 4.9 Building 21 (townhouse) weather normalized average annual energy consumption.

4.2.3 Calibrated Energy Model

In the case of Building 21, notable adjustments were needed to align the modelled electricity and gas outputs to the metered data, including:

→ Increasing plug loads

→ Increasing gas fireplace consumption

→ Increasing DHW flow rate

→ Increasing air infiltration rate

→ Increasing heating set point temperature

Similar to Building 15, the original inputs for Building 21 were taken from standard energy codes, from building drawings, a site visit, and the building's depreciation report. The initial uncalibrated model for Building 21 significantly under predicted electric heating, while the gas consumption was initially within 20% of metered. Since the exact number of wood-burning fireplaces that had been converted to gas fireplaces was unknown, gas consumption was calibrated by adding and adjusting gas fireplace use. Electricity was calibrated by increasing the heating set point temperature from 21˚C to 23˚C and infiltration rate from 0.10 cfm/ft² to 0.20 cfm/ft² at operating pressure.

After adjusting inputs within a reasonable range, the model still under predicted winter electricity consumption. As such, additional infiltration was added in the form of natural ventilation. Occupants may open their windows during the winter months to receive natural ventilation given the lack of supply air and absence of a MUA unit. Further investigation is required to confirm the significant metered winter electricity consumption.

Figure 4.10 and Figure 4.11 show the metered energy consumption compared with the final calibrated model results for electricity and gas, respectively. Percentage differences between the metered and modelled consumption are within ±10% during each month, with annual consumption ±1%.

To assess the quality of the model calibration, ASHRAE Guideline 14[11] 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 Building 21 model calibration has a CVRMSE and a NMBE below 1% for gas and below 2% for electricity, both within the recommended limits.

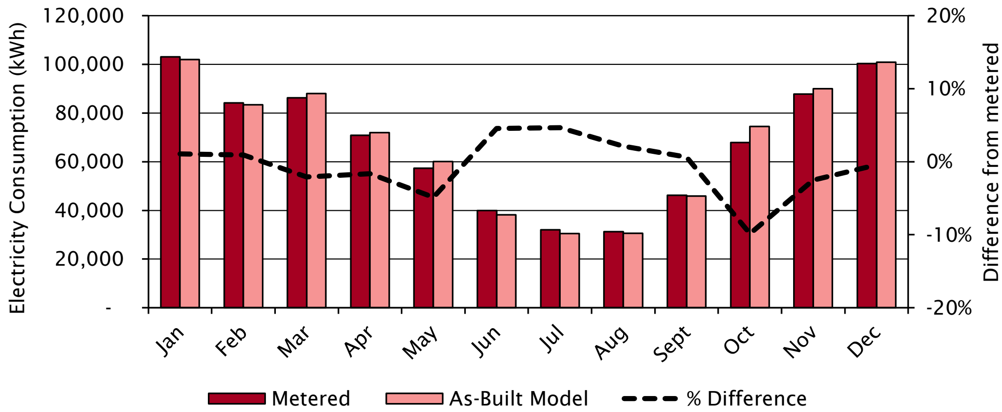


Figure 4.10 Calibration of modelled electricity consumption for Building 21, townhouse.

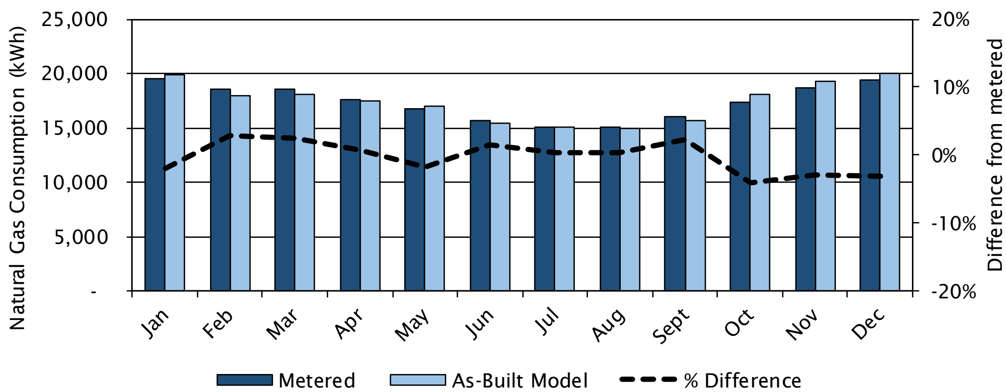


Figure 4.11 Calibration of modelled gas consumption for Building 21, townhouse.

Building 21 has an EUI of 273 kWh/m^2. The breakdown of annual energy consumption by end use is shown in Figure 4.12. Compared to Building 15, Building 21 has a smaller fraction of gas consumption (21% of total, 18% for DHW) since it has no make-up air. The townhomes rely on electric baseboards for heating (43% of total), although some units have converted their wood-burning fireplaces to natural gas fireplaces for supplemental heating (3% of total) which is metered through a single building meter. Indoor lighting and miscellaneous electrical equipment account for 34% of energy consumption.

[11] ASHRAE Guideline 14-2002 Measurement of Energy and Demand Savings

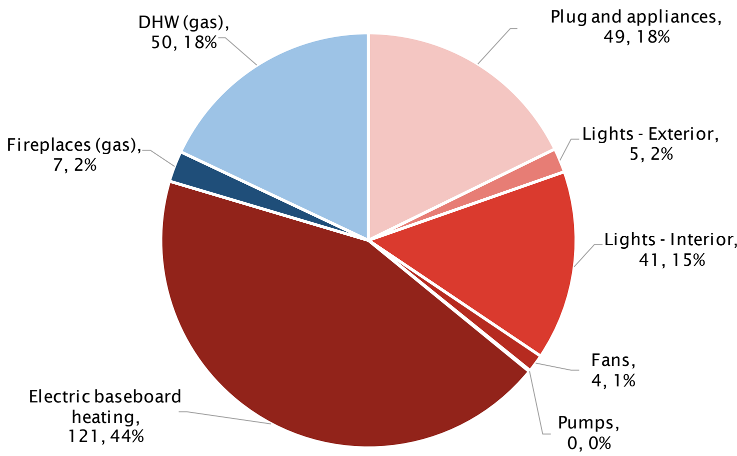


Figure 4.12 Annual energy consumption by end use (kWh/m², % of total) for Building 21, townhouse.

5 Opportunities for Energy Conservation

5.1 Energy Conservation Measures Considered

In addition to quantifying how energy is used in low-rise residential building stock, this study aimed to identify opportunities how to improve the energy efficiency and reduce energy-related operating costs in existing low-rise residential buildings. This information is intended to be used to prioritize alternate building enclosure designs, space heating, and domestic hot water strategies for existing and new MURBs.

Energy Conservation Measures (ECMs) were modelled using the calibrated energy models for the two case study buildings, a four-storey MURB (Building 15) and a townhouse complex (Building 21). The ECMs were chosen to reflect feasible changes that would impart significant energy savings to each building during their operation. ECMs were first modelled independently and then in three tiers of bundles. These results are presented in Sections 5.2 and 5.3.

The following is a list of ECMs that were modelled:

Add R-5 to walls

Increase thermal resistance (R-value) of walls by R-5 $ft^2 \cdot °F \cdot hr/Btu$. This was modelled by increasing the effective R-value of the walls from building drawings by R-5 overall. This could be achieved by adding approximately 1.5" of rigid insulation at the exterior of the building, with cladding attached by screws through insulation or low conductivity clips to minimize thermal bridging. Other methods such as interior insulation or upgraded fill insulation are other strategies which can be used to increase the effective insulation levels within existing wood-frame walls.

Add R-10 to walls

Increase thermal resistance (R-value) of walls by R-10 $ft^2 \cdot °F \cdot hr/Btu$. This was modelled by increasing the effective R-value of the walls from building drawings by R-10. This could be achieved by adding approximately 3" of rigid insulation at the exterior of the building, with cladding attached by screws through insulation or low conductivity clips to minimize thermal bridging.

Add R-10 to roof

Increase thermal resistance (R-value) of roof by R-10 $ft^2 \cdot °F \cdot hr/Btu$. This was modelled by increasing the effective R-value of the roof from building drawings by R-10. This could be achieved by adding 3" to 4" of blown or batt insulation to an empty attic space, or by adding 2" of rigid insulation to a roof with insulation above the sheathing when re-roofing.

Add R-20 to roof

Increase thermal resistance (R-value) of roof by R-20 $ft^2 \cdot °F \cdot hr/Btu$. This was modelled by increasing the effective R-value of the roof from building drawings by R-20. This could be achieved by adding 6" to 8" of blown or batt insulation to an attic space, or by adding 4" of rigid foam insulation to a roof with insulation above the sheathing when re-roofing.

Add R-40 to roof

Increase thermal resistance (R-value) of roof by R-40 ft²·°F·hr/Btu. This was modelled by increasing the effective R-value of the roof from building drawings by R-40. This was only realistic for Building 21, which started with an estimated R-18 roof. In contrast, Building 15 had an R-38 roof in its original plans. This would be achieved by adding 8” of rigid foam insulation above the sheathing.

Install new double-glazed windows

Upgrade windows to U-0.35 by installing double-glazed windows with low-conductivity vinyl frames. This was only modelled for Building 21 as Building 15 had better performing windows in the baseline condition. In the model for Building 21, the U-value of the glazing units was changed from U-0.40 to U-0.35 Btu/hr·°F·ft².

High performance double-glazed windows

Upgrade windows to U-0.28 by installing high performance double-glazed windows with insulated low-conductivity vinyl frames. This was modelled by decreasing the U-value of the glazing units to U-0.28 Btu/hr·°F·ft² in both buildings.

Triple-glazed low-conductivity windows

Upgrade windows to U-0.17 by installing triple-glazed low-conductivity frames. This was modelled by decreasing the U-value of the glazing units to 0.17 Btu/hr·°F·ft² in both buildings.

Improve airtightness to 0.10 cfm/ft² (@4 Pa)

Decrease air infiltration rate to 0.10 cfm/ft² (at operating pressure). This value is based on a previous RDH study[12] as a reasonable mid-range air infiltration rate.

Improve airtightness to 0.04 cfm/ft² (@4 Pa)

Decrease air infiltration rate to 0.04 cfm/ft² (at operating pressure). This value is based on the standard required by the US Army Corp of Engineers[13,14] (0.043 cfm/ft² @ 5Pa) and between the low-average and lowest expected air leakage value from RDH project experience. This value is representative of airtight new buildings.

Install 70% efficient HRVs in suites

Install 70% efficient heat recovery ventilation in each suite, and reduce the MUA flow rate to provide minimal outdoor air for corridor ventilation. As Building 21 (townhouse) does not have MUA, it was assumed that HRVs would reduce the need for occupants to open windows as much during the heating season, and so natural ventilation was reduced in this ECM.

Install 85% efficient HRVs in suites

Install 85% efficient heat recovery ventilation in each suite, and reduce the MUA flow rate to provide minimal outdoor air for corridor ventilation. As Building 21 (townhouse) does not have MUA, it was assumed that HRVs would reduce the need for occupants to open

[12] Energy Consumption and Conservation in Mid- and High-Rise Residential Buildings in British Columbia. Available online: https://www.bchousing.org/research-centre/library/building-science-reports

[13] U.S. Army Corps of Engineers and Air Barrier Association of America. 2012. U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes. Champaign: U.S. Army Corps of Engineers

[14] U.S. Army Corps of Engineers. 2012. Building Air Tightness and Air Barrier Continuity Requirements.

windows as much during the heating season, and so natural ventilation was reduced in this ECM.

Upgrade MUA to 93% efficiency

Upgrade the make-up air (MUA) unit heating to a high efficiency condensing unit (93% efficiency). This was only modelled for Building 15 since Building 21 does not have a MUA unit.

Reduce MUA (corridor air) set point temperature to 17˚C

Reduce the corridor ventilation air set point temperature of the make-up air (MUA) unit to 17˚C. This was only modelled for Building 15 since Building 21 does not have a MUA unit. This may increase suite heating slightly.

Remove in-suite gas fireplaces

Building 21 was originally built with a wood fireplace in each townhome, some of which were converted to gas fireplaces in recent years (confirmed during calibration). This ECM was modelled by turning gas fireplaces off in the model for Building 21.

Install low-flow water fixtures

Install low-flow faucets and showers in each suite to decrease hot water consumption. This was modelled by decreasing DHW flow rate and tank size by 20% (estimated from standard and low flow fixture water flow rates).[15]

Install drain water heat recovery coils

Install drain water heat recovery on drains throughout building. This was modelled by manually decreasing DHW energy consumption by 10% from the baseline. Note that this is only feasible in some existing buildings.

Upgrade domestic water heater to 93% efficient condensing gas boiler

Upgrade to condensing service water heater. This was modelled by increasing the efficiency of the water heater to 93.

Install occupancy sensors for common area lighting

Install occupancy sensors for common area lighting. This was modelled by decreasing lighting power densities by 15% in corridors, lobby, amenities room, and parkade.[16]

Switch to LED lighting

Switch all lights to LED bulbs. This was modelled by using the calculated wattage of LED products equivalent to the existing lighting in order to recalculate lighting power the density.

5.2 Building 15: Four-Storey MURB

5.2.1 Individual ECMs

The ECMs listed in Section 5.1 were modelled for Building 15, to achieve estimated energy savings. Each ECM was modelled independently in order to measure individual

[15] According to the US Department of Energy, installing low-flow water fixtures can achieve DHW savings of 25%–60%.

[16] ASHRAE 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings, Appendix G. Table G3.2.

improvements before bundles were put together (Section 5.2.2). The following table shows the EUI, total energy consumption savings, and heating savings for the four-storey MURB.

TABLE 5.1 LIST OF ECMS FOR BUILDING 15			
ECM Description	**Total EUI (kWh/m²)**	**Total Energy Savings (%)**	**Heating Savings (%)**
Baseline	181	—	—
Add R-5 to walls (R-21 total)	180	1%	2%
Add R-10 to walls (R-26 total)	179	1%	4%
Add R-10 to attic roof (R-48 total)	181	0.2%	1%
Add R-20 to attic roof (R-58 total)	180	0.3%	1%
Double-glazed low-conductivity frame windows (U-0.28)	178	2%	5%
Triple-glazed low-conductivity frame windows (U-0.17)	173	4%	14%
Improve airtightness to 0.10 cfm/ft² (@4 Pa)	177	2%	7%
Improve airtightness to 0.04 cfm/ft² (@4 Pa)	172	5%	15%
Install 70% efficient HRVs in suites	171	5%	39%
Install 85% efficient HRVs in suites	166	8%	47%
Upgrade MUA to 93% efficient	176	3%	8%
Reduce MUA set point temperature to 17°C	171	5%	17%
Install low-flow fixtures	175	5%	N/A
Install drain water heat recovery	177	3%	N/A
Upgrade water heater to 93% efficient	175	4%	N/A
Install occupancy sensors	177	2%	(1%)
Switch to LED lighting	168	7%	(5%)

The ECM with the highest impact is the addition of in-suite HRVs. The high heating savings from this measure are due to the decreased MUA flow rate, which results in decreased ventilation heating energy consumption. The heat recovery units deliver ventilation directly to suites while recovering heat from the exhaust air. Supplementary heating is provided by the suite electric baseboards.

Energy efficient lighting measures — occupancy sensors and LED lighting — improve overall energy consumption yet increase heating energy consumption (noted by the negative percentage of heating savings). This is due to less radiative heat from the interior lighting compared with the less efficient baseline lighting, thus a higher heating demand from mechanical space heating.

5.2.2 ECM Bundles

Three tiers of ECM bundles were assembled for Building 15, reflecting:

1. A better enclosure

2. A “best” enclosure
3. The addition of mechanical and lighting upgrades to the best enclosure case

The energy savings for each bundle are shown in Table 5.2 and in Figure 5.1.

TABLE 5.2 BUILDING 15 ECM BUNDLES					
ECM Description	**Total EUI (kWh/m^2)**	**Heating EUI (kWh/m^2)**	**Total Energy Savings (%)**	**Heating Savings (%)**	**GHG Savings (%)**
Baseline	181	57	—	—	—
Bundle 01 – Better Enclosure → Add R5 to walls (R21 total) → Add R10 to roof (R48 total) → Double glazed low-conductivity windows (U-0.28) → Air tightness to 0.10 cfm/ft^2 (@4 Pa)	172	48	5%	16%	1%
Bundle 02 – Best Enclosure → Add R10 to walls (R26 total) → Add R10 to roof (R48 total) → Triple glazed low-conductivity 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 03a – Best Enclosure plus MUA Changes → Bundle 02, plus: → High efficiency MUA (93%) → MUA set point lowered to 17°C	140	4	22%	93%	37%
Bundle 03 – Best Enclosure plus Mechanical and Electrical → Bundle 03a, plus: → Low-flow in-suite fixtures → High efficiency boiler (93%) → Occupancy sensors → LED lighting	106	5	41%	91%	55%

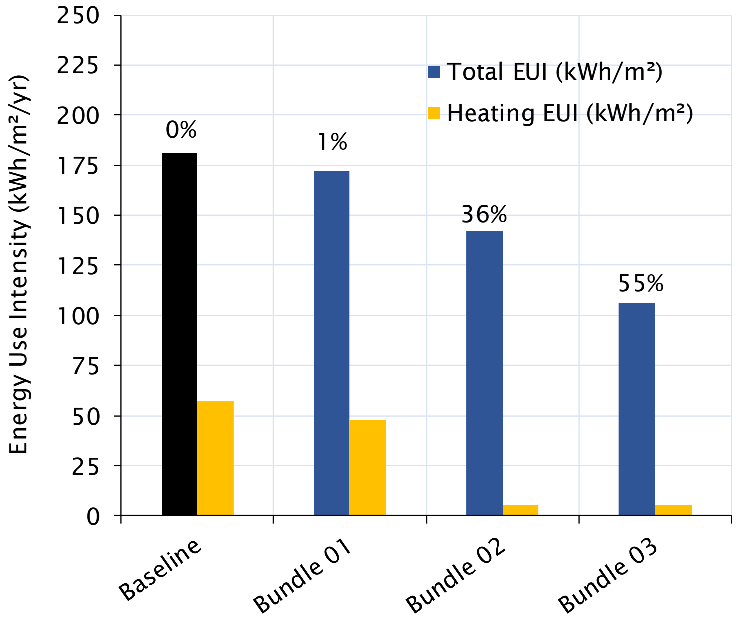


Figure 5.1 The total EUI (black and blue), heating EUI (yellow), and % GHG emission reductions for the baseline Building 15 model and for the three ECM bundles.

The energy conservation bundles in Table 5.2 result in extremely low heating EUI's (as low as 5 $kWh/m^2/yr$). In contrast, the Passive House standard aims for a heating EUI of 15 $kWh/m^2/yr$ or less. It should be noted that the software is optimized for energy simulations at typical building energy consumption levels and may not accurately calculate energy consumption at such low levels. PHPP or another software that includes a more thorough analysis of thermal bridging could be used for comparison, although this would not be as relatable to the baseline case.

In the analysis for Building 15, Bundle 03a represents the maximum heating savings. Once additional electrical energy savings measures for lighting are implemented in Bundle 03, heating savings are reduced due to less radiative losses from inefficient lights. It should be noted, however, that although Bundle 03a has the highest heating savings, Bundle 03 with DHW and lighting ECMs still has the greatest total energy savings. Only moderate increases in savings are seen by adding the MUA measures in Bundle 03 (and 03a) because the MUA outdoor flow rate was already diminished by adding in-suite HRVs in Bundle 02 (in order to maintain constant total outdoor air rate in all cases). Bundle 03a was only modelled for the low-rise Building 15 to see how "deep" into heating energy savings a retrofit could go in this type of building. This analysis was omitted for Building 21, as the townhouse has no MUA unit. Therefore, Bundle 02 is the "deepest" energy retrofit option.

5.3 Building 21: Townhouse

5.3.1 Individual ECMs

The ECMs listed in Section 5.1 were modelled for Building 21, to achieve estimated energy savings. Each ECM was modelled independently in order to measure individual improvements before bundles were assembled (Section 5.3.2). The following table shows the EUI, total energy consumption savings, and heating savings for the townhouse complex.

TABLE 5.3 LIST OF ECM'S FOR BUILDING 21			
ECM Description	**Total EUI (kWh/m^2)**	**Total Energy Savings (%)**	**Heating Savings (%)**
Baseline	277	—	—
Add R5 to walls (R16 total)	270	3%	5%
Add R10 to walls (R21total)	265	4%	8%
Add R10 to flat roof (R28 total)	274	1%	3%
Add R20 to flat roof (R38 total)	272	2%	4%
Add R40 to flat roof (R58 total)	271	2%	5%
Install double-glazed windows (U-0.35)	275	1%	2%
High performance double-glazed windows (U-0.28)	271	2%	5%
Install triple-glazed windows (U-0.17)	265	5%	10%
Improve airtightness to 0.10 cfm/ft^2 (@4 Pa)	260	6%	13%
Improve airtightness to 0.04 cfm/ft^2 (@4 Pa)	247	11%	24%
Install 70% efficient HRVs in suites	288	(4%)	7%
Install 85% efficient HRVs in suites	273	1%	19%
Remove gas fireplaces	276	0.5%	1%
Install low-flow fixtures	267	4%	N/A
Install drain water heat recovery	272	2%	N/A
Upgrade water heater to 93% efficient	270	3%	N/A
Install occupancy sensors	275	1%	(0.3%)
Switch to LED lighting	269	3%	(1%)

5.3.2 ECM Bundles

Three tiers of ECM bundles were assembled for Building 21, reflecting:

1. A better enclosure
2. A "best" enclosure
3. The addition of mechanical upgrades to the best enclosure case.

The energy savings for each bundle are shown in Table 5.4 and in Figure 5.2.

TABLE 5.4 BUILDING 21 ECM BUNDLES					
ECM Description	**Total EUI (kWh/m^2)**	**Heating EUI (kWh/m^2)**	**Total Energy Savings (%)**	**Heating Savings (%)**	**GHG Savings (%)**
Baseline	277	128	—	—	—
Bundle 01 – Better Enclosure → Add R5 to walls (R16 total) → Add R10 to roof (R28 total) → Double glazed low-conductivity windows (U-0.28 → Air tightness to 0.10 cfm/ft^2 (@4 Pa)	243	95	12%	26%	4%
Bundle 02 – Best Enclosure → Add R10 to walls (R21 total) → Add R20 to roof (R38 total) → Triple glazed low-conductivity windows (U-0.17) → Air tightness to 0.04 cfm/ft2 (@4 Pa) → 85% efficient HRVs in suites	189	32	32%	75%	10%
Bundle 03 – Best Enclosure plus Mechanical and Electrical → Bundle 02, plus: → Low-flow in-suite fixtures → High efficiency boiler (93%) → Occupancy sensors → LED lighting	164	33	41%	74%	32%

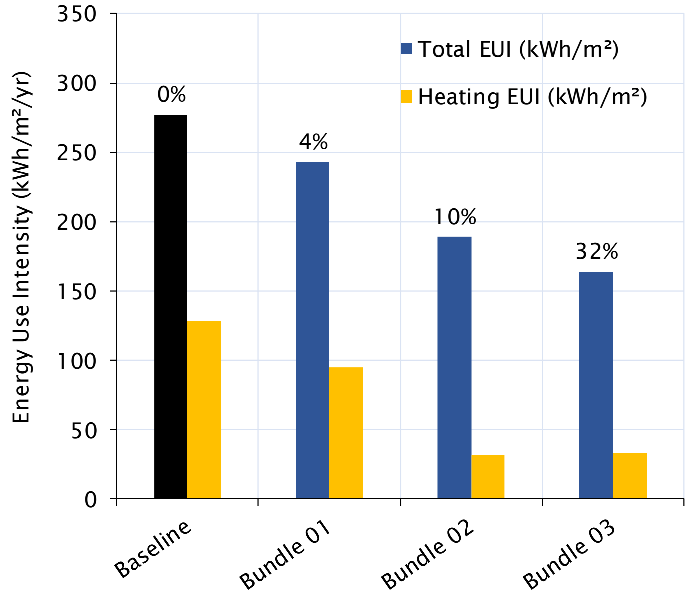


Figure 5.2 The total EUI (black and blue), heating EUI (yellow), and percentage of GHG emission reductions for the baseline Building 21 model and for the three ECM bundles.

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

Less heating savings can also be attributed to the gas fireplaces in Building 21. These are modelled as static loads to the suites, so improving the enclosure and decreasing heating demand do not affect the modelled fireplaces. Although this is an artefact of the modelling program, it may also reflect reality since many occupants use their fireplaces for ambiance and not only for heat. Since the fireplace consumption remains unchanged, the observed heating savings are lower than Building 15. If we were to look at baseboard heating savings alone, the two buildings may be more comparable.

6 Archetypical Pre-Retrofit Building Models

Following the calibrated modelling and ECM analysis for two case study buildings, one low-rise and one townhouse, information collected from the larger study sample was used to develop two archetypical older building models. These models are intended to represent typical older existing wood-frame townhouses and multi-storey MURB developments that have not yet undergone building enclosure retrofits. This analysis allows the study results to be extrapolated to a wider range of buildings in southwest B.C.

The calibrated models of the four-storey MURB (Building 15, 2000s) and the townhouse (Building 21, retrofitted 1980s) were adjusted to reflect more typical construction practices and materials/equipment installed in the 1970s 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 replace existing equipment. This analysis was performed as these buildings represent a large part of the building stock and are already in need of renewal work.

The analysis of ECMs on these archetypical older building models is presented in this section.

6.1 Archetypical Low-Rise MURB

Low-rise MURBs in the Lower Mainland typically have wood-frame construction similar to that of Building 15, although older buildings have walls with less insulation. Windows have also gone through many iterations of improvements over the past decades. Below is a summary of the changes made to the Building 15 model to make it more representative of low-rise MURBs that were built in the 1970s and have not yet undergone any energy retrofits. Boiler efficiencies were not altered since they are typically replaced every 20 years and therefore would be a similar efficiency to the calibrated building model.

TABLE 6.1 CHANGES TO BUILDING 15 MODEL (2000S TO 1970S)

	Building 15 (2000s)	Archetypical Building (1970s)
Wall	R-16 – 2x6 framing with R-20 batt and insulated balconies	R-7.5 – 2x4 framing with R-11 batt and uninsulated[17] balconies
Window	U-0.35 – Double glazed with vinyl frame	U-1.0 – Single glazed with aluminum frame
Air Infiltration	0.15 cfm/sf at operating pressure	0.20 cfm/sf at operating pressure
MUA Ventilation Rate	2,400 cfm	3,300 cfm

[17] In the 1970s it was uncommon to insulate the outside of the spacers between the beams under the surface of the balcony. Presently, it has become common practice to at least use batt insulation in line with the wall in the cavity within the balcony protrusion. Best practice would be to use spray foam to achieve the added benefit of air sealing.

6.1.1 ECM Bundles

The same ECM bundles as for Section 5.2.2 were modelled on the archetypical low-rise MURB. The savings for the archetypical building are greater than for Building 15 because the baseline was altered to reflect the lower energy performance of an older building type. The archetypical low-rise MURB baseline EUI is 214 kWh/m², compared with 181 kWh/m² for Building 15.

TABLE 6.2 ARCHETYPICAL LOW-RISE MURB – ECM BUNDLES

Description	Total EUI (kWh/m²)	Heating EUI (kWh/m²)	Total Energy Savings (%)	Heating Savings (%)	GHG Savings (%)
Baseline	214	90	—	—	—
Bundle 01 – Better Enclosure → Add R5 to walls and insulate balconies (R16) → Add R10 to attic roof (R30) → Double glazed low-conductivity windows (U-0.28) → Air tightness to 0.10 cfm/ft² (@4 Pa)	189	65	12%	28%	2%
Bundle 02 – Best Enclosure → Add R10 to walls and insulate balconies (R21) → Add R20 to attic roof (R40) → Triple glazed low-conductivity windows (U-0.17) → Air tightness to 0.04 cfm/ft² (@4 Pa) → 85% efficient HRVs in suites	144	7	33%	92%	44%
Bundle 03a – Best Enclosure plus MUA Changes → Bundle 02, plus: → High efficiency MUA (93%) → MUA set point lowered to 17°C	142	6	34%	94%	61%

TABLE 6.2 ARCHETYPICAL LOW-RISE MURB – ECM BUNDLES					
Bundle 03 – Best Enclosure plus Mechanical and Electrical → Bundle 03a, plus: → Low-flow DHW fixtures → High efficiency boiler (93%) → Occupancy sensors → LED lighting	108	7	49%	92%	61%

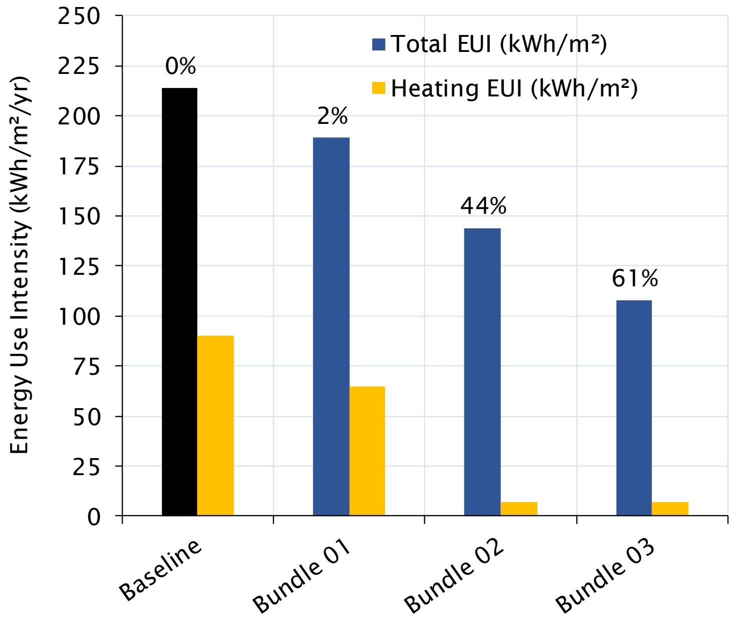


Figure 6.1 The total EUI (black and blue), heating EUI (yellow), and percentage of GHG emission reductions for the archetypical, pre-retrofit 1970s low-rise model and for its three ECM bundles.

As with Section 5.2.2, the energy conservation bundles in Table 6.2 result in extremely low heating EUIs (as low as 6 kWh/m^2/yr). For comparison, the Passive House standard aims for a heating EUI of 15 kWh/m^2/yr or less and the EnerPHit certification for retrofits aims for a heating EUI of 25 kWh/m²/yr.

In reality, occupant behaviour may have a greater effect on heating consumption than was captured here. For example, occupants may still open their windows for fresh air, even with efficient HRV systems. Factors such as this are difficult to predict and may result in 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.

6.2 Archetypical Townhouse

Townhouses in the Lower Mainland typically have wood-frame construction similar to that of Building 21, although older buildings have thinner walls with less insulation. Windows have also gone through many iterations of improvements over the past decades. Building 21 invested in improved windows and upgraded theirs during an enclosure retrofit in 2002. Below is a summary of the changes made to the Building 21 model to make it more representative of low-rise MURBs that were built in the 1970s and have not yet undergone any energy retrofits. Boiler efficiencies were not altered since they are typically replaced every 20 years and therefore would be a similar efficiency to the calibrated building model.

TABLE 6.3 CHANGES TO BUILDING 21 MODEL (1980S TO 1970S)

	Building 21 (1980s)	Archetypical Building (1970s)
Wall	R-11 – 2x4 framing with R-12 batt and insulated balconies	R-7.5 – 2x4 framing with R-11 batt and uninsulated[17] balconies
Window	U-0.40 – Double glazed with vinyl frame	U-1.0 – Single glazed with aluminum frame
Window-to-Wall Ratio	23% – East, west, and north elevations, 0% – South elevation	23% – All elevations

6.2.1 ECM Bundles

The same ECM bundles as for Section 5.3.2 were modelled on the archetypical townhouse. The savings for the archetypical building are greater than for Building 21, because the baseline was altered to reflect the lower energy performance of an older building type. The typical townhouse baseline EUI is 316 kWh/m²/yr, compared with 277 kWh/m²/yr for Building 21.

TABLE 6.4 ARCHETYPICAL TOWNHOUSE – ECM BUNDLES

Description	Total EUI (kWh/m²)	Heating EUI (kWh/m²)	Total Energy Savings (%)	Heating Savings (%)	GHG Savings (%)
Baseline	316	166	—	—	—
Bundle 01 – Better Enclosure → Add R5 to walls and insulate balconies (R16) → Add R10 to flat roof (R21) → Double glazed low-conductivity windows (U-0.28) → Air tightness to 0.10 cfm/ft² (@4 Pa)	243	95	23%	43%	8%

TABLE 6.4 ARCHETYPICAL TOWNHOUSE – ECM BUNDLES					
Bundle 02 – Best Enclosure → Add R10 to walls and insulate balconies (R21) → Add R20 to flat roof (R40) → Triple glazed low-conductivity windows (U-0.17) → Air tightness to 0.04 cfm/ft² (@4 Pa) → 85% efficient HRVs in suites	189	32	40%	81%	13%
Bundle 03 – Best Enclosure plus Mechanical and Electrical → Bundle 02, plus: → Low-flow in-suite fixtures → High efficiency boiler (93%) → Occupancy sensors → LED lighting	164	33	48%	80%	35%

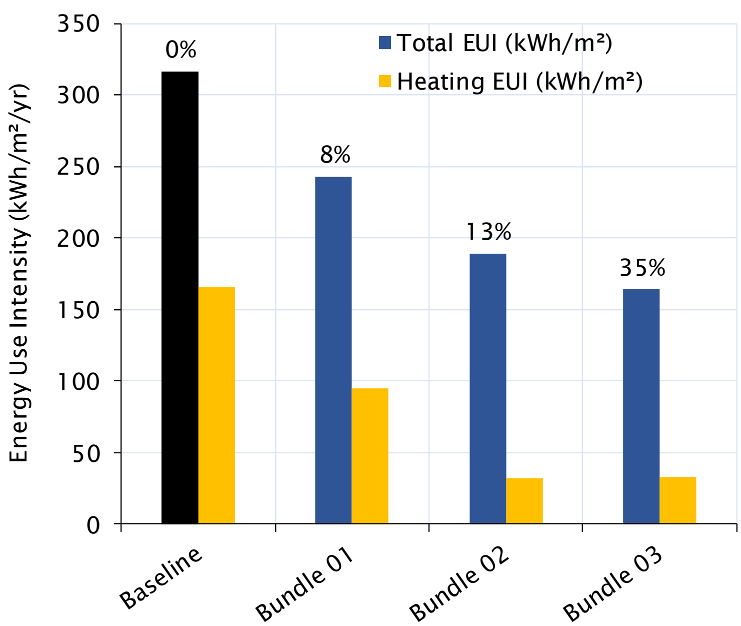


Figure 6.2 The total EUI (black and blue), heating EUI (yellow), and percentage of GHG emission reductions for the archetypical, pre-retrofit 1970s townhouse model and for its three ECM bundles.

Compared with 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 the Lower Mainland. The following section elaborates on best practices and regional benefits.

7 Conclusions

This study aimed to address the following objectives:

→ Benchmark and characterize end-use energy consumption of low- to mid-rise wood-frame MURBs in the Lower Mainland of B.C. Building types include townhouse developments and three-to six-storey wood-frame MURBs constructed from the 1970s through to the present.

→ Compare the energy characterization of low- to mid-rise wood-frame MURBs to mid- to high-rise non-combustible MURBs (from a previous RDH study) and identify similarities, differences, and trends.

→ Identify opportunities for low-rise MURBs to improve energy efficiency, such as building enclosure, HVAC systems, equipment, and operations, and to reduce energy use and GHG emissions in both new and existing MURBs.

Key conclusions drawn from this research are outlined below.

7.1 Benchmarking

Energy consumption was documented for 23 MURBs in southwest B.C. These included MURBS as small as 14 residential units, to a maximum of 267 units. Construction dates varied from 1974 to 2012. Many have electric baseboards as their primary space heating source, and only two (1970s era buildings) have gas hydronic heating.

The median energy consumption 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, with a maximum of 279 kWh/m^2/yr. The lowest consuming building is 95 kWh/m^2/yr, constructed in 1991 with 14 residential units.

Energy consumption per suite varied from 8,660 to 31,741 kWh per year, for all electricity and natural gas. The median was 15,847 kWh and average was 18,494 kWh.

The trend is toward reduced energy demand per unit floor area for newer constructed buildings, both in terms of space heating and total energy demand. The trend shows a slight reduction in total energy consumption from 1974 to 2012.

MURBs with window-to-wall ratios of between 12% and 43% were studied. There is little correlation between these ratios and total energy demand per unit floor area.

7.2 Comparison with High-Rise MURBs

Table 7.1 highlights similarities and differences between mid- to high-rise and low-rise MURBs.

TABLE 7.1 COMPARISON OF LOW- AND HIGH-RISE STUDY RESULTS

Variable	Low-Rise	Mid-to-High-Rise
Median EUI	160 kWh/m^2/yr	217 kWh/m^2/yr
Average EUI	171 kWh/m^2/yr	213 kWh/m^2/yr
Maximum EUI	279 kWh/m^2/yr	299 kWh/m^2/yr
Minimum EUI	95 kWh/m^2/yr	144 kWh/m^2/yr

Average Energy	18,500 kWh/suite/yr	21,900 kWh/suite/yr
Median Energy	15,800 kWh/suite/yr	21,300 kWh/suite/yr
Average Window-to-Wall Ratio	26% glazing	47% glazing
Average Space Heating % (including fireplaces)	45% space heating	37% space heating
GHG Intensity (Median)	15 kg CO_2/m^2	21 kg CO_2/m^2
GHG Intensity (Average)	17 kg CO_2/m^2	21 kg CO_2/m^2

The table illustrates the key difference between low-rise and high-rise MURBs. Energy consumption per suite is 18% higher for high-rises on average, or 35% higher compared to the median.

The primary reasons for higher consumption in high-rises may include:

→ More buildings with heated make-up air

→ Higher window-to-wall ratios

→ Reduced thermal performance of building enclosure

7.3 Energy and GHG Reduction Opportunities

A number of ECMs and emission reduction opportunities were explored for two case study buildings – 17 ECMs for a four-storey wood frame building, and 18 ECMs for a townhouse complex. Energy savings varied from marginal to 13% for individual ECMs.

The two buildings that were chosen for calibrated energy modelling were modified to reflect archetypical older MURBs with no previous upgrades. The bundled energy savings are outlined in the table below. Detailed descriptions of the archetype pre-retrofit buildings and the ECM bundles can be found in Section 6.

TABLE 7.2 SUMMARY OF ECM BUNDLE ENERGY SAVINGS FOR ARCHETYPICAL MURBS

ECM Bundle	**Four-Storey MURB (archetypical)** **EUI, kWh/m²** **(% reduction from total)**	**Townhouse (archetypical)** **EUI, kWh/m²** **(% reduction from total)**
Baseline	214	316
Bundle 01 – Better Enclosure	189 (12%)	243 (23%)
Bundle 02 – Best Enclosure	144 (33%)	189 (40%)
Bundle 03a – Best Enclosure plus MUA Changes	142 (34%)	n/a
Bundle 03 – Best Enclosure plus Mechanical, DHW, and Lighting	108 (49%)	164 (48%)

The ECM Bundle 03, Best Enclosure plus Mechanical, DHW, and Lighting, has the greatest total energy savings for both the archetypical four-storey MURB and the achetypical townhouse, 49% and 48%, respectively. For the four-storey MURB, only a moderate increase in savings is seen in Bundle 03a by adding mechanical (MUA) measures alone to Bundle 02

- Best Enclosure, as the MUA outdoor flow rate was already diminished by adding in-suite HRVs in Bundle 02. The Bundle 03a analysis was omitted for the archetypical townhouse because the townhouse has no MUA unit. Energy savings from the townhouse archetype can be interpreted as representative of low-rise MURBs that do not have MUA ventilation.

Adding DHW and lighting ECMs in Bundle 03 brings both building archetypes to their maximum energy savings from undergoing an energy retrofit in the Lower Mainland: 48–49% total building energy savings. This type of energy retrofit also results in 80–92% 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 may be implemented in renovation retrofit codes by provincial and municipal governments.

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 61%. These energy upgrades to existing buildings, coupled with near net-zero emission new construction, can help to achieve near-decarbonisation of buildings in B.C. by 2050.

Appendix A

Literature Review

In addition to RDH's previous work on energy consumption and conservation in mid- and high-rise MURBs, the following benchmarking studies were reviewed.

New York City Local Law 84 Benchmarking Report (PlaNYC, 2012)

New York City (NYC) has been collecting benchmarking data since 2009 as part of Local Law 84[18]. This law requires all privately-owned properties with individual buildings that are over 50,000 ft², as well as multiple buildings with a combined floor area of over 100,000 ft² measure and report their energy and water use on an annual basis. This report analyzes the first two years of benchmarking data recorded under this law.

The data was categorized and separated into multifamily residential, office, retail, hotels and education buildings. Multifamily buildings include low- to high-rise buildings. The data showed that multifamily residential buildings made up the majority of area at 63%. Overall energy consumption from multifamily buildings was slightly less than 50% of total energy consumption. The data set was comprised of 6,000 multifamily buildings.

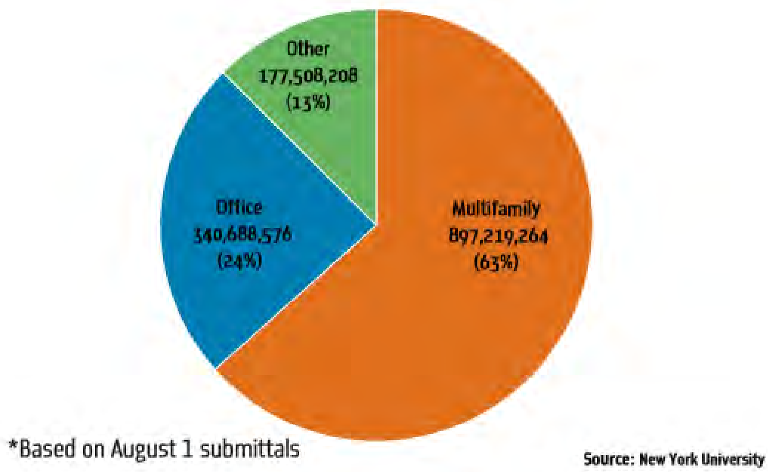


Figure 7.1 Square footage (ft²) by sector of NYC Benchmarked properties (PlaNYC, 2012).

The following results are pertinent to this study:

→ Multifamily buildings are responsible for 20% of GHG emissions from large buildings in New York City.

→ The mean site EUI for the multifamily buildings in their data set is 132.2 Btu/ft^2 (417 kWh/m^2).

→ The age of multifamily buildings is negatively correlated with EUI, meaning newer buildings tend to have lower EUIs.

→ The size of building is negatively correlated with EUI, meaning larger buildings tend to have lower EUIs.

→ If all inefficient large buildings in NYC were brought up to the mean EUI in their respective category, overall energy consumption for the city's building stock would be reduced by approximately 18%.

[18] http://www.nyc.gov/html/gbee/downloads/pdf/nyc_ll84_benchmarking_report_2012.pdf

Although this report provides average EUIs for MURBs, comparison to this study is limited due to the inclusion of both low- and high-rise building types, and the different climate zone.

Seattle Building Energy Benchmarking Analysis Report 2013 (Seattle Office of Sustainability and Environment)

This report focuses on the analysis of the benchmarking data collected in accordance with the City of Seattle's building energy benchmarking disclosure policy[19]. The policy requires that all multifamily and non-residential buildings with a gross floor area of 20,000 ft² or greater must benchmark their energy consumption and report it annually.

In 2013, the City of Seattle had a 99% compliance rate resulting in energy data for 1,451 multifamily buildings. Low- and mid-rise buildings made up 94% of the multifamily buildings benchmarked.

	2013 Annual Energy Use Intensity (Site EUI in kBtu/sf)								
Type of Building	Median	Lowest Use (1st Quartile)	Medium-Low (2nd Quartile)	Medium-High (3rd Quartile)	Highest Use (4th Quartile)	Number of Buildings	Year Built (median)	Size (median sf)	EPA ENERGY STAR (median)[1]
Low -Rise Multifamily[2]	30.3	≤24	25-30	31-38	≥39	918	1987	29,652	77*
Mid-Rise Multifamily[2]	34.3	≤27	28-34	35-45	≥46	445	1995	52,020	85*
High-Rise Multifamily[2]	49.0	≤42	43-49	50-63	≥64	88	1980	139,684	47*

Figure 7.2 Energy performance ranges for Seattle buildings by building type (Seattle Office of Sustainability and Environment, 2013).

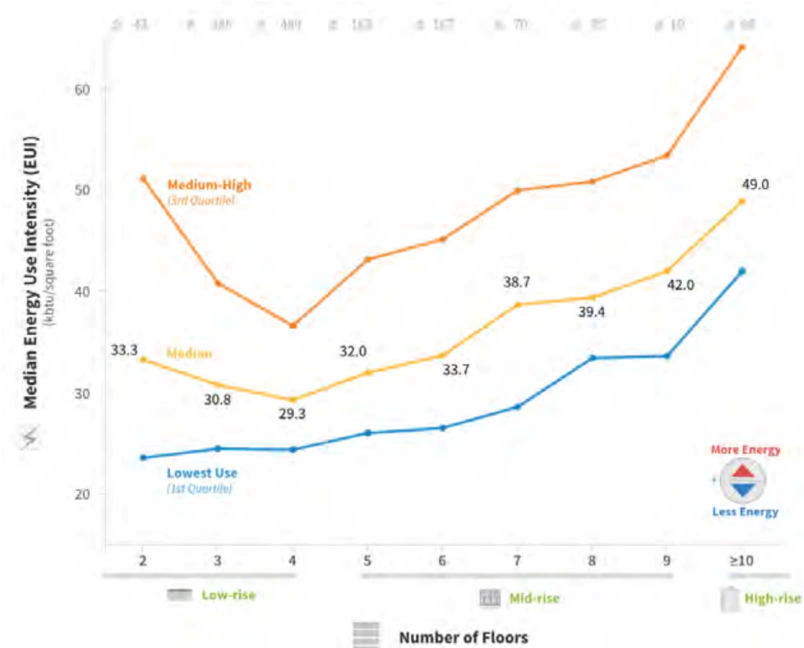


Figure 7.3 Site EUI by number of floors for multifamily housing (Seattle Office of Sustainability and Environment, 2013).

[19] http://www.seattle.gov/Documents/Departments/OSE/EBR-2013-report.pdf

The following results are pertinent to this study:

- → The median EUI increased as the building height increased.
- → Low-rise buildings had the lowest EUI.
- → If all buildings in Seattle with EUIs higher than the median reduced their energy use intensity to the median value, the building stock's total annual energy use would decrease by 1,014 MWh. Multifamily and office buildings would account for 43% of savings.
- → Buildings constructed between 1887 and 1945 had the highest EUIs.

The EUIs reported in this study may be of value due to the separation of low- and high-rise buildings, and the similar climate.

Residential Buildings Stock Assessment: Multifamily Characteristics and Energy Use (David Baylon, et. al., 2013)

Ecotope, with support and assistance from the Northwest Energy Efficiency Alliance (NEEA), prepared this report as part of a series summarizing the results of the Residential Building Stock Assessment[20]. The study included investor-owned buildings from Washington, Oregon, Idaho, and western Montana. The data set is comprised of 230 multifamily buildings, with 91% of these buildings low- to mid-rise buildings. More than 97% of buildings in the data set are wood-framed construction.

The buildings' fuel types were analysed, with the results showing that 87% of primary heat is electric, and the remaining 13% of primary heat is natural gas.

The following results are pertinent to this study:

- → The average EUI for multifamily buildings in this data set is 10 kWh/ft^2 (108 kWh/m^2)
- → The mean EUI for low-rise multifamily units in the data set is 11 kWh/ft^2 (118 kWh/m^2). The mean EUI for mid-rise multifamily units is 7.5 kWh/ft^2 (80.7 kWh/m^2)
- → Energy use intensity decreases as the building size increases

The EUIs reported in this study may be of value, because the study comprised primarily low-rise MURBs. However, the EUIs are generally lower than findings from RDH's findings for both low- and high-rise buildings. It is not known whether all energy end uses were counted for buildings in this study.

20 http://neea.org/

Appendix B
Summary of Model Inputs

Summary of Energy Model Inputs

Energy modelling inputs were taken from architectural, electrical, and mechanical drawings of each building in addition to prior site visits by RDH. Where building-specific information could not be found, standard values from ASHRAE 90.1-2010, the 2011 National Energy Code of Canada for Buildings (NECB), or other previous research were used, as noted in the following tables. These values were adjusted as appropriate during the calibration process.

B.1 Building 15: Four-Storey MURB

TABLE B.3 ENERGY MODEL INPUTS FOR BUILDING 15			
	Units	**Value**	**Notes and References**
Building Geometry			
Total Conditioned Area	m^2 (sf)	4,800 (52,000)	Modelled architectural drawings
Number of Suites	-	60	
Site			
Location	-	Vancouver, BC	Metered data was weather normalized to a standard year for comparison to model year
Orientation	Degrees	45˚	
Internal Space Use			
Occupant Density	Person/ m^2	0.04	Estimated two occupants per first bedroom, plus one occupant per subsequent bedroom for each suite
Occupancy Schedule	-	ASHRAE 90.1 residential occupancy schedule.	
DHW Consumption Rate	L/m^2-day	2.5	ASHRAE 90.1 User Manual – Table 7-C (2.19 L/m^2-day), then increased during calibration
Heating Set Point Temperature	˚C	21.8	Varied during calibration
Heating Setback	˚C	18.0	Varied during calibration
Mechanical Ventilation Rate – Corridors	L/s-m^2	2.3	MUA is labeled at 3300 cfm, altered in calibration to 2379 cfm. MUA area corresponds to the corridors and basement lobby.
Lighting Power Density	W/m^2	5.0 – Suites 17.2 – Corridors 8.7 – Lobby/stairs 3.7 – Parkade	From lighting schedule in electrical drawings and calibrated for the suites where current bulb types were not known.

TABLE B.3 ENERGY MODEL INPUTS FOR BUILDING 15			
Lighting Schedule	-	ASHRAE 90.1 residential lighting schedule adapted to account for seasonal variation. Common area lighting on 24/7.	
Exterior Lighting	W	2256	From lighting schedule in electrical drawings
Miscellaneous Electricity	W/m²	4.5	Calibrated for appliances and plug loads
Elevators	kW	14.6	Based on one elevator, BC Hydro New Construction Program energy modelling guidelines
Building Enclosure			
Exterior Walls	hr-sf-˚F/Btu	R-16	ASHRAE 90.1 Table A3.4 effective R-value for 2x6 wood studs with R-20 batt insulation
Attic	hr-sf-˚F/Btu	R-38	ASHRAE 90.1 Table A2.4 for R40 batt insulation
Floor Above Parkade	hr-sf-˚F/Btu	R-15	ASHRAE 90.1 Table A5.2 for reinforced concrete slab with R-12 spray foam
Infiltration Rate	cfm/sf @ 5 Pa	0.15	Near the “mid-high average” value from RDH high-rise study
Window U-Value	Btu/hr-sf-˚F	U-0.35	Assumption for double-glazed, vinyl frame, with argon gas fill, one low-e coating
Window SHGC	-	0.25	Assumption for double-glazed, vinyl frame, with one low-e coating
Window-to-Wall Ratio	%	36	Area takeoffs from architectural drawings
Ventilation			
Make-Up Air Fuel	-	Natural gas	
Make-Up Air Efficiency	%	81%	From site visit, Engineered Air Model DJE-20-0
Supply Fan Total Efficiency	%	70%	
Supply Fan Pressure Rise	Pa	249	From site visit
Supply Fan Motor Efficiency	%	90%	
Make-Up Air Set Point	˚C	20	
Parking Exhaust Fan			
Fan Efficiency	%	60%	
Pressure Rise	Pa	62	From site visit
Maximum flow rate	m^3/s	0.4 – Lockers	

TABLE B.3 ENERGY MODEL INPUTS FOR BUILDING 15			
		7.98 – Parkade	
DHW Loop			
Water Heater Fuel Type	-	Natural gas	
Water Heater Efficiency	%	81%	From site visit, Laars Heating Systems Model VW-0715
Electric Baseboards			
Design Capacity	W/suite	500	Limited electric baseboard capacity during calibration
Efficiency	%	100%	

A.2 Building 21: Townhouse

The energy model of Building 21 utilized a simplified geometry. Building 21 was constructed on a steep hill, thus the townhome floors do not line up with adjacent suites—rather they rise southbound up the hill. As such, the model geometry was simplified for each floor to exist on the same plane. This could have affected the baseline model by underestimating the overall wall U-value, although during the calibration process, the baseline was adjusted to match the metered data, correcting for any inaccuracies.

TABLE A.2 ENERGY MODEL INPUTS FOR BUILDING 21			
	Units	**Value**	**Notes and References**
Building Geometry – from architectural drawings			
Total Conditioned Area	m^2 (sf)	3,500 (37,700)	Modelled area of drawn building geometry
Number of Suites	-	32	
Site			
Location	-	Vancouver, BC	Metered data was weather normalized to a standard year for comparison to model year
Orientation	Degrees	175˚	
Internal Space Use			
Occupant Density	Person/ m^2	0.026	Estimated two occupants per first bedroom, plus one occupant per subsequent bedroom for each suite
Occupancy Schedule	-	ASHRAE 90.1 residential occupancy schedule.	
DHW Consumption Rate	L/m^2-day	2.2	ASHRAE 90.1 User Manual – Table 7-C (1.42 L/m^2-day), then increased during calibration
Heating Set Point Temperature	˚C	23.0	Varied during calibration
Heating Setback	˚C	19.0	Varied during calibration

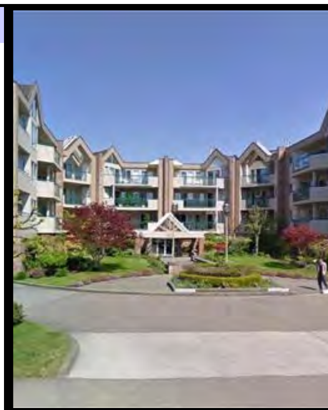
TABLE A.2 ENERGY MODEL INPUTS FOR BUILDING 21			
Mechanical ventilation - Corridors	L/s-m²	-	No MUA, except spa amenities room 1.6 L/s-m²
Lighting Power Density	W/m²	7.0 – suites 2.5 – parkade	Estimated, no lighting schedule in electrical drawings
Lighting Schedule	-	ASHRAE 90.1 residential lighting schedule adapted to account for seasonal variation. Common area lighting on 24/7.	
Exterior Lighting	W	4440	Estimated lighting type to be 60 W for 42 fixtures in walkways, plus 32 fixtures at suite doors
Miscellaneous Electricity	W/m²	7.0	Calibrated
Elevators	kW	14.6	Based on one elevator, BC Hydro New Construction Program energy modelling guidelines
Gas Fireplaces	W/m²	7.5	Calibrated
Sauna	kW	15	Calibrated
Building Enclosure			
Exterior Walls	hr-sf-˚F/Btu	R-11	ASHRAE 90.1 Table A3.4 effective R-value for 2 x 4 wood studs with R-12 batt insulation
Flat Roof	hr-sf-˚F/Btu	R-18	ASHRAE 90.1 Table A2.4 effective R-value for flat roof with R-19 batt insulation
Parkade Ceiling	hr-sf-˚F/Btu	R-11	Estimation for concrete ceiling with fibreglass insulation
Infiltration Rate	cfm/sf @ 5 Pa	0.20	Near the "high" value from RDH high-rise study
Glazing U-Value	Btu/hr-sf-˚F	U-0.40	Assumption for double-glazed vinyl (2002)
Glazing SHGC		0.25	Assumption for double-glazed vinyl (2002)
Window-to-Wall Ratio	%	23% - E, N, W 0% - S	Area takeoffs from architectural drawings
Ventilation – Spa Zone			
AHU Heating Coil Fuel	-	Electric	Assumptions; no information available
AHU Heating Coil Efficiency	%	100%	
Supply Fan Total efficiency	%	70%	
Supply Fan Pressure Rise	Pa	600	

TABLE A.2 ENERGY MODEL INPUTS FOR BUILDING 21			
Supply Fan Motor Efficiency	%	90%	
Set Point Temperature	˚C	21	
Parking Exhaust Fan			
Fan Efficiency	%	60%	
Pressure Rise	Pa	62	
Maximum Flow rRate	m^3/s	7.98	
Availability Schedule	-	Parkade exhaust fans	Different steps for low and peak times of parkade use
DHW Loop			
Water Heater Fuel Type	-	Natural gas	
Water Heater Efficiency	%	80%	Bradford White model D80T2503N
Electric Baseboards			
Design Capacity	W/suite	Autosized	
Efficiency	%	100%	

Appendix C

Study Buildings Energy Data

Building Description:



Building 01

Date of Construction	→	1989		
Number of Suites	→	78		
Number of Floors	→	4		
Gross Floor Area	→	10,958	m^2	(121,818 sqft)
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	43%		

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	2,318,724	kWh		% Total Energy is Space Heat	→	36%
Total Energy/Suite	→	29,727	kWh		% of Space Heat Energy is Gas	→	83%
Total Energy/Floor Area	→	212	kWh/m^2		% of Space Heat Energy is Elec	→	17%

Gas - Annual Average

Total	→	1,606,080	kWh	(5,782 GJ)	% of Total Gas Used for Space Heat	→	59%
Total Consumption/Suite	→	20,591	kWh	(74 GJ)			
Total Gas Used for Space Heat	→	940,682	kWh	(3,386 GJ)			

Electricity - Annual Average

Total	→	712,643	kWh		Total Suite Elec used for Space Heat	→	198,979	kWh
Total Suite Consumption	→	540,911	kWh	(76%)	Suite Elec for Suite Heat/Suite	→	2,551	kWh
Total Common Consumption	→	171,732	kWh	(24%)	% of Total Elec used for Suite Heat	→	28%	
Total Consumption/Suite	→	9,136	kWh		% of Suite Elec used for Heat	→	37%	
Total Suite Consumption/Suite	→	6,935	kWh					
Total Common Consumption/Suite	→	2,202	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$65,675	Total Space Heat Energy	→	$44,043
Total Gas	→	$6,597	Total Gas Space Heat Energy	→	$21,829
Total Electricity	→	$59,078	Total Elec Space Heat Energy	→	$22,214

Per Suite - Annual Average

Total Energy/Suite	→	$842	Gas Used for Heat Energy/Suite	→	$50
Total Heat Energy/Suite	→	$261	Elec Used for Heat Energy/Suite	→	$211

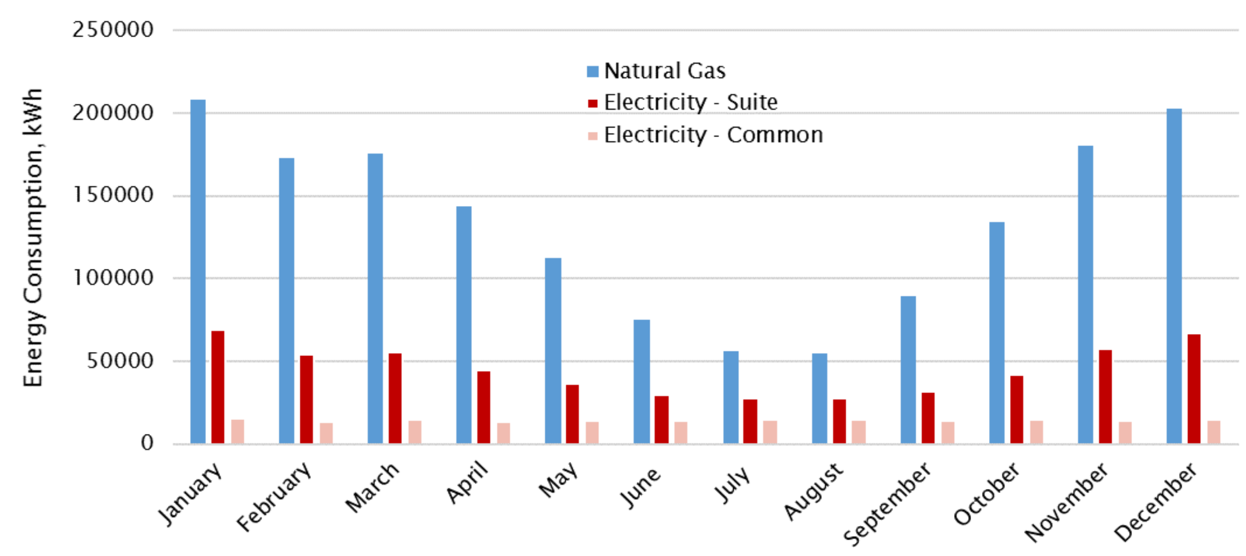
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

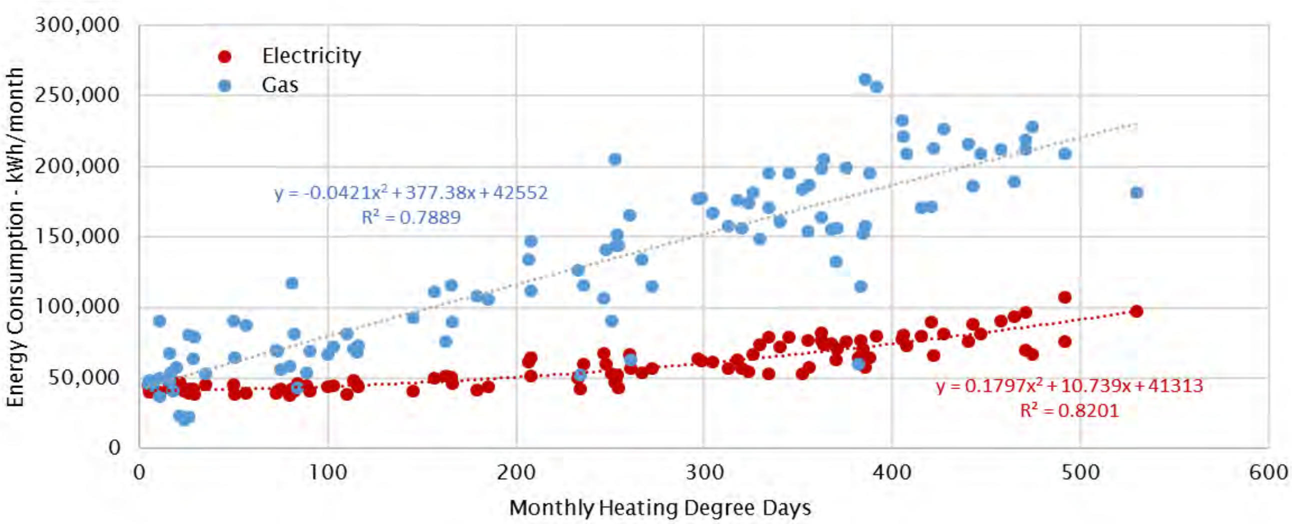
Building - Annual Average

Total CO_2	→	296	tons	Total CO_2/Suite	→	3.8	tons
Gas CO_2	→	288	tons	Gas CO_2/Suite	→	3.7	tons
Electricity CO_2	→	8	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.03	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Date of Construction	→	1989		
Number of Suites	→	51		
Number of Floors	→	3		
Gross Floor Area	→	8,315	m^2	(89,502 sqft)
Building Height	→	8	m	(27 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	25%		

Building 02

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	1,365,251	kWh		% Total Energy is Space Heat	→	52%	
Total Energy/Suite	→	26,770	kWh		% of Space Heat Energy is Gas	→	62%	
Total Energy/Floor Area	→	164	kWh/m^2		% of Space Heat Energy is Elec	→	38%	

Gas - Annual Average

Total	→	513,320	kWh	(1,848 GJ)	% of Total Gas Used for Space Heat	→	85%	
Total Consumption/Suite	→	10,065	kWh	(36 GJ)				
Total Gas Used for Space Heat	→	435,625	kWh	(1,568 GJ)				

Electricity - Annual Average

Total	→	851,931	kWh		Total Suite Elec used for Space Heat	→	272,742	kWh
Total Suite Consumption	→	687,821	kWh	(81%)	Suite Elec for Suite Heat/Suite	→	5,348	kWh
Total Common Consumption	→	164,110	kWh	(19%)	% of Total Elec used for Suite Heat	→	32%	
Total Consumption/Suite	→	16,705	kWh		% of Suite Elec used for Heat	→	40%	
Total Suite Consumption/Suite	→	13,487	kWh					
Total Common Consumption/Suite	→	3,218	kWh					

Energy Costs:

Gas: \$1.141/GJ Electricity: \$0.0829/kWh

Building - Annual Average

Total Energy	→	\$72,734	Total Space Heat Energy	→	\$24,400
Total Gas	→	\$2,109	Total Gas Space Heat Energy	→	\$1,789
Total Electricity	→	\$70,625	Total Elec Space Heat Energy	→	\$22,610

Per Suite - Annual Average

Total Energy/Suite	→	\$1,426	Gas Used for Heat Energy/Suite	→	\$35
Total Heat Energy/Suite	→	\$478	Elec Used for Heat Energy/Suite	→	\$443

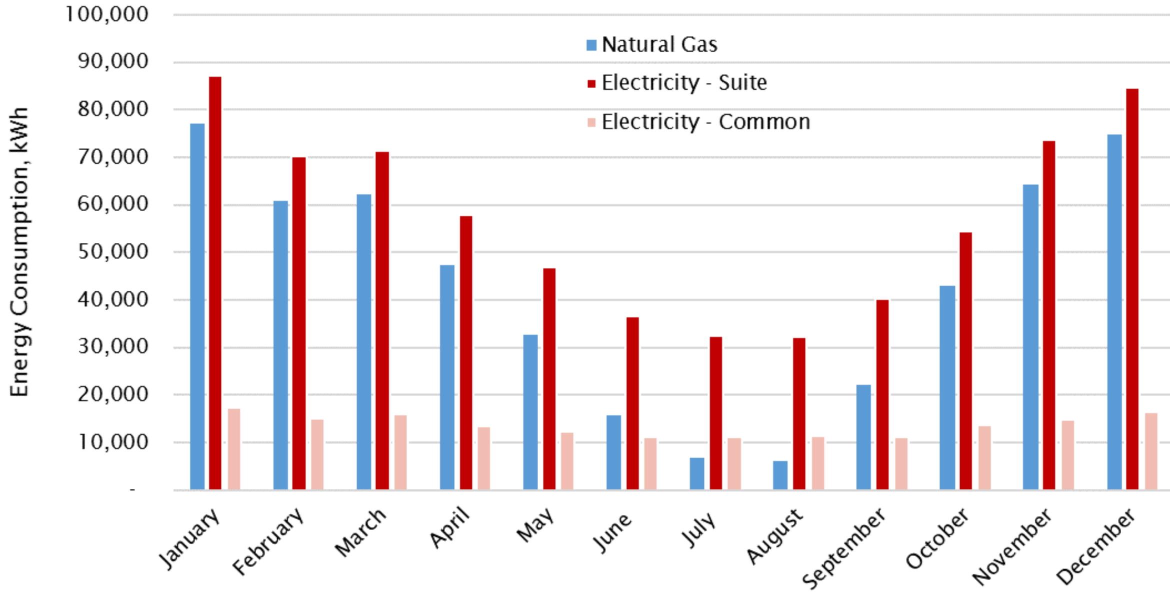
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

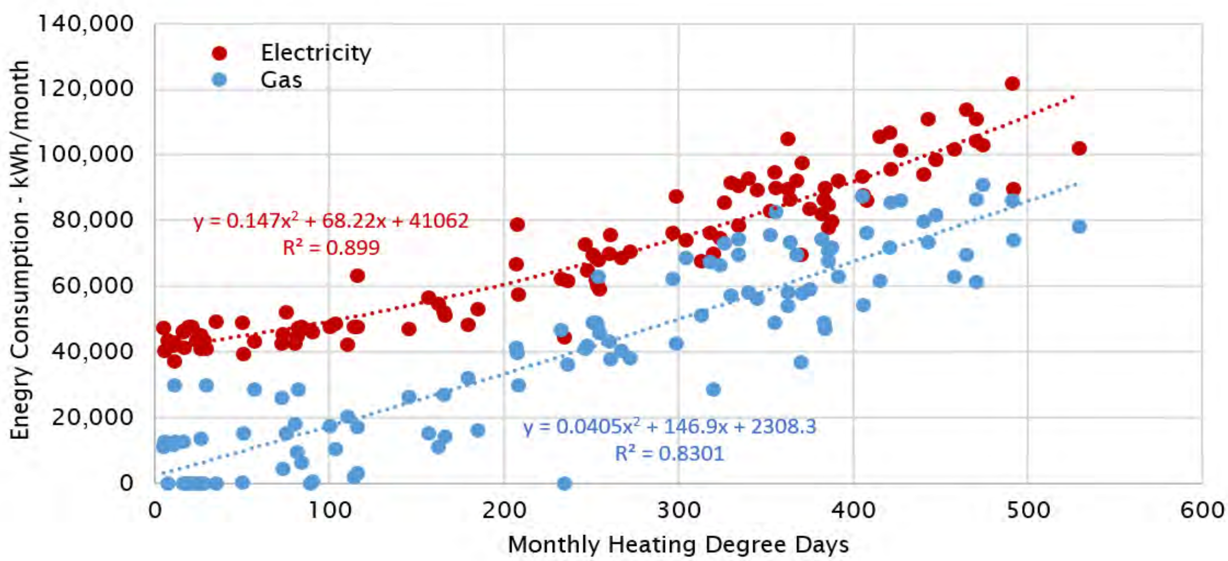
Building - Annual Average

Total CO_2	→	101	tons	Total CO_2/Suite	→	2.0	tons
Gas CO_2	→	92	tons	Gas CO_2/Suite	→	1.8	tons
Electricity CO_2	→	9	tons	Electricity CO_2/Suite	→	0.2	tons
Total CO_2/Floor Area	→	0.01	tons/m^2				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Building 03

Date of Construction	→	1974		
Number of Suites	→	33		
Number of Floors	→	3		
Gross Floor Area	→	2,170	m^2	(23,358 sqft)
Building Height	→	8	m	(27 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	16%		

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	660,354	kWh		% Total Energy is Space Heat	→	51%
Total Energy/Suite	→	20,011	kWh		% of Space Heat Energy is Gas	→	98%
Total Energy/Floor Area	→	244	kWh/m^2		% of Space Heat Energy is Elec	→	2%

Gas - Annual Average

Total	→	530,393	kWh	(1,909 GJ)	% of Total Gas Used for Space Heat	→	63%
Total Consumption/Suite	→	16,073	kWh	(58 GJ)			
Total Gas Used for Space Heat	→	331,911	kWh	(1,195GJ)			

Electricity - Annual Average

Total	→	1,129,961	kWh		Total Suite Elec used for Space Heat	→	274,544	kWh
Total Suite Consumption	→	834,202	kWh	(74%)	Suite Elec for Suite Heat/Suite	→	8,320	kWh
Total Common Consumption	→	287,867	kWh	(25%)	% of Total Elec used for Suite Heat	→	24%	
Total Consumption/Suite	→	6,719	kWh		% of Suite Elec used for Heat	→	33%	
Total Suite Consumption/Suite	→	25,279	kWh					
Total Common Consumption/Suite	→	8,723	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$95,852	Total Space Heat Energy	→	$24,123
Total Gas	→	$2,179	Total Gas Space Heat Energy	→	$1,363
Total Electricity	→	$93,674	Total Elec Space Heat Energy	→	$22,760

Per Suite - Annual Average

Total Energy/Suite	→	$623	Gas Used for Heat Energy/Suite	→	$41
Total Heat Energy/Suite	→	$731	Elec Used for Heat Energy/Suite	→	$690

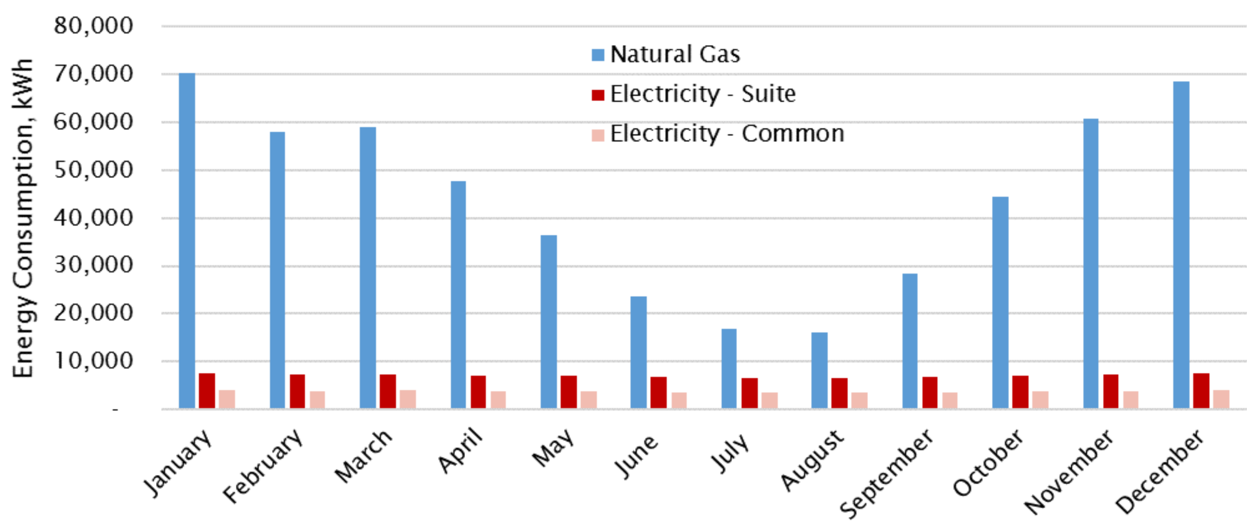
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

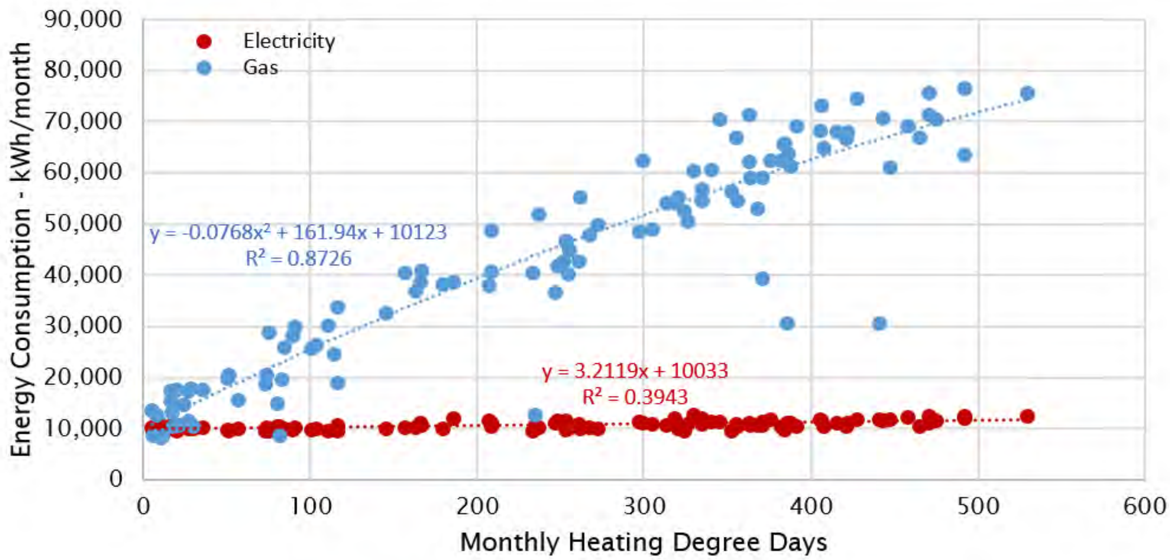
Building - Annual Average

Total CO_2	→	107	tons	Total CO_2/Suite	→	3.3	tons
Gas CO_2	→	95	tons	Gas CO_2/Suite	→	2.9	tons
Electricity CO_2	→	12	tons	Electricity CO_2/Suite	→	0.4	tons
Total CO_2/Floor Area	→	0.05	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Building 04

Date of Construction	→	1995		
Number of Suites	→	167		
Number of Floors	→	4		
Gross Floor Area	→	15,786	m^2	(196,919 sqft)
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	31%		

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	2,427,379	kWh		% Total Energy is Space Heat	→	56%	
Total Energy/Suite	→	20,011	kWh		% of Space Heat Energy is Gas	→	80%	
Total Energy/Floor Area	→	244	kWh/m^2		% of Space Heat Energy is Elec	→	20%	

Gas - Annual Average

Total	→	1,305,310	kWh	(4,699GJ)	% of Total Gas Used for Space Heat	→	82%	
Total Consumption/Suite	→	7,816	kWh	(28 GJ)				
Total Gas Used for Space Heat	→	1,075,629	kWh	(3,872 GJ)				

Electricity - Annual Average

Total	→	1,122,069	kWh		Total Suite Elec used for Space Heat	→	5,407	kWh
Total Suite Consumption	→	834,202	kWh	(74%)	Suite Elec for Suite Heat/Suite	→	32	kWh
Total Common Consumption	→	287,867	kWh	(26%)	% of Total Elec used for Suite Heat	→	0%	
Total Consumption/Suite	→	6,719	kWh		% of Suite Elec used for Heat	→	1%	
Total Suite Consumption/Suite	→	4,995	kWh					
Total Common Consumption/Suite	→	1,724	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$98,381	Total Space Heat Energy	→	$4,866
Total Gas	→	$5,362	Total Gas Space Heat Energy	→	$4,418
Total Electricity	→	$93,020	Total Elec Space Heat Energy	→	$448

Per Suite - Annual Average

Total Energy/Suite	→	$589	Gas Used for Heat Energy/Suite	→	$26
Total Heat Energy/Suite	→	$29	Elec Used for Heat Energy/Suite	→	$3

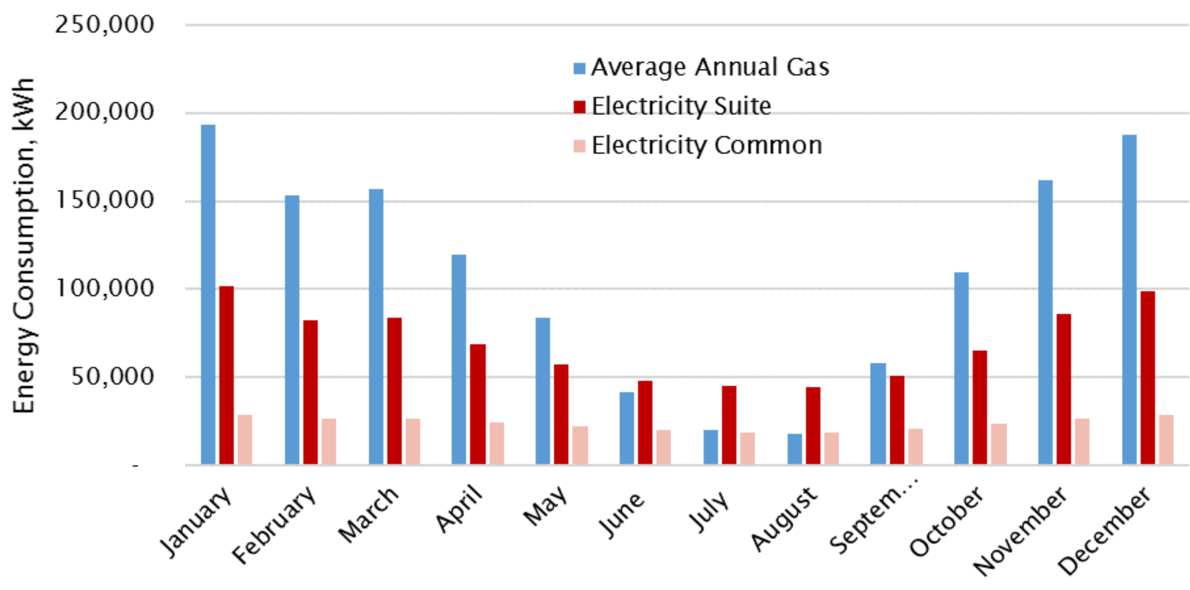
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

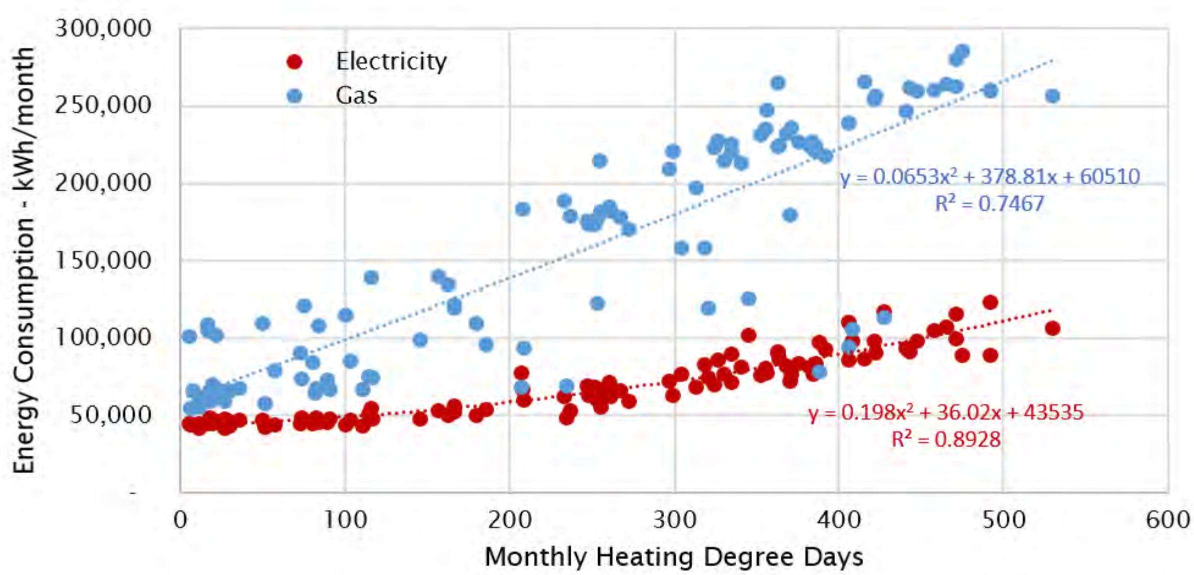
Building - Annual Average

Total CO_2	→	246	tons	Total CO_2/Suite	→	1.5	tons
Gas CO_2	→	234	tons	Gas CO_2/Suite	→	1.4	tons
Electricity CO_2	→	12	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.02	tons/m^2				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Date of Construction	→	1979		
Number of Suites	→	40		
Number of Floors	→	4		
Gross Floor Area	→	3,992	m^2	(42,970 sqft)
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	13%		

Building 05

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	646,760	kWh	% Total Energy is Space Heat	→	45%	
Total Energy/Suite	→	16,169	kWh	% of Space Heat Energy is Gas	→	98%	
Total Energy/Floor Area	→	162	kWh/m^2	% of Space Heat Energy is Elec	→	2%	

Gas - Annual Average

Total	→	494,504	kWh	(1,780 GJ)	% of Total Gas Used for Space Heat	→	58%
Total Consumption/Suite	→	12,363	kWh	((45 GJ)			
Total Gas Used for Space Heat	→	288,401	kWh	(1,038 GJ)			

Electricity - Annual Average

Total	→	152,256	kWh		Total Suite Elec used for Space Heat	→	4,130	kWh
Total Suite Consumption	→	105,824	kWh	(70%)	Suite Elec for Suite Heat/Suite	→	103	kWh
Total Common Consumption	→	46,413	kWh	(30%)	% of Total Elec used for Suite Heat	→	3%	
Total Consumption/Suite	→	3,806	kWh		% of Suite Elec used for Heat	→	4%	
Total Suite Consumption/Suite	→	2,646	kWh					
Total Common Consumption/Suite	→	1,160	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$14,653	Total Space Heat Energy	→	$1,527
Total Gas	→	$2,031	Total Gas Space Heat Energy	→	$1,185
Total Electricity	→	$12,622	Total Elec Space Heat Energy	→	$342

Per Suite - Annual Average

Total Energy/Suite	→	$366	Gas Used for Heat Energy/Suite	→	$30
Total Heat Energy/Suite	→	$38	Elec Used for Heat Energy/Suite	→	$9

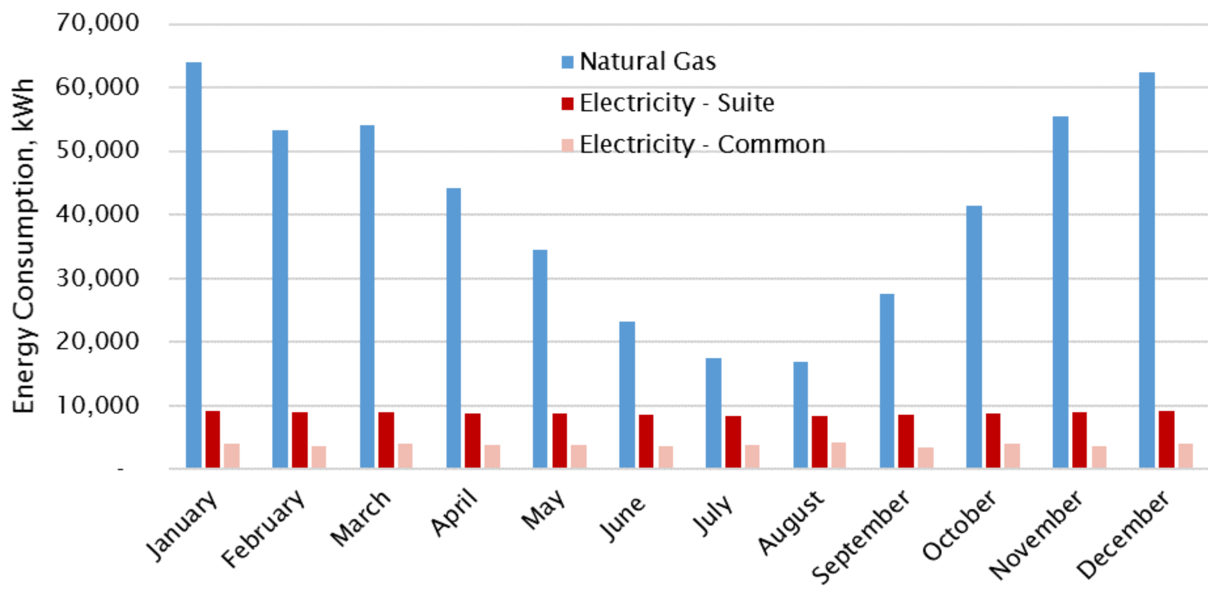
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

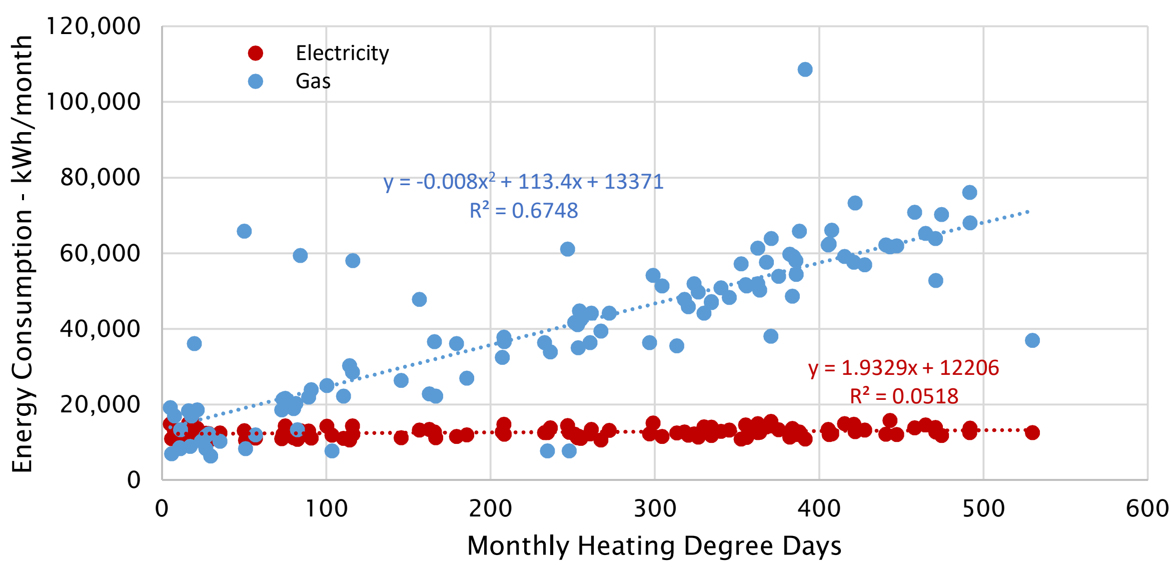
Building - Annual Average

Total CO_2	→	90	tons	Total CO_2/Suite	→	2.3	tons
Gas CO_2	→	89	tons	Gas CO_2/Suite	→	2.2	tons
Electricity CO_2	→	2	tons	Electricity CO_2/Suite	→	0.0	tons
Total CO_2/Floor Area	→	0.02	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Date of Construction	→	1989		
Number of Suites	→	46		
Number of Floors	→	3		
Gross Floor Area	→	3,992	m^2	(42,970 sqft)
Building Height	→	8	m	(27 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	28%		

Building 06

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	1,069,241	kWh	% Total Energy is Space Heat	→	54%
Total Energy/Suite	→	23,244	kWh	% of Space Heat Energy is Gas	→	74%
Total Energy/Floor Area	→	167	kWh/m^2	% of Space Heat Energy is Elec	→	26%

Gas - Annual Average

Total	→	516,352	kWh	(1,859 GJ)	% of Total Gas Used for Space Heat	→	83%
Total Consumption/Suite	→	11,225	kWh	(40 GJ)			
Total Gas Used for Space Heat	→	426,634	kWh	(1,536 GJ)			

Electricity - Annual Average

Total	→	552,889	kWh		Total Suite Elec used for Space Heat	→	150,164	kWh
Total Suite Consumption	→	488,369	kWh	(88%)	Suite Elec for Suite Heat/Suite	→	3,264	kWh
Total Common Consumption	→	64,521	kWh	(12%)	% of Total Elec used for Suite Heat	→	27%	
Total Consumption/Suite	→	12,019	kWh		% of Suite Elec used for Heat	→	31%	
Total Suite Consumption/Suite	→	10,617	kWh					
Total Common Consumption/Suite	→	1,403	kWh					

Energy Costs:

Gas: $1.141/GJ   Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$47,955	Total Space Heat Energy	→	$14,201
Total Gas	→	$2,121	Total Gas Space Heat Energy	→	$1,752
Total Electricity	→	$45,834	Total Elec Space Heat Energy	→	$12,449

Per Suite - Annual Average

Total Energy/Suite	→	$1,042	Gas Used for Heat Energy/Suite	→	$38
Total Heat Energy/Suite	→	$309	Elec Used for Heat Energy/Suite	→	$271

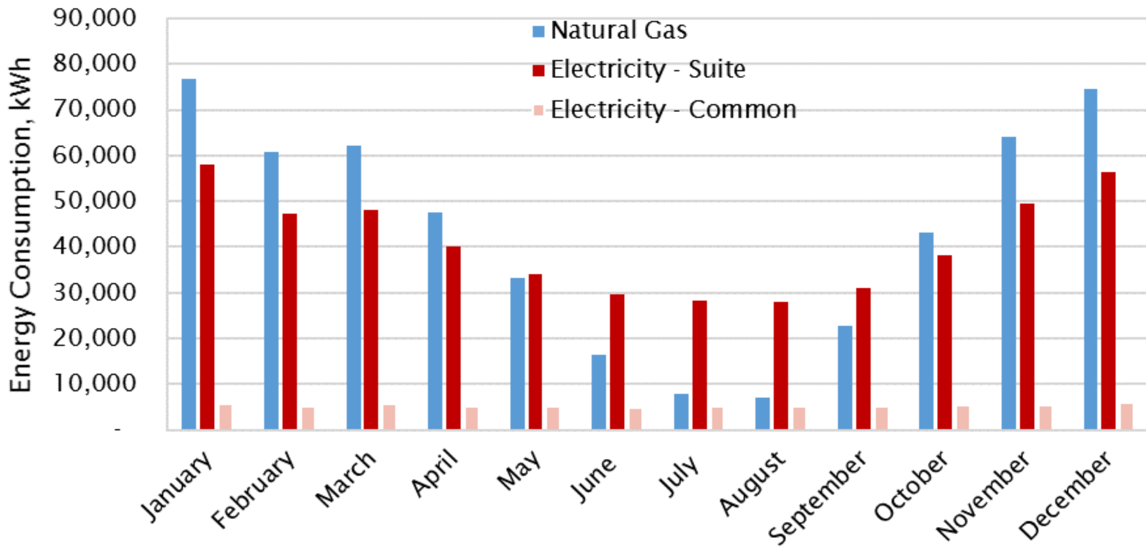
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ   Electricity: 2.964 kg CO2 /GJ

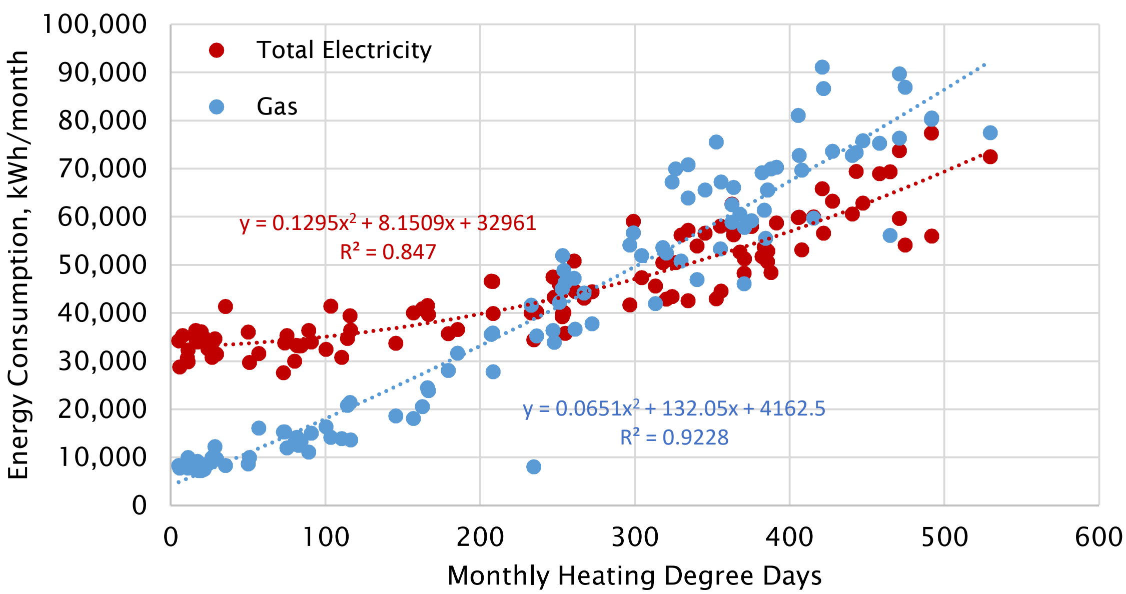
Building - Annual Average

Total CO_2	→	99	tons	Total CO_2/Suite	→	2.1	tons
Gas CO_2	→	93	tons	Gas CO_2/Suite	→	2.0	tons
Electricity CO_2	→	6	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.02	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Date of Construction	→	2010		
Number of Suites	→	267		
Number of Floors	→	4		
Gross Floor Area	→	16,349	m^2	(175,979 sqft)
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	30%		

Building 07

Consumption and Distribution Summary:

Gas and Electric Data From March 2010 to December 2013

Total Energy - Annual Average

Total Energy	→	2,312,190	kWh		% Total Energy is Space Heat	→	22%
Total Energy/Suite	→	8,660	kWh		% of Space Heat Energy is Gas	→	19%
Total Energy/Floor Area	→	141	kWh/m^2		% of Space Heat Energy is Elec	→	81%

Gas - Annual Average

Total	→	164,528	kWh	(592 GJ)	% of Total Gas Used for Space Heat	→	59%
Total Consumption/Suite	→	616	kWh	(2 GJ)			
Total Gas Used for Space Heat	→	96,440	kWh	(347 GJ)			

Electricity - Annual Average

Total	→	2,147,662	kWh		Total Suite Elec used for Space Heat	→	414,765	kWh
Total Suite Consumption	→	1,163,207	kWh	(54%)	Suite Elec for Suite Heat/Suite	→	1,553	kWh
Total Common Consumption	→	984,455	kWh	(46%)	% of Total Elec used for Suite Heat	→	19%	
Total Consumption/Suite	→	8,044	kWh		% of Suite Elec used for Heat	→	36%	
Total Suite Consumption/Suite	→	4,357	kWh					
Total Common Consumption/Suite	→	3,687	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$178,717	Total Space Heat Energy	→	$34,780
Total Gas	→	$676	Total Gas Space Heat Energy	→	$396
Total Electricity	→	$178,041	Total Elec Space Heat Energy	→	$34,384

Per Suite - Annual Average

Total Energy/Suite	→	$669	Gas Used for Heat Energy/Suite	→	$1
Total Heat Energy/Suite	→	$130	Elec Used for Heat Energy/Suite	→	$129

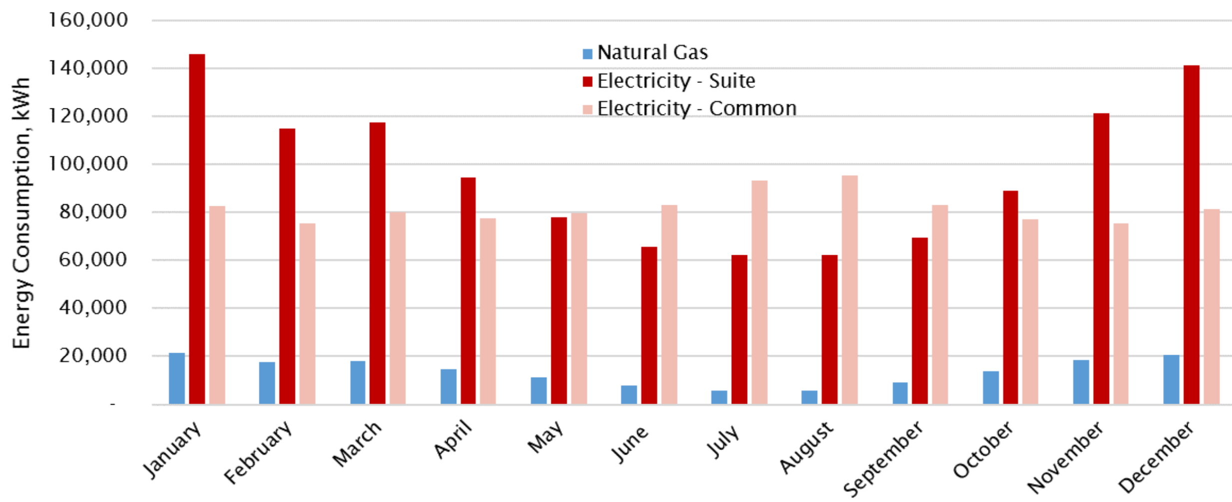
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

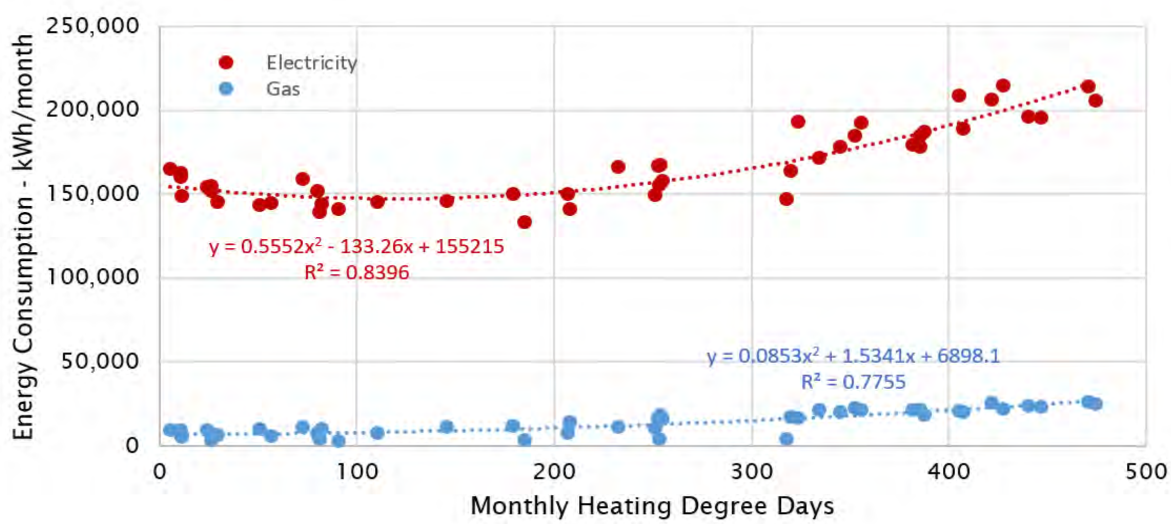
Building - Annual Average

Total CO_2	→	52	tons	Total CO_2/Suite	→	0.2	tons
Gas CO_2	→	30	tons	Gas CO_2/Suite	→	0.1	tons
Electricity CO_2	→	23	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.00	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Building 08

Date of Construction	→	2010		
Number of Suites	→	190		
Number of Floors	→	3		
Gross Floor Area	→	19,069	m^2	(175,979 sqft)
Building Height	→	8	m	(27 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	25%		

Consumption and Distribution Summary:

Gas and Electric Data From April 2010 to December 2013

Total Energy - Annual Average

Total Energy	→	3,767,216	kWh		% Total Energy is Space Heat	→	22%
Total Energy/Suite	→	19,069	kWh		% of Space Heat Energy is Gas	→	46%
Total Energy/Floor Area	→	198	kWh/m^2		% of Space Heat Energy is Elec	→	54%

Gas - Annual Average

Total	→	977,541	kWh	(3,519 GJ)	% of Total Gas Used for Space Heat	→	39%
Total Consumption/Suite	→	5,145	kWh	(18 GJ)			
Total Gas Used for Space Heat	→	383,150	kWh	(1,379 GJ)			

Electricity - Annual Average

Total	→	2,789,675	kWh		Total Suite Elec used for Space Heat	→	453,491	kWh
Total Suite Consumption	→	1,197,207	kWh	(43%)	Suite Elec for Suite Heat/Suite	→	2,387	kWh
Total Common Consumption	→	1,592,469	kWh	(57%)	% of Total Elec used for Suite Heat	→	16%	
Total Consumption/Suite	→	14,683	kWh		% of Suite Elec used for Heat	→	38%	
Total Suite Consumption/Suite	→	6,301	kWh					
Total Common Consumption/Suite	→	8,381	kWh					

Energy Costs:

Gas: \$1.141/GJ Electricity: \$0.0829/kWh

Building - Annual Average

Total Energy	→	\$235,279	Total Space Heat Energy	→	\$39,168
Total Gas	→	\$4,015	Total Gas Space Heat Energy	→	\$1,574
Total Electricity	→	\$231,264	Total Elec Space Heat Energy	→	\$37,594

Per Suite - Annual Average

Total Energy/Suite	→	\$1,238	Gas Used for Heat Energy/Suite	→	\$8
Total Heat Energy/Suite	→	\$206	Elec Used for Heat Energy/Suite	→	\$198

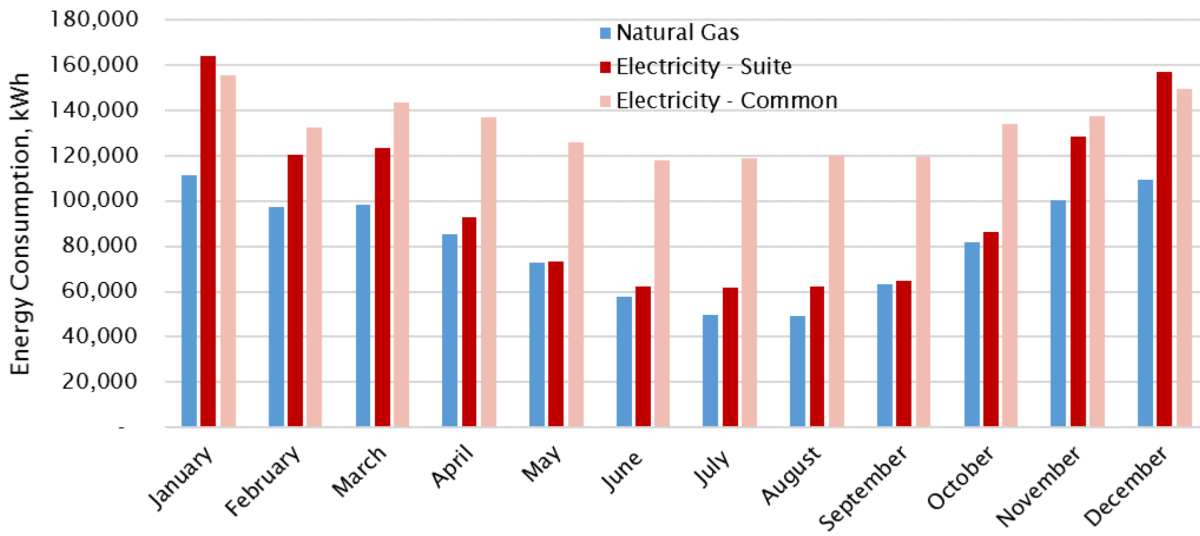
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

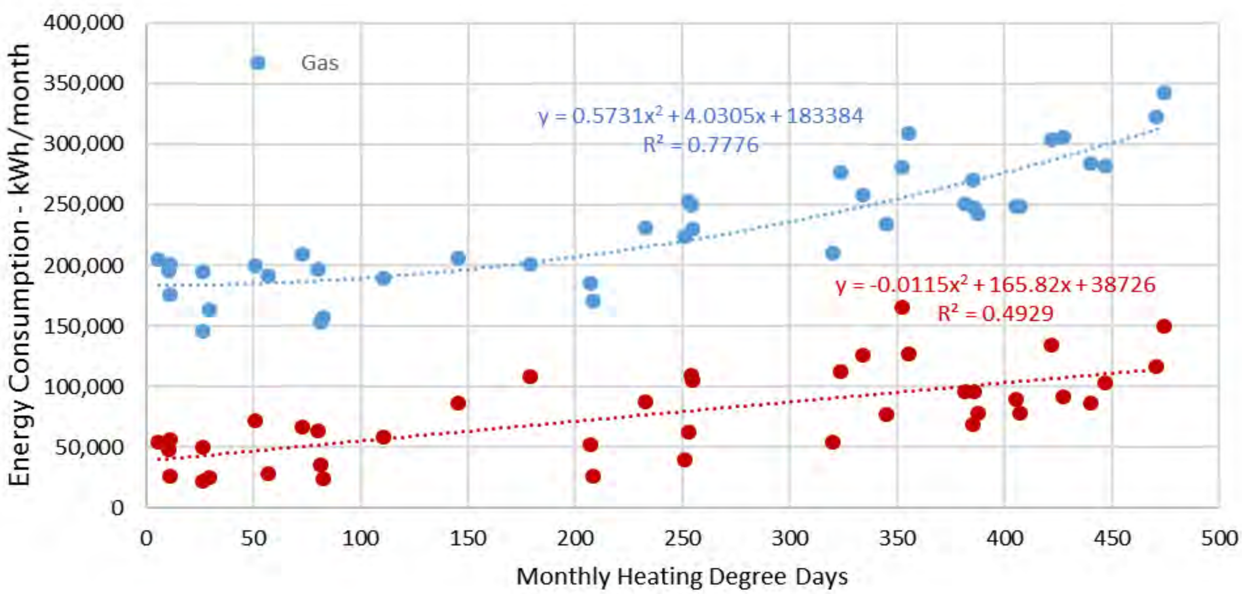
Building - Annual Average

Total CO_2	→	205	tons	Total CO_2/Suite	→	1.1	tons
Gas CO_2	→	175	tons	Gas CO_2/Suite	→	0.9	tons
Electricity CO_2	→	30	tons	Electricity CO_2/Suite	→	0.2	tons
Total CO_2/Floor Area	→	0.01	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Building 09

Date of Construction	→	1978		
Number of Suites	→	27		
Number of Floors	→	3		
Gross Floor Area	→	2,220	m^2	(23,895 sqft)
Building Height	→	8	m	(27 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	12%		

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	279,498	kWh		% Total Energy is Space Heat	→	23%
Total Energy/Suite	→	10,352	kWh		% of Space Heat Energy is Gas	→	32%
Total Energy/Floor Area	→	126	kWh/m^2		% of Space Heat Energy is Elec	→	68%

Gas - Annual Average

Total	→	152,629	kWh	(549 GJ)	% of Total Gas Used for Space Heat	→	14%
Total Consumption/Suite	→	5,653	kWh	(20 GJ)			
Total Gas Used for Space Heat	→	20,681	kWh	(74 GJ)			

Electricity - Annual Average

Total	→	126,869	kWh		Total Suite Elec used for Space Heat	→	44,810	kWh
Total Suite Consumption	→	102,487	kWh	(81%)	Suite Elec for Suite Heat/Suite	→	1,660	kWh
Total Common Consumption	→	24,382	kWh	(19%)	% of Total Elec used for Suite Heat	→	35%	
Total Consumption/Suite	→	4,699	kWh		% of Suite Elec used for Heat	→	44%	
Total Suite Consumption/Suite	→	3,796	kWh					
Total Common Consumption/Suite	→	903	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$11,144	Total Space Heat Energy	→	$3,800
Total Gas	→	$627	Total Gas Space Heat Energy	→	$85
Total Electricity	→	$10,517	Total Elec Space Heat Energy	→	$3,715

Per Suite - Annual Average

Total Energy/Suite	→	$413	Gas Used for Heat Energy/Suite	→	$3
Total Heat Energy/Suite	→	$141	Elec Used for Heat Energy/Suite	→	$138

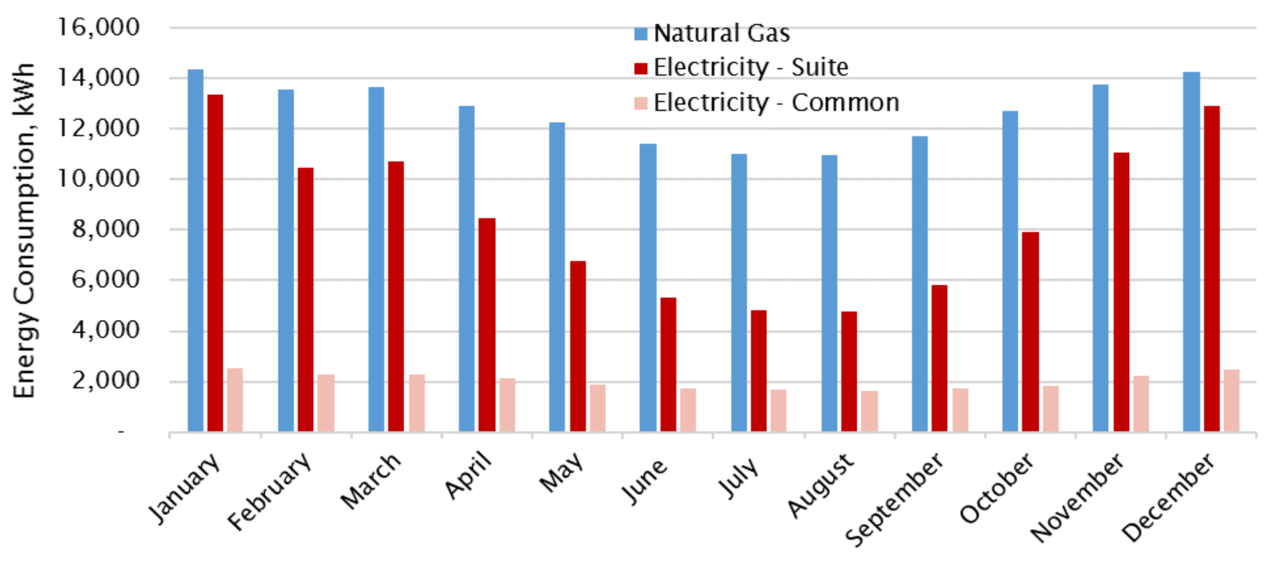
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

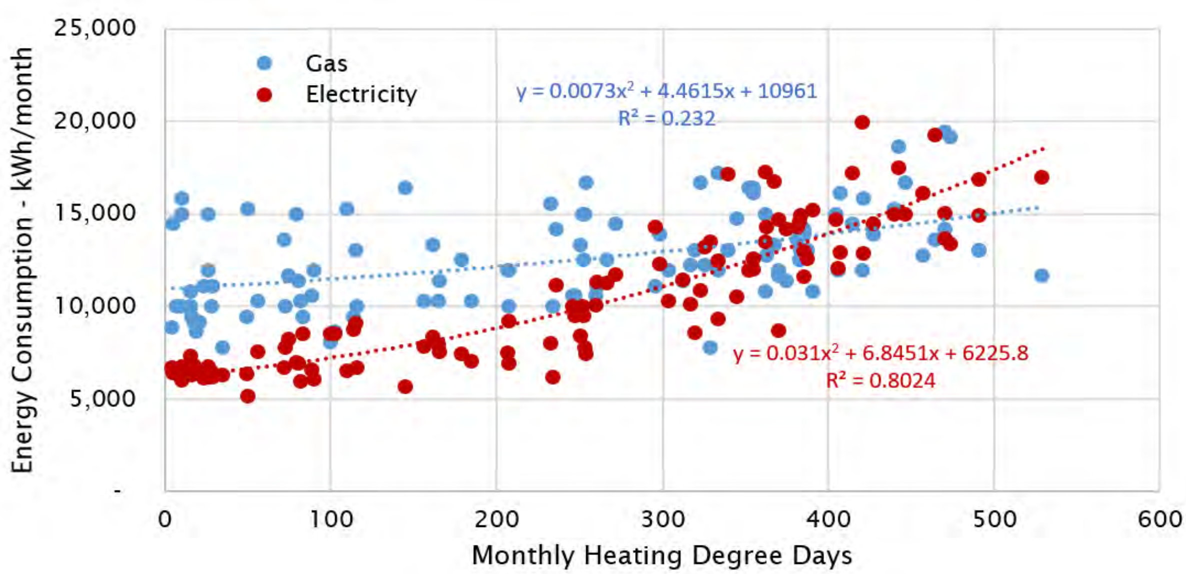
Building - Annual Average

Total CO_2	→	29	tons	Total CO_2/Suite	→	1.1	tons
Gas CO_2	→	27	tons	Gas CO_2/Suite	→	1.0	tons
Electricity CO_2	→	1	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.01	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Building 10

Date of Construction	→	1995		
Number of Suites	→	40		
Number of Floors	→	3		
Gross Floor Area	→	4,785	m^2	(23,895 sqft)
Building Height	→	8	m	(27 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	15%		

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	765,960	kWh		% Total Energy is Space Heat	→	33%
Total Energy/Suite	→	19,149	kWh		% of Space Heat Energy is Gas	→	90%
Total Energy/Floor Area	→	160	kWh/m^2		% of Space Heat Energy is Elec	→	10%

Gas - Annual Average

Total	→	488,350	kWh	(1,758 GJ)	% of Total Gas Used for Space Heat	→	47%
Total Consumption/Suite	→	12,209	kWh	(44 GJ)			
Total Gas Used for Space Heat	→	229,257	kWh	(825 GJ)			

Electricity - Annual Average

Total	→	277,610	kWh		Total Suite Elec used for Space Heat	→	25,794	kWh
Total Suite Consumption	→	192,034	kWh	(69%)	Suite Elec for Suite Heat/Suite	→	645	kWh
Total Common Consumption	→	85,576	kWh	(31%)	% of Total Elec used for Suite Heat	→	9%	
Total Consumption/Suite	→	6,940	kWh		% of Suite Elec used for Heat	→	13%	
Total Suite Consumption/Suite	→	4,801	kWh					
Total Common Consumption/Suite	→	2,139	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$25,020	Total Space Heat Energy	→	$3,080
Total Gas	→	$2,006	Total Gas Space Heat Energy	→	$942
Total Electricity	→	$23,014	Total Elec Space Heat Energy	→	$2,138

Per Suite - Annual Average

Total Energy/Suite	→	$625	Gas Used for Heat Energy/Suite	→	$24
Total Heat Energy/Suite	→	$77	Elec Used for Heat Energy/Suite	→	$53

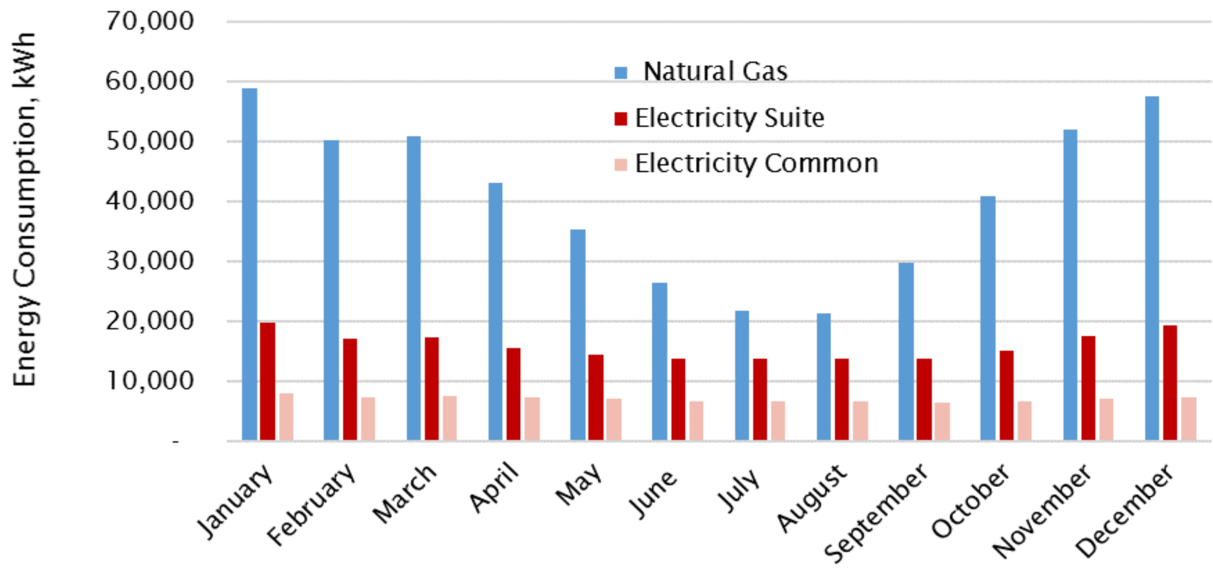
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

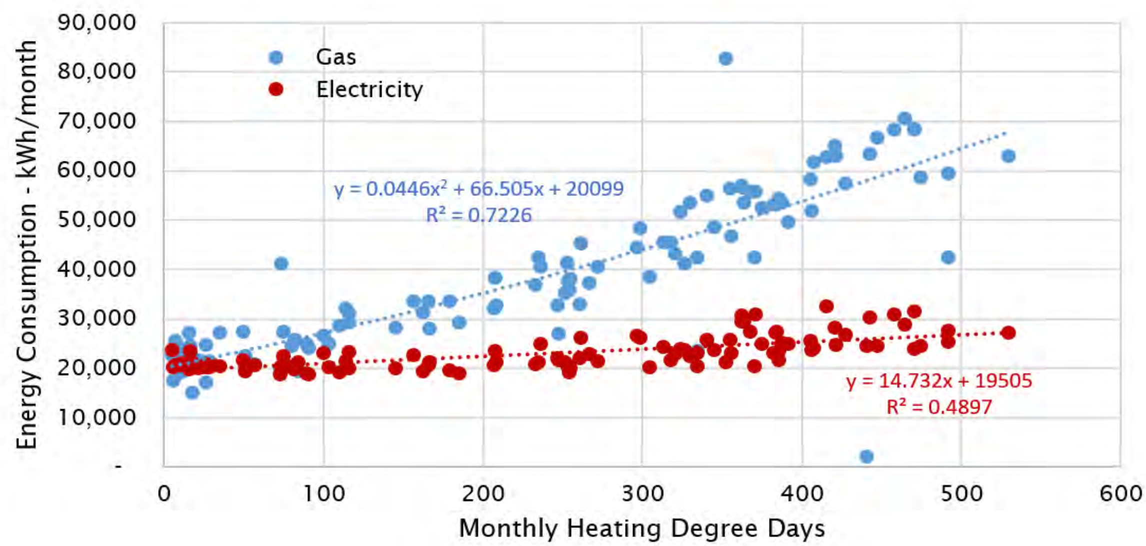
Building - Annual Average

Total CO_2	→	91	tons	Total CO_2/Suite	→	2.3	tons
Gas CO_2	→	88	tons	Gas CO_2/Suite	→	2.2	tons
Electricity CO_2	→	3	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.02	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Date of Construction	→	1991		
Number of Suites	→	14		
Number of Floors	→	4		
Gross Floor Area	→	1,769	m^2	(19,041 sqft)
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	20%		

Building 11

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	167,350	kWh		% Total Energy is Space Heat	→	26%
Total Energy/Suite	→	11,954	kWh		% of Space Heat Energy is Gas	→	8%
Total Energy/Floor Area	→	95	kWh/m^2		% of Space Heat Energy is Elec	→	92%

Gas - Annual Average

Total	→	3,571	kWh	(13 GJ)	% of Total Gas Used for Space Heat	→	100%
Total Consumption/Suite	→	255	kWh	(1 GJ)			
Total Gas Used for Space Heat	→	3,571	kWh	(13 GJ)			

Electricity - Annual Average

Total	→	163,779	kWh		Total Suite Elec used for Space Heat	→	40,506	kWh
Total Suite Consumption	→	123,006	kWh	(75%)	Suite Elec for Suite Heat/Suite	→	2,893	kWh
Total Common Consumption	→	40,773	kWh	(25%)	% of Total Elec used for Suite Heat	→	25%	
Total Consumption/Suite	→	11,699	kWh		% of Suite Elec used for Heat	→	33%	
Total Suite Consumption/Suite	→	8,786	kWh					
Total Common Consumption/Suite	→	2,912	kWh					

Energy Costs:

Gas: \$1.141/GJ Electricity: \$0.0829/kWh

Building - Annual Average

Total Energy	→	\$13,592	Total Space Heat Energy	→	\$3,373
Total Gas	→	\$15	Total Gas Space Heat Energy	→	\$15
Total Electricity	→	\$13,577	Total Elec Space Heat Energy	→	\$3,358

Per Suite - Annual Average

Total Energy/Suite	→	\$971	Gas Used for Heat Energy/Suite	→	\$1
Total Heat Energy/Suite	→	\$241	Elec Used for Heat Energy/Suite	→	\$240

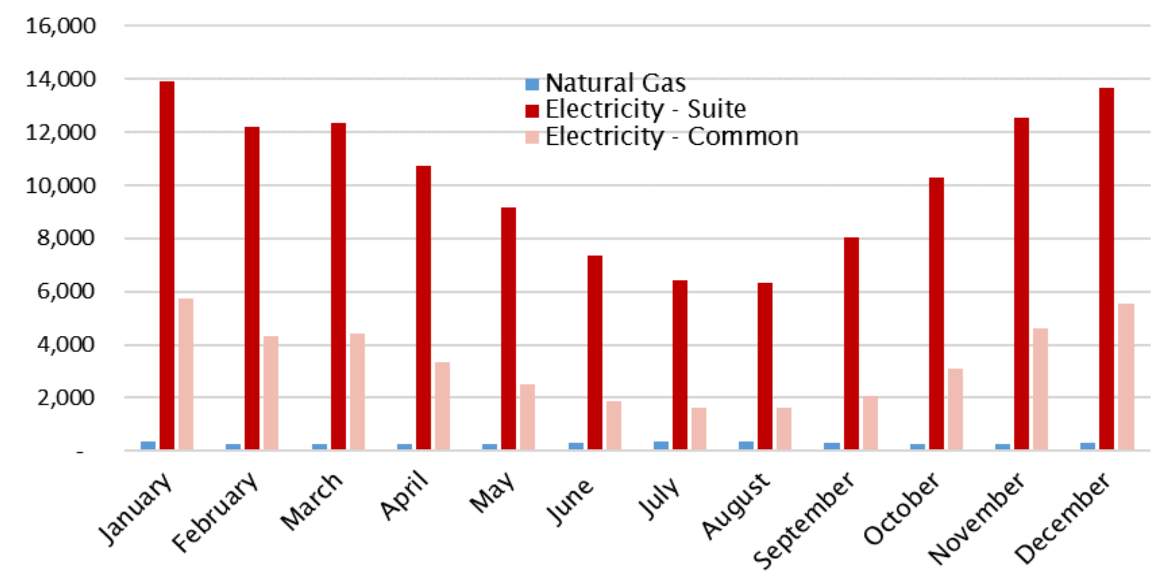
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

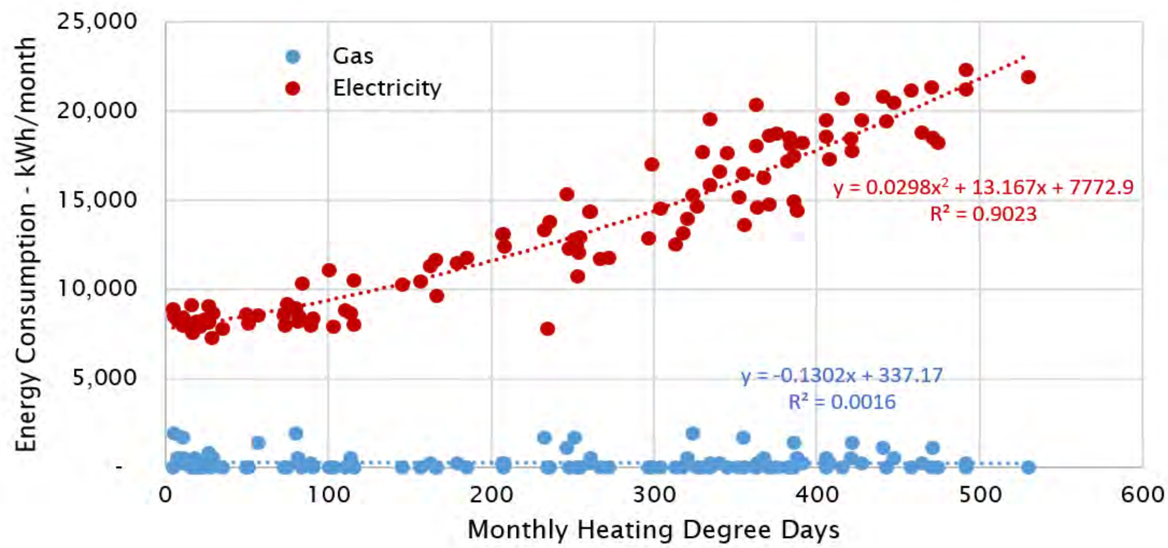
Building - Annual Average

Total CO_2	→	2	tons	Total CO_2/Suite	→	0.2	tons
Gas CO_2	→	1	tons	Gas CO_2/Suite	→	0.0	tons
Electricity CO_2	→	2	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.00	$tons/m^2$				

Average Monthly Energy Consumption Comparison

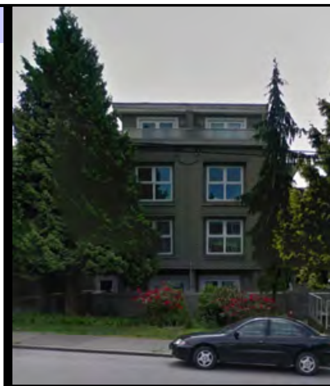


Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Date of Construction	→	1989		
Number of Suites	→	8		
Number of Floors	→	4		
Gross Floor Area	→	626	m^2	(7,061sqft)
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	20%		



Building 12

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	99,885	kWh	% Total Energy is Space Heat	→	33%
Total Energy/Suite	→	12,489	kWh	% of Space Heat Energy is Gas	→	10%
Total Energy/Floor Area	→	160	kWh/m^2	% of Space Heat Energy is Elec	→	90%

Gas - Annual Average

Total	→	16,074	kWh	(58 GJ)	% of Total Gas Used for Space Heat	→	21%
Total Consumption/Suite	→	2,009	kWh	(7 GJ)			
Total Gas Used for Space Heat	→	3,334	kWh	(12 GJ)			

Electricity - Annual Average

Total	→	83,811	kWh		Total Suite Elec used for Space Heat	→	29,984	kWh
Total Suite Consumption	→	73,336	kWh	(88%)	Suite Elec for Suite Heat/Suite	→	3,748	kWh
Total Common Consumption	→	10,475	kWh	(12%)	% of Total Elec used for Suite Heat	→	36%	
Total Consumption/Suite	→	10,476	kWh		% of Suite Elec used for Heat	→	41%	
Total Suite Consumption/Suite	→	9,167	kWh					
Total Common Consumption/Suite	→	1,309	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$7,014	Total Space Heat Energy	→	$2,499
Total Gas	→	$66	Total Gas Space Heat Energy	→	$14
Total Electricity	→	$6,948	Total Elec Space Heat Energy	→	$2,486

Per Suite - Annual Average

Total Energy/Suite	→	$877	Gas Used for Heat Energy/Suite	→	$2
Total Heat Energy/Suite	→	$312	Elec Used for Heat Energy/Suite	→	$311

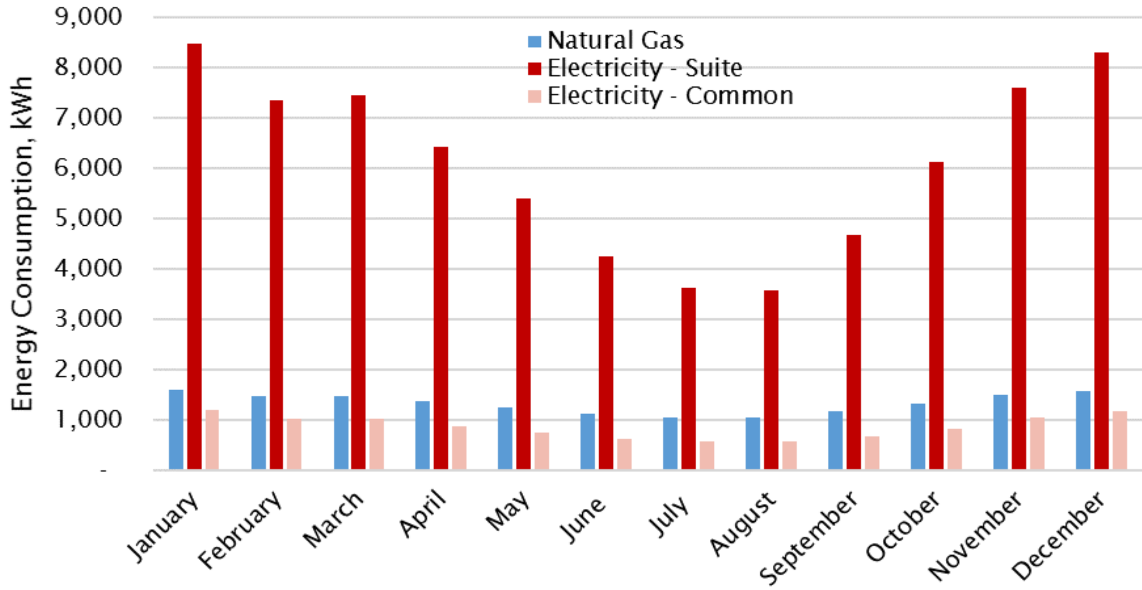
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

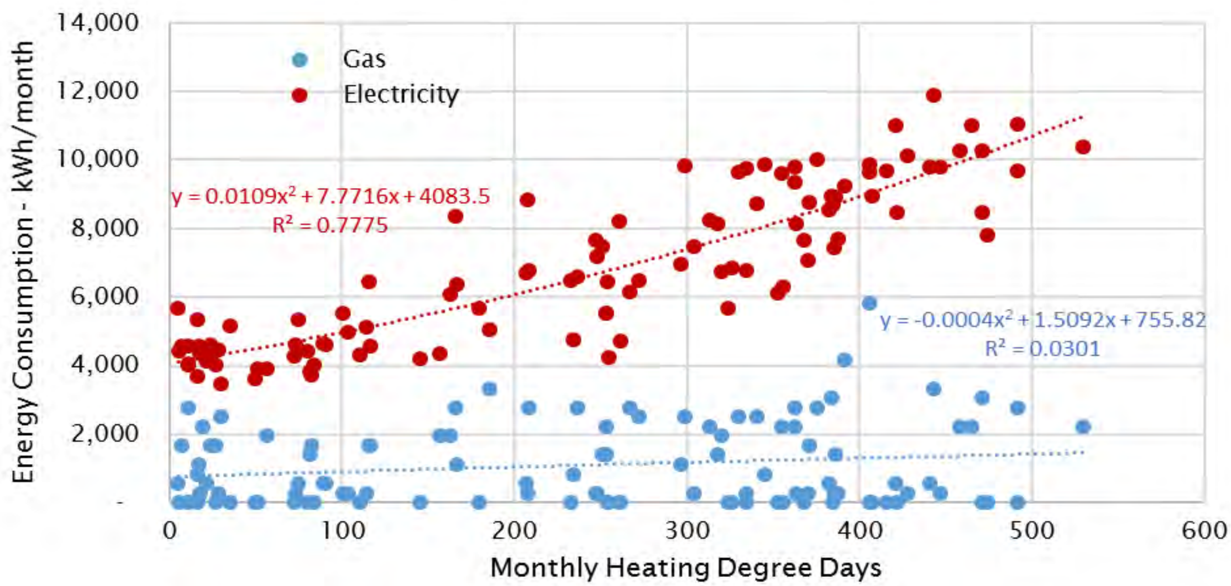
Building - Annual Average

Total CO_2	→	4	tons	Total CO_2/Suite	→	0.5	tons
Gas CO_2	→	3	tons	Gas CO_2/Suite	→	0.4	tons
Electricity CO_2	→	1	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.01	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Date of Construction	→	2006		
Number of Suites	→	55		
Number of Floors	→	4		
Gross Floor Area	→	6,906	m^2	(74,336 sqft)
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→			

Building 12

Consumption and Distribution Summary:

Gas and Electric Data From January 2012 to June 2015

Total Energy - Annual Average

Total Energy	→	844,061	kWh		% Total Energy is Space Heat	→	41%
Total Energy/Suite	→	15,347	kWh		% of Space Heat Energy is Gas	→	56%
Total Energy/Floor Area	→	122	kWh/m^2		% of Space Heat Energy is Elec	→	44%

Gas - Annual Average

Total	→	393,018	kWh	(1,415 GJ)	% of Total Gas Used for Space Heat	→	50%
Total Consumption/Suite	→	7,146	kWh	(26 GJ)			
Total Gas Used for Space Heat	→	194,706	kWh	(701 GJ)			

Electricity - Annual Average

Total	→	451,043	kWh	Total Suite Elec used for Space Heat	→	153,894	kWh
Total Suite Consumption	→	N/A	kWh	Suite Elec for Suite Heat/Suite	→	2,798	kWh
Total Common Consumption	→	N/A	kWh	% of Total Elec used for Suite Heat	→	34%	
Total Consumption/Suite	→	8,201	kWh	% of Suite Elec used for Heat	→	N/A	
Total Suite Consumption/Suite	→	N/A	kWh				
Total Common Consumption/Suite	→	N/A	kWh				

Energy Costs:

Gas: \$1.141/GJ   Electricity: \$0.0829/kWh

Building - Annual Average

Total Energy	→	\$39,006	Total Space Heat Energy	→	\$13,558
Total Gas	→	\$1,614	Total Gas Space Heat Energy	→	\$800
Total Electricity	→	\$37,391	Total Elec Space Heat Energy	→	\$12,758

Per Suite - Annual Average

Total Energy/Suite	→	\$709	Gas Used for Heat Energy/Suite	→	\$15
Total Heat Energy/Suite	→	\$247	Elec Used for Heat Energy/Suite	→	\$232

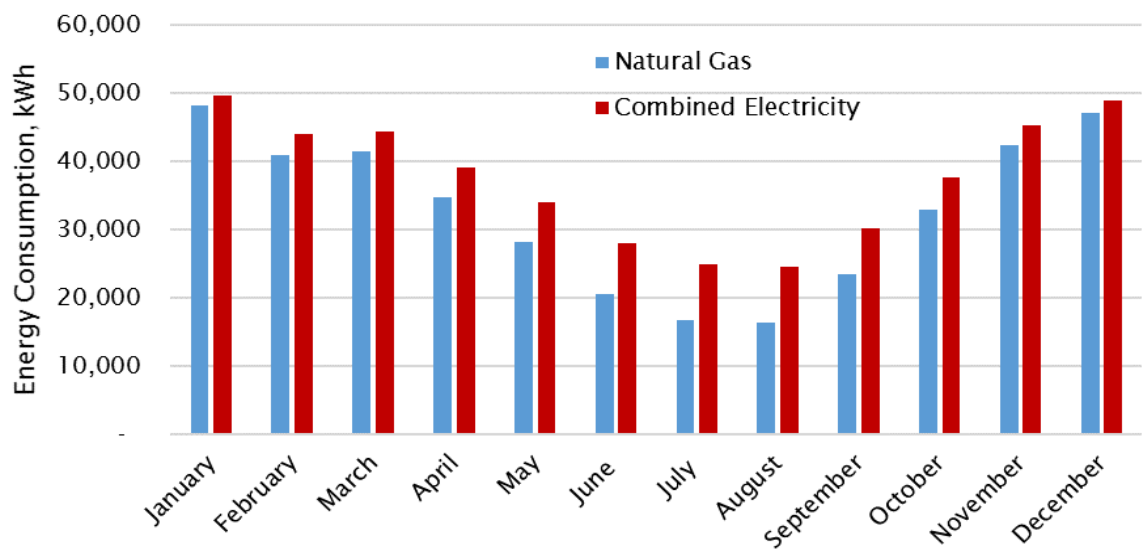
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ   Electricity: 2.964 kg CO2 /GJ

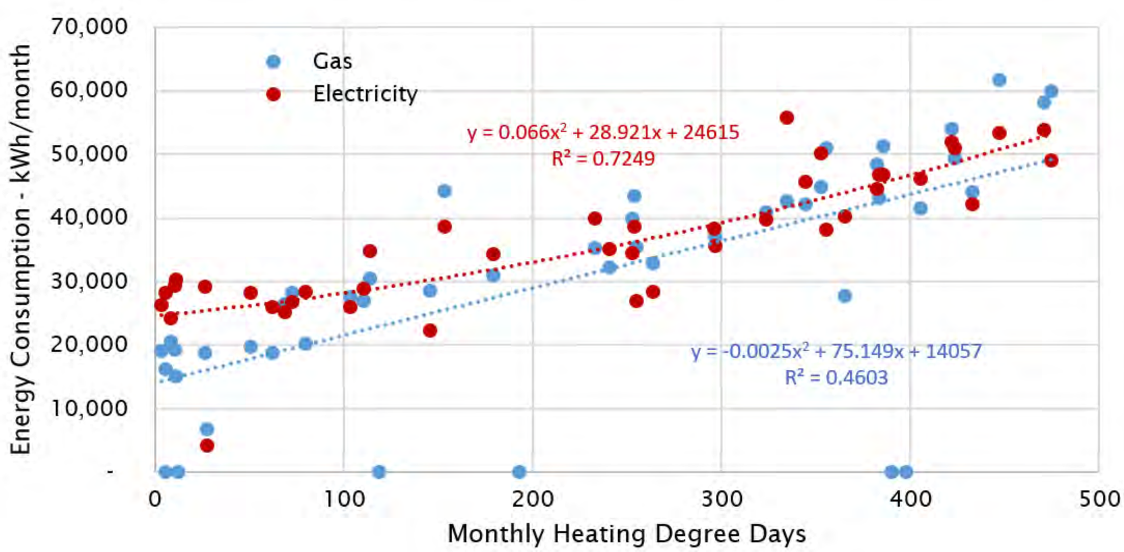
Building - Annual Average

Total CO_2	→	75	tons	Total CO_2/Suite	→	1.4	tons
Gas CO_2	→	71	tons	Gas CO_2/Suite	→	1.3	tons
Electricity CO_2	→	5	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.01	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Energy Consumption (Monthly)



Building Description:

Date of Construction	→	2012		
Number of Suites	→	107		
Number of Floors	→	4		
Gross Floor Area	→	9,848	m^2	(106,0013 ft^2)
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→			

Building 14

Consumption and Distribution Summary:

Gas and Electric Data From July 2012 to May 2015

Total Energy - Annual Average

Total Energy	→	1,461,830	kWh		% Total Energy is Space Heat	→	39%	
Total Energy/Suite	→	13,662	kWh		% of Space Heat Energy is Gas	→	57%	
Total Energy/Floor Area	→	148	kWh/m^2		% of Space Heat Energy is Elec	→	43%	

Gas - Annual Average

Total	→	885,278	kWh	(3,186 GJ)	% of Total Gas Used for Space Heat	→	36%	
Total Consumption/Suite	→	8,274	kWh	(30 GJ)				
Total Gas Used for Space Heat	→	320,685	kWh	(1,154 GJ)				

Electricity - Annual Average

Total	→	576,552	kWh		Total Elec for Space Heat/Suite	→	243,700	kWh
Total Suite Consumption	→	N/A	kWh		Suite Elec for Suite Heat/Suite	→	2,278	kWh
Total Common Consumption	→	N/A	kWh		% of Total Elec used for Suite Heat	→	42%	
Total Consumption/Suite	→	5,388	kWh		% of Suite Elec used for Heat	→	NA	
Total Suite Consumption/Suite	→	N/A	kWh					
Total Common Consumption/Suite	→	N/A	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$47,796	Total Space Heat Energy	→	$21,520
Total Gas	→	$3,636	Total Gas Space Heat Energy	→	$1,317
Total Electricity	→	$47,796	Total Elec Space Heat Energy	→	$20,203

Per Suite - Annual Average

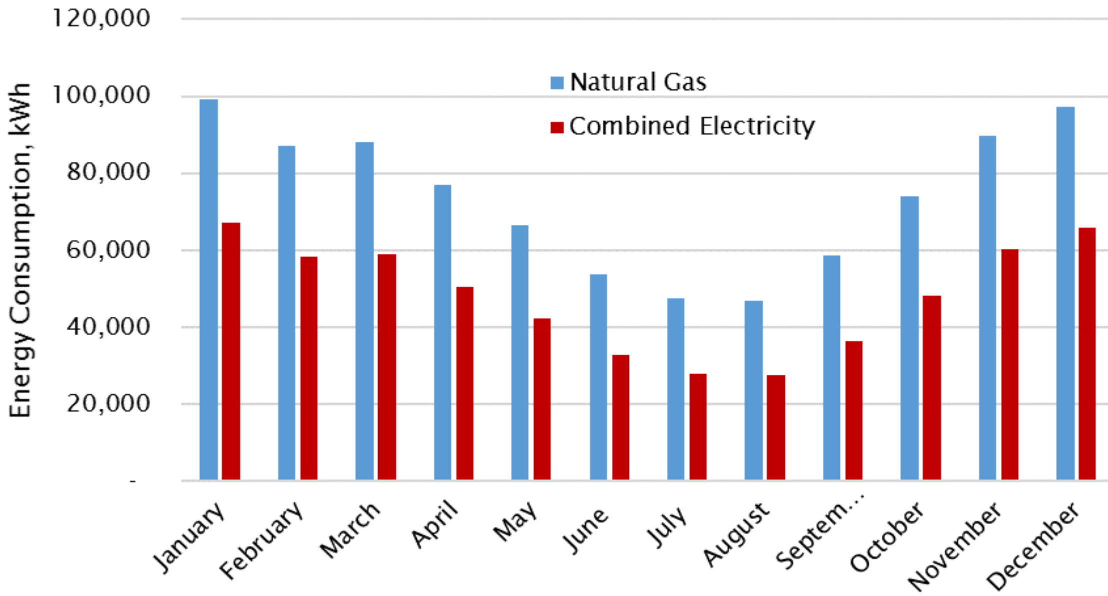
Total Energy/Suite	→	$481	Gas Used for Heat Energy/Suite	→	$12
Total Heat Energy/Suite	→	$201	Elec Used for Heat Energy/Suite	→	$189

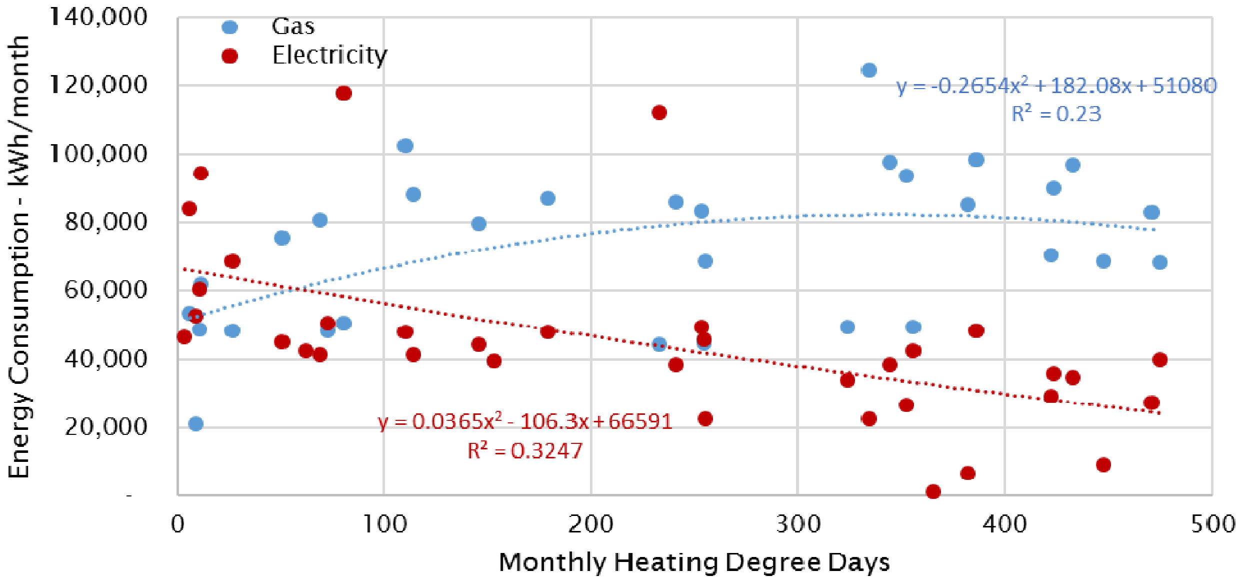
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

Building - Annual Average

Total CO_2	→	165	tons	Total CO_2/Suite	→	1.5	tons
Gas CO_2	→	159	tons	Gas CO_2/Suite	→	1.5	tons
Electricity CO_2	→	6	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.02	$tons/m^2$				


Energy Consumption, kWh
120,000
100,000
80,000
60,000
40,000
20,000
-
Natural Gas
Combined Electricity
January
February
March
April
May
June
July
August
Septem...
October
November
December


Energy Consumption - kWh/month
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
Gas
Electricity
y = -0.2654x² + 182.08x + 51080
R² = 0.23
y = 0.0365x² - 106.3x + 66591
R² = 0.3247
0
100
200
300
400
500
Monthly Heating Degree Days

Building Description:

Building 15

Date of Construction	→	2008		
Number of Suites	→	60		
Number of Floors	→	4		
Gross Floor Area	→	3,387	m^2	
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→			

Consumption and Distribution Summary:

Gas and Electric Data From January 2011 to May 2015

Total Energy - Annual Average

Total Energy	→	879,306	kWh		% Total Energy is Space Heat	→	26%
Total Energy/Suite	→	14,655	kWh		% of Space Heat Energy is Gas	→	48%
Total Energy/Floor Area	→	260	kWh/m^2		% of Space Heat Energy is Elec	→	52%

Gas - Annual Average

Total	→	412,943	kWh	(1,486 GJ)	% of Total Gas Used for Space Heat	→	26%
Total Consumption/Suite	→	6,882	kWh	(25 GJ)			
Total Gas Used for Space Heat	→	108,667	kWh	(391 GJ)			

Electricity - Annual Average

Total	→	466,362	kWh	Total Suite Elec used for Space Heat	→	115,842	kWh
Total Suite Consumption	→	N/A	kWh	Suite Elec for Suite Heat/Suite	→	1,931	kWh
Total Common Consumption	→	N/A	kWh	% of Total Elec used for Suite Heat	→	25%	
Total Consumption/Suite	→	7,773	kWh	% of Suite Elec used for Heat	→	N/A	
Total Suite Consumption/Suite	→	N/A	kWh				
Total Common Consumption/Suite	→	N/A	kWh				

Energy Costs:

Gas: \$1.141/GJ Electricity: \$0.0829/kWh

Building - Annual Average

Total Energy	→	\$40,358	Total Space Heat Energy	→	\$10,050
Total Gas	→	\$1,696	Total Gas Space Heat Energy	→	\$446
Total Electricity	→	\$38,661	Total Elec Space Heat Energy	→	\$9,603

Per Suite - Annual Average

Total Energy/Suite	→	\$673	Gas Used for Heat Energy/Suite	→	\$7
Total Heat Energy/Suite	→	\$167	Elec Used for Heat Energy/Suite	→	\$160

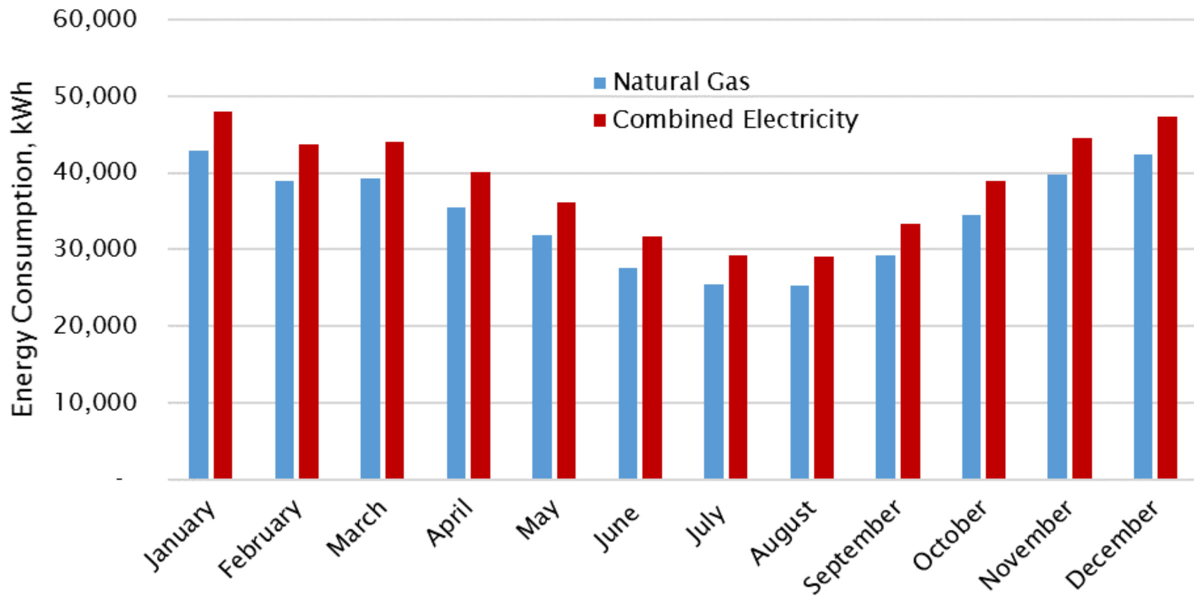
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

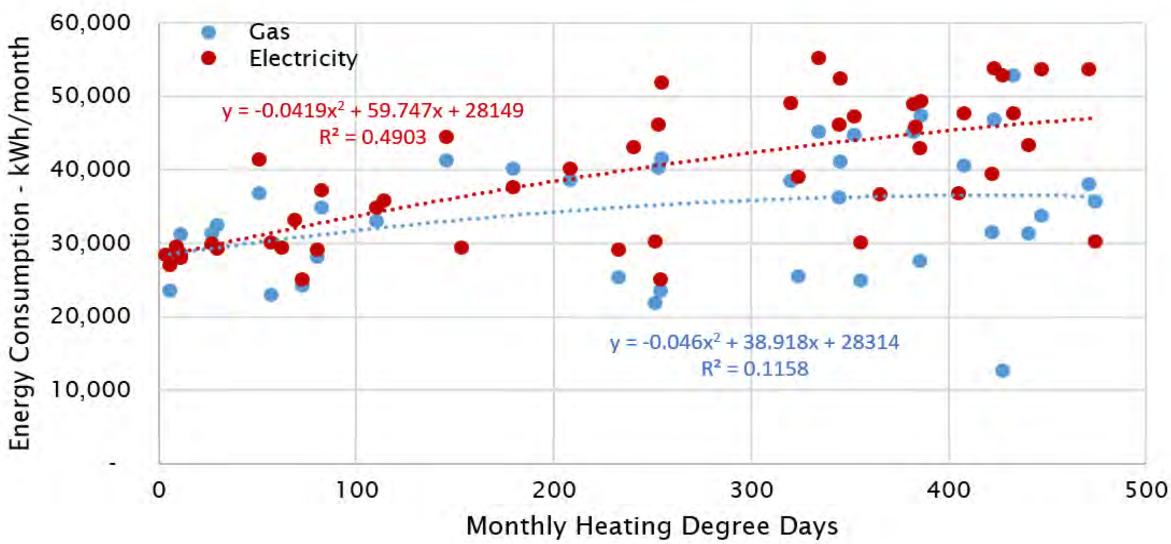
Building - Annual Average

Total CO_2	→	79	tons	Total CO_2/Suite	→	1.3	tons
Gas CO_2	→	74	tons	Gas CO_2/Suite	→	1.2	tons
Electricity CO_2	→	5	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.02	$tons/m^2$				

AVERAGE MONTHLY ENERGY CONSUMPTION COMPARISON



HEATING DEGREE DAYS VERSUS SPACE HEAT CONSUMPTION (MONTHLY)



Building Description:

Date of Construction	→	2009		
Number of Suites	→	46		
Number of Floors	→	4		
Gross Floor Area	→	5,127	m^2	
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→			

Building 16

Consumption and Distribution Summary:

Gas and Electric Data From January 2011 to May 2015

Total Energy - Annual Average

Total Energy	→	698,243	kWh	% Total Energy is Space Heat	→	28%
Total Energy/Suite	→	15,179	kWh	% of Space Heat Energy is Gas	→	42%
Total Energy/Floor Area	→	136	kWh/m^2	% of Space Heat Energy is Elec	→	58%

Gas - Annual Average

Total	→	317,478	kWh	(1,142 GJ)	% of Total Gas Used for Space Heat	→	26%
Total Consumption/Suite	→	6,902	kWh	(25 GJ)			
Total Gas Used for Space Heat	→	82,611	kWh	(297 GJ)			

Electricity - Annual Average

Total	→	380,765	kWh	Total Suite Elec used for Space Heat	→	113,991	kWh
Total Suite Consumption	→	N/A	kWh	Suite Elec for Suite Heat/Suite	→	2,478	kWh
Total Common Consumption	→	N/A	kWh	% of Total Elec used for Suite Heat	→	30%	
Total Consumption/Suite	→	8,278	kWh	% of Suite Elec used for Heat	→	N/A	
Total Suite Consumption/Suite	→	N/A	kWh				
Total Common Consumption/Suite	→	N/A	kWh				

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$32,869	Total Space Heat Energy	→	$9,789
Total Gas	→	$1,304	Total Gas Space Heat Energy	→	$339
Total Electricity	→	$31,565	Total Elec Space Heat Energy	→	$9,450

Per Suite - Annual Average

Total Energy/Suite	→	$715	Gas Used for Heat Energy/Suite	→	$7
Total Heat Energy/Suite	→	$213	Elec Used for Heat Energy/Suite	→	$205

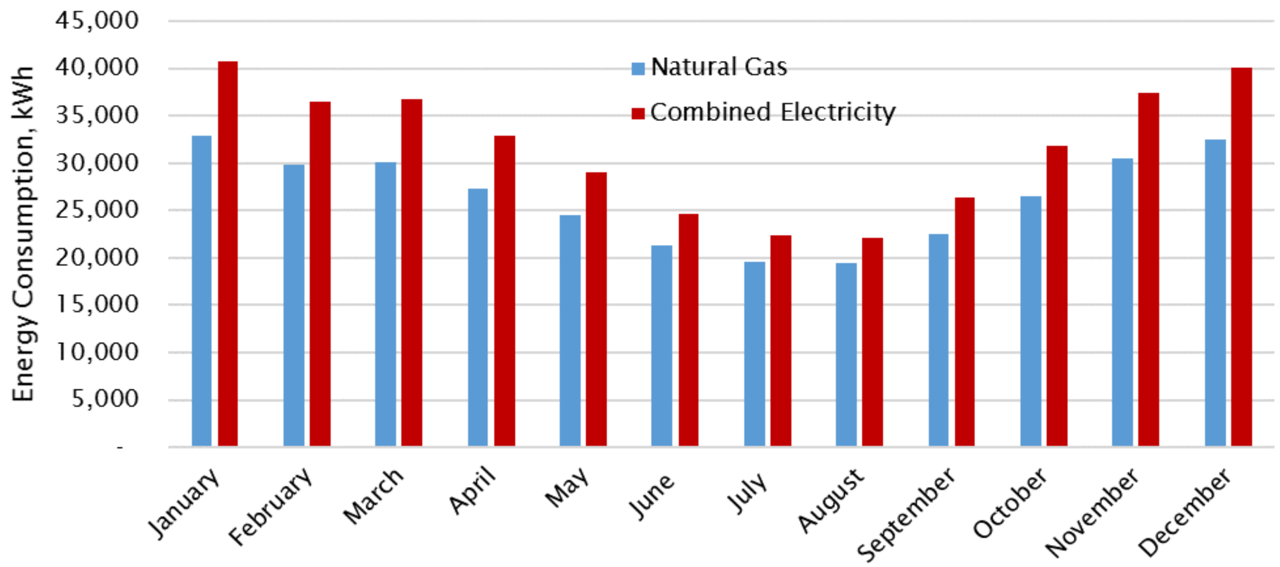
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

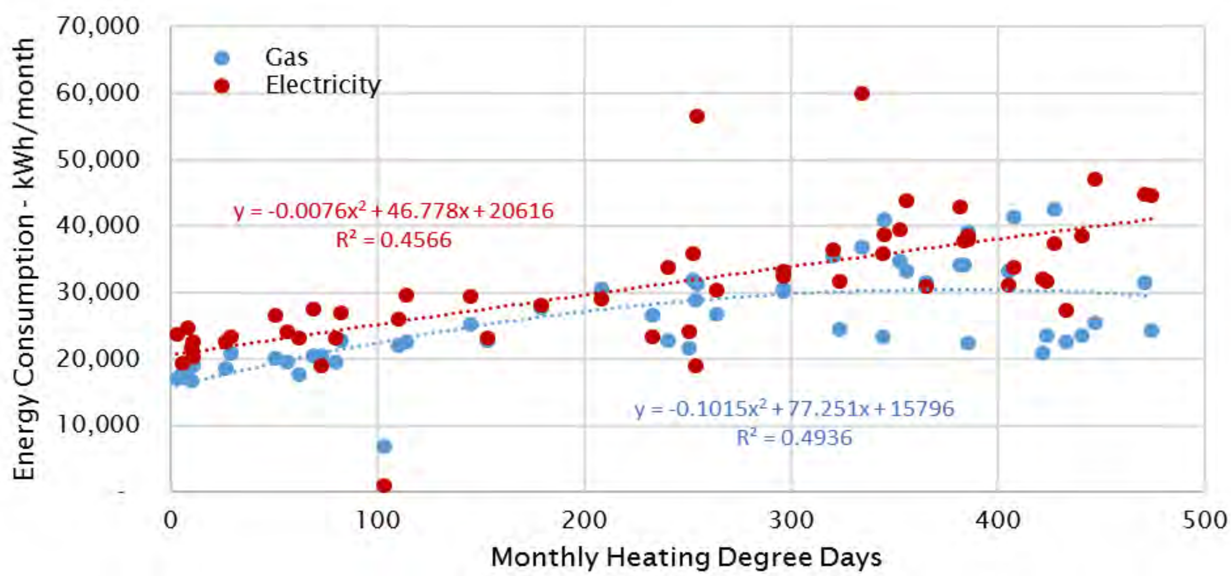
Building - Annual Average

Total CO_2	→	61	tons	Total CO_2/Suite	→	1.3	tons
Gas CO_2	→	57	tons	Gas CO_2/Suite	→	1.2	tons
Electricity CO_2	→	4	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.01	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Space Heat Consumption (Monthly)



Building Description:

Building 17

Date of Construction	→	1994		
Number of Suites	→	142		
Number of Floors	→	4		
Gross Floor Area	→	14,945	m^2	
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→			

Consumption and Distribution Summary:

Gas and Electric Data From January 2012 to August 2015

Total Energy - Annual Average

Total Energy	→	4,168,973	kWh	% Total Energy is Space Heat	→	52%
Total Energy/Suite	→	29,359	kWh	% of Space Heat Energy is Gas	→	89%
Total Energy/Floor Area	→	279	kWh/m^2	% of Space Heat Energy is Elec	→	11%

Gas - Annual Average

Total	→	3,042,216	kWh	(10,952 GJ)	% of Total Gas Used for Space Heat	→	63%
Total Consumption/Suite	→	21,424	kWh	(77 GJ)			
Total Gas Used for Space Heat	→	1,921,930	kWh	(6,918 GJ)			

Electricity - Annual Average

Total	→	1,126,757	kWh	Total Suite Elec used for Space Heat	→	242,231	kWh
Total Suite Consumption	→	N/A	kWh	Suite Elec for Suite Heat/Suite	→	1,706	kWh
Total Common Consumption	→	N/A	kWh	% of Total Elec used for Suite Heat	→	21%	
Total Consumption/Suite	→	7,935	kWh	% of Suite Elec used for Heat	→	N/A	
Total Suite Consumption/Suite	→	N/A	kWh				
Total Common Consumption/Suite	→	N/A	kWh				

Energy Costs:

Gas: \$1.141/GJ Electricity: \$0.0829/kWh

Building - Annual Average

Total Energy	→	\$105,904	Total Space Heat Energy	→	\$27,975
Total Gas	→	\$12,496	Total Gas Space Heat Energy	→	\$7,894
Total Electricity	→	\$93,408	Total Elec Space Heat Energy	→	\$20,081

Per Suite - Annual Average

Total Energy/Suite	→	\$746	Gas Used for Heat Energy/Suite	→	\$56
Total Heat Energy/Suite	→	\$197	Elec Used for Heat Energy/Suite	→	\$141

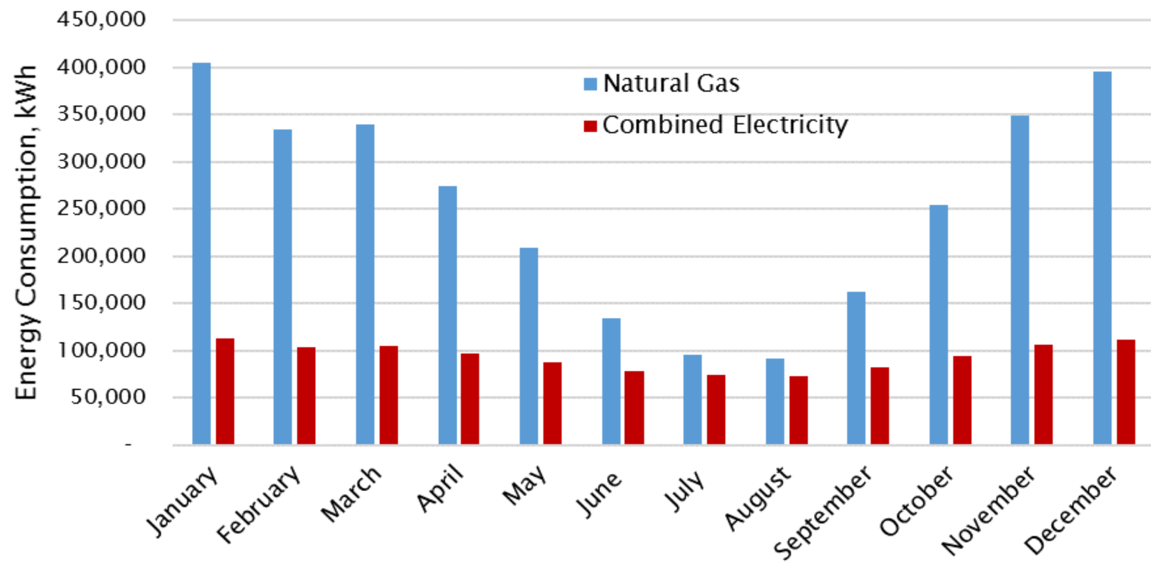
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

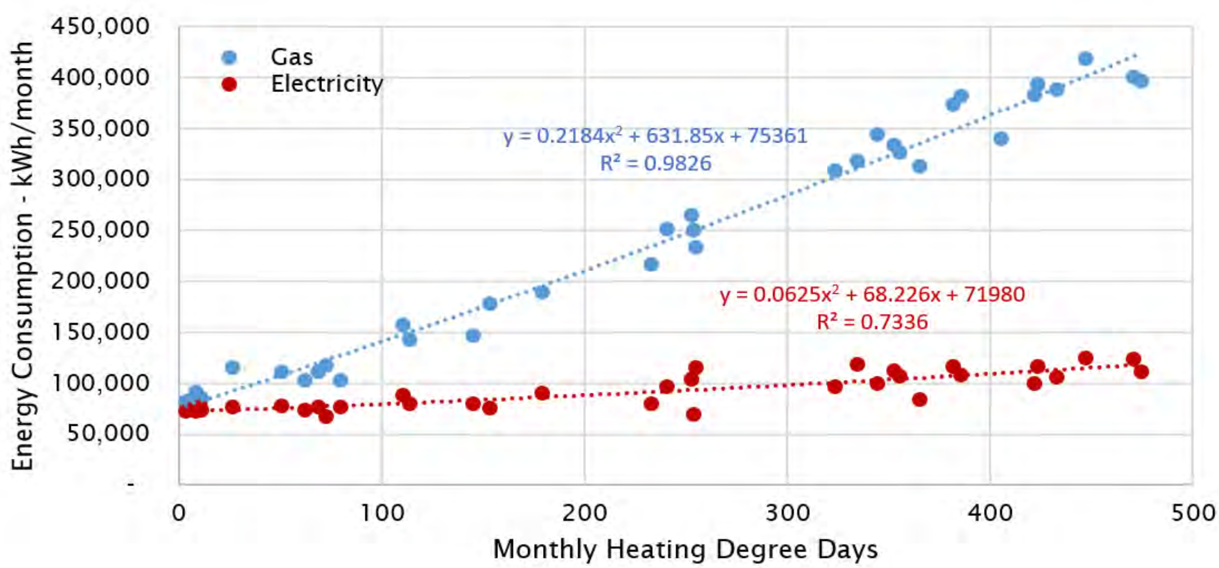
Building - Annual Average

Total CO_2	→	558	tons	Total CO_2/Suite	→	3.9	tons
Gas CO_2	→	546	tons	Gas CO_2/Suite	→	3.8	tons
Electricity CO_2	→	12	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.04	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Space Heat Consumption (Monthly)



Building Description:

Date of Construction	→	2001		
Number of Suites	→	78		
Number of Floors	→	4		
Gross Floor Area	→	7,009	m^2	
Building Height	→	11	m	(36 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→			

Building 18

Consumption and Distribution Summary:

Gas and Electric Data From January 2012 to July 2007

Total Energy - Annual Average

Total Energy	→	1,613,217	kWh	% Total Energy is Space Heat	→	36%	
Total Energy/Suite	→	20,682	kWh	% of Space Heat Energy is Gas	→	93%	
Total Energy/Floor Area	→	230	kWh/m^2	% of Space Heat Energy is Elec	→	7%	

Gas - Annual Average

Total	→	1,117,625	kWh	(4,023 GJ)	% of Total Gas Used for Space Heat	→	48%
Total Consumption/Suite	→	14,329	kWh	(52 GJ)			
Total Gas Used for Space Heat	→	534,160	kWh	(1,923 GJ)			

Electricity - Annual Average

Total	→	495,565	kWh		Total Suite Elec used for Space Heat	→	40,405	kWh
Total Suite Consumption	→	322,435	kWh	(65%)	Suite Elec for Suite Heat/Suite	→	518	kWh
Total Common Consumption	→	173,130	kWh	(35%)	% of Total Elec used for Suite Heat	→	8%	
Total Consumption/Suite	→	6,353	kWh		% of Suite Elec used for Heat	→	13%	
Total Suite Consumption/Suite	→	4,134	kWh					
Total Common Consumption/Suite	→	2,220	kWh					

Energy Costs:

Gas: $1.141/GJ   Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$45,673	Total Space Heat Energy	→	$5,544
Total Gas	→	$4,591	Total Gas Space Heat Energy	→	$2,194
Total Electricity	→	$41,082	Total Elec Space Heat Energy	→	$3,350

Per Suite - Annual Average

Total Energy/Suite	→	$586	Gas Used for Heat Energy/Suite	→	$28
Total Heat Energy/Suite	→	$71	Elec Used for Heat Energy/Suite	→	$43

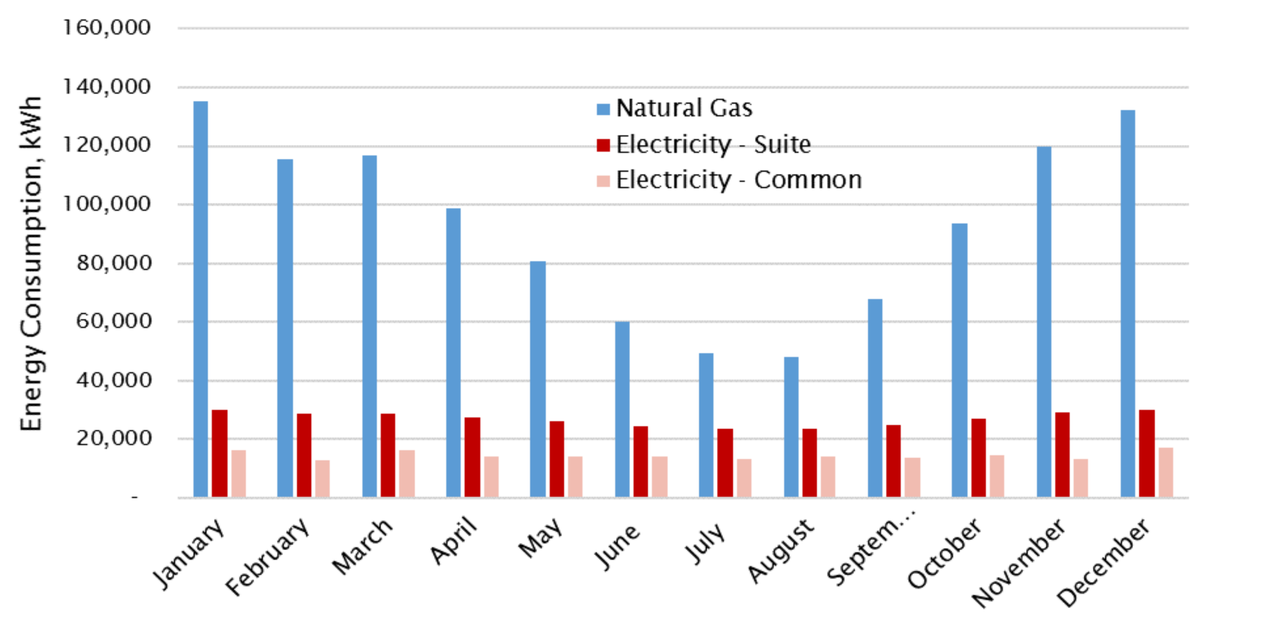
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ   Electricity: 2.964 kg CO2 /GJ

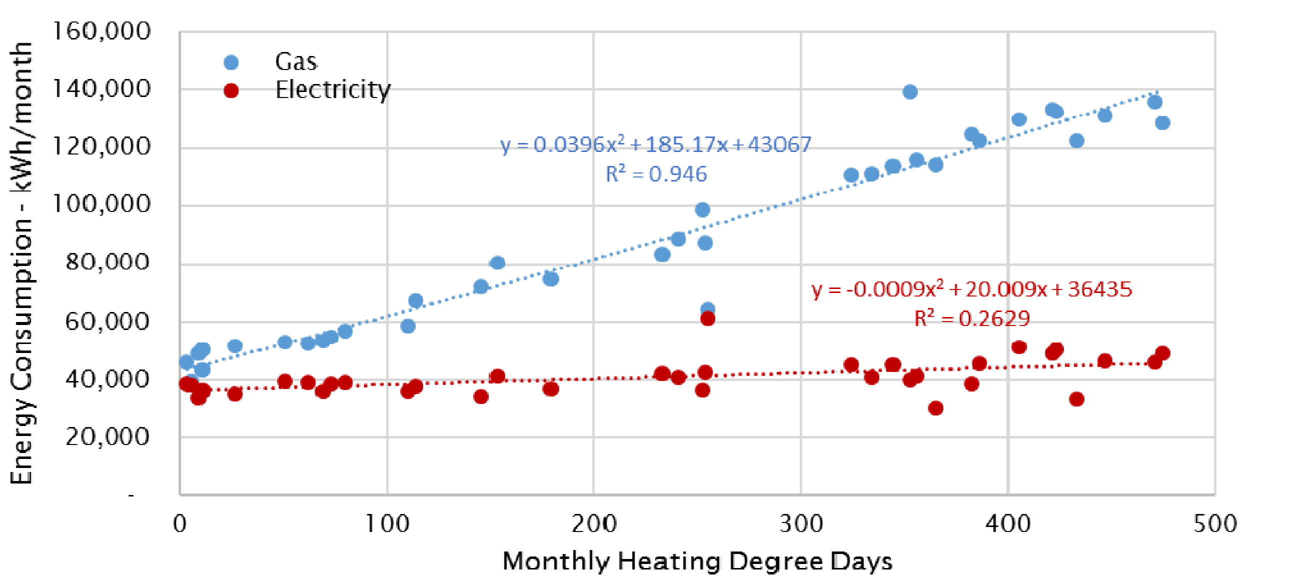
Building - Annual Average

Total CO_2	→	206	tons	Total CO_2/Suite	→	2.6	tons
Gas CO_2	→	201	tons	Gas CO_2/Suite	→	2.6	tons
Electricity CO_2	→	5	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.03	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Space Heat Consumption (Monthly)



Building Description:

Building 19

Date of Construction	→	2006	
Number of Suites	→	71	
Number of Floors	→	4	
Gross Floor Area	→	7,659	m^2
Building Height	→	12	m
Floor Height (?)	→	3	m
% Glazing Area	→		

Consumption and Distribution Summary:

Gas and Electric Data From January 2011 to May 2015

Total Energy - Annual Average

Total Energy	→	1,119,818	kWh	% Total Energy is Space Heat	→	29%
Total Energy/Suite	→	15,772	kWh	% of Space Heat Energy is Gas	→	44%
Total Energy/Floor Area	→	146	kWh/m^2	% of Space Heat Energy is Elec	→	56%

Gas - Annual Average

Total	→	501,014	kWh	(1,803 GJ)	% of Total Gas Used for Space Heat	→	28%
Total Consumption/Suite	→	7,057	kWh	(25 GJ)			
Total Gas Used for Space Heat	→	139,392	kWh	(502 GJ)			

Electricity - Annual Average

Total	→	618,804	kWh	Total Suite Elec used for Space Heat	→	180,586	kWh
Total Suite Consumption	→	N/A	kWh	Suite Elec for Suite Heat/Suite	→	2,543	kWh
Total Common Consumption	→	N/A	kWh	% of Total Elec used for Suite Heat	→	29%	
Total Consumption/Suite	→	8,716	kWh	% of Suite Elec used for Heat	→	N/A	
Total Suite Consumption/Suite	→	N/A	kWh				
Total Common Consumption/Suite	→	N/A	kWh				

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$53,357	Total Space Heat Energy	→	$15,543
Total Gas	→	$2,058	Total Gas Space Heat Energy	→	$573
Total Electricity	→	$51,299	Total Elec Space Heat Energy	→	$14,971

Per Suite - Annual Average

Total Energy/Suite	→	$752	Gas Used for Heat Energy/Suite	→	$8
Total Heat Energy/Suite	→	$219	Elec Used for Heat Energy/Suite	→	$211

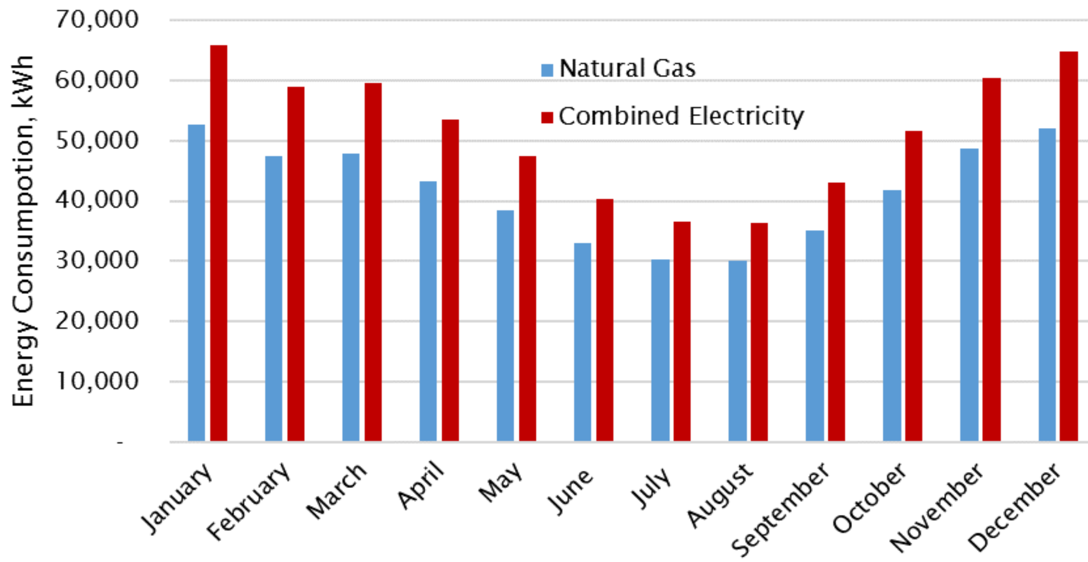
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

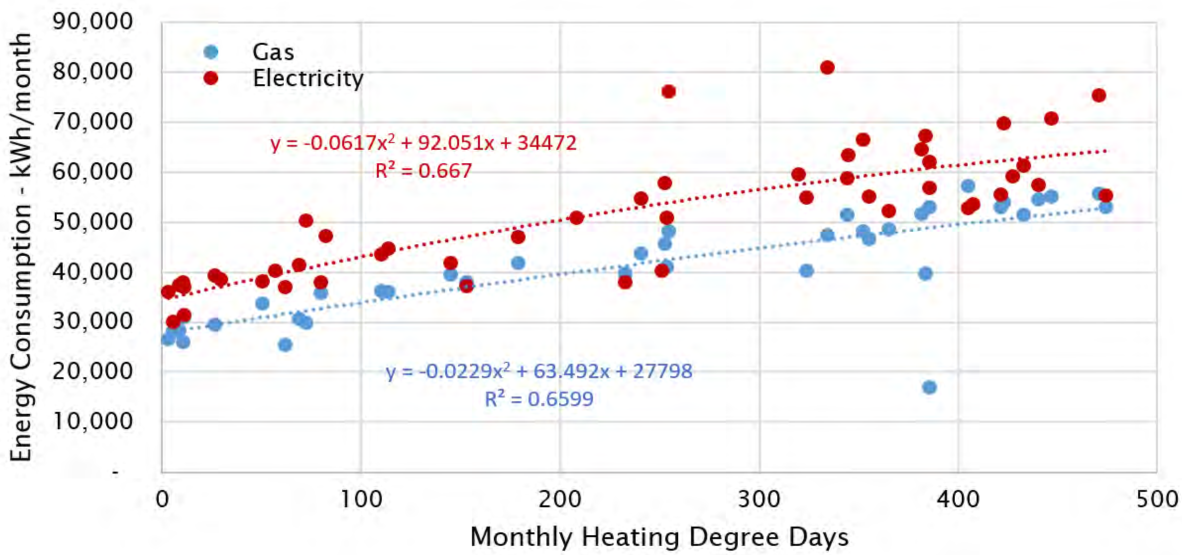
Building - Annual Average

Total CO_2	→	97	tons	Total CO_2/Suite	→	1.4	tons
Gas CO_2	→	90	tons	Gas CO_2/Suite	→	1.3	tons
Electricity CO_2	→	7	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.01	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Space Heat Consumption (Monthly)



Building Description:

Building 20

Date of Construction	→	1991	
Number of Suites	→	120	
Number of Floors	→	3	
Gross Floor Area	→	14,073	m^2
Building Height	→	9	m
Floor Height (?)	→	3	m
% Glazing Area	→	33%	

Consumption and Distribution Summary:

Gas and Electric Data FromJanuary 2013 to August 2015

Total Energy - Annual Average

Total Energy	→	3,411,948	kWh	% Total Energy is Space Heat	→	50%	
Total Energy/Suite	→	28,433	kWh	% of Space Heat Energy is Gas	→	84%	
Total Energy/Floor Area	→	242	kWh/m^2	% of Space Heat Energy is Elec	→	16%	

Gas - Annual Average

Total	→	2,537,430	kWh	(9,135 GJ)	% of Total Gas Used for Space Heat	→	57%
Total Consumption/Suite	→	21,145	kWh	(76 GJ)			
Total Gas Used for Space Heat	→	1,439,562	kWh	(5,182 GJ)			

Electricity - Annual Average

Total	→	874,518	kWh		Total Suite Elec used for Space Heat	→	270,031	kWh
Total Suite Consumption	→	660,510	kWh	(76%)	Suite Elec for Suite Heat/Suite	→	2,250	kWh
Total Common Consumption	→	214,008	kWh	(24%)	% of Total Elec used for Suite Heat	→	31%	
Total Consumption/Suite	→	7,288	kWh		% of Suite Elec used for Heat	→	41%	
Total Suite Consumption/Suite	→	5,504	kWh					
Total Common Consumption/Suite	→	1,783	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$82,920	Total Space Heat Energy	→	$28,299
Total Gas	→	$10,423	Total Gas Space Heat Energy	→	$5,913
Total Electricity	→	$72,498	Total Elec Space Heat Energy	→	$22,386

Per Suite - Annual Average

Total Energy/Suite	→	$691	Gas Used for Heat Energy/Suite	→	$49
Total Heat Energy/Suite	→	$236	Elec Used for Heat Energy/Suite	→	$187

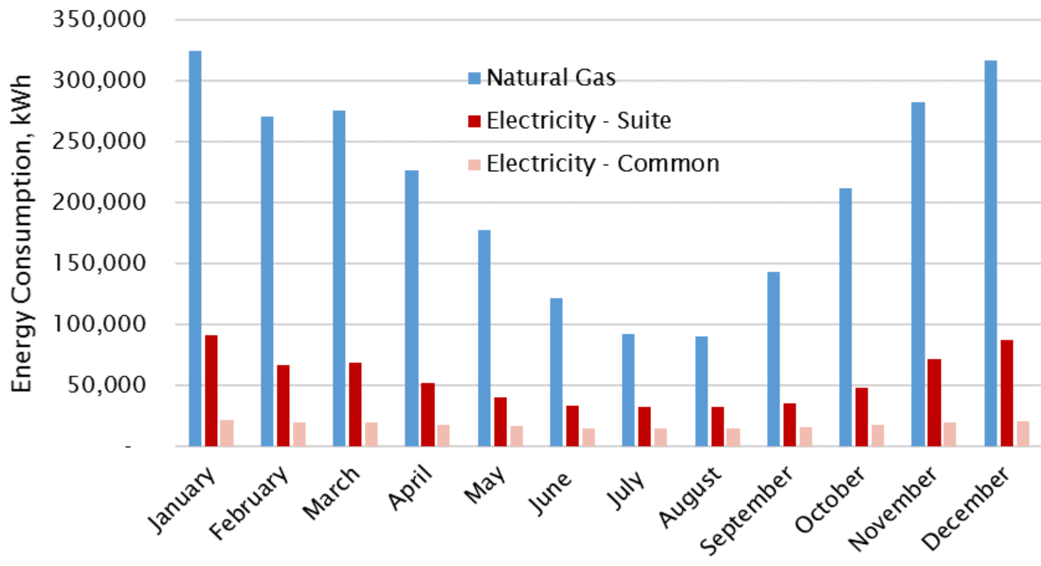
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

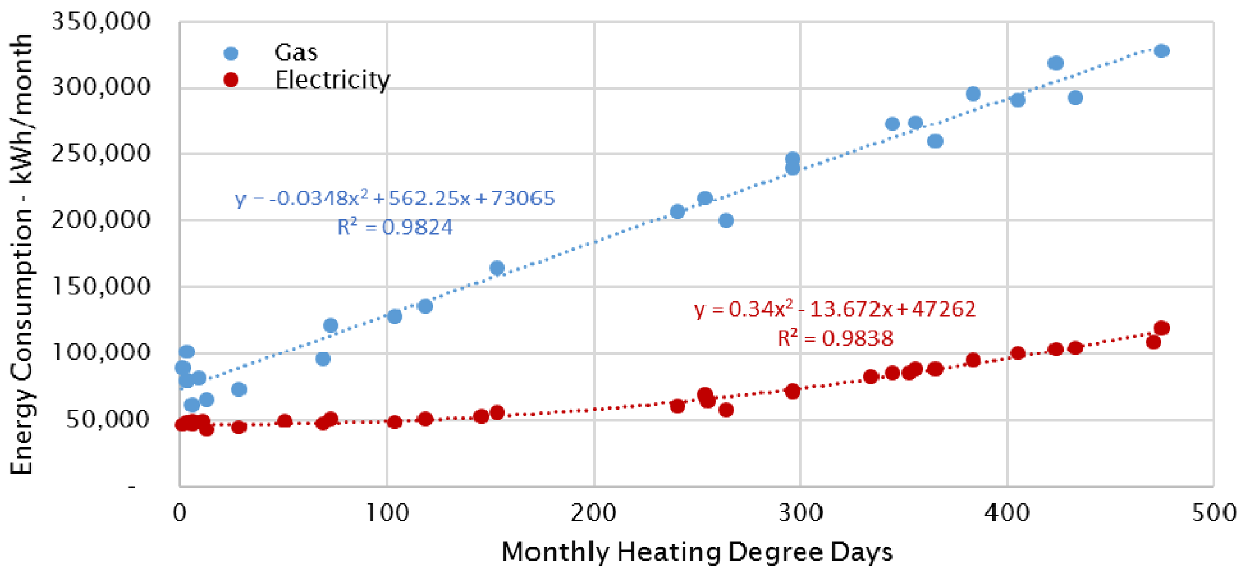
Building - Annual Average

Total CO_2	→	465	tons	Total CO_2/Suite	→	3.9	tons
Gas CO_2	→	456	tons	Gas CO_2/Suite	→	3.8	tons
Electricity CO_2	→	9	tons	Electricity CO_2/Suite	→	0.1	tons
Total CO_2/Floor Area	→	0.03	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Space Heat Consumption (Monthly)



Building Description:

Date of Construction	→	1983	
Number of Suites	→	32	
Number of Floors	→	3	
Gross Floor Area	→	3,964	m^2
Building Height	→	9	m
Floor Height (?)	→	3	m
% Glazing Area	→	14%	

Building 21

Consumption and Distribution Summary:

Gas and Electric Data From January 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	1,015,737	kWh		% Total Energy is Space Heat	→	43%
Total Energy/Suite	→	31,742	kWh		% of Space Heat Energy is Gas	→	6%
Total Energy/Floor Area	→	256	kWh/m^2		% of Space Heat Energy is Elec	→	94%

Gas - Annual Average

Total	→	208,399	kWh	(750 GJ)	% of Total Gas Used for Space Heat	→	13%
Total Consumption/Suite	→	6,512	kWh	(23 GJ)			
Total Gas Used for Space Heat	→	27,562	kWh	(99 GJ)			

Electricity - Annual Average

Total	→	807,338	kWh		Total Suite Elec used for Space Heat	→	411,859	kWh
Total Suite Consumption	→	698,077	kWh	(86%)	Suite Elec for Suite Heat/Suite	→	12,871	kWh
Total Common Consumption	→	109,261	kWh	(14%)	% of Total Elec used for Suite Heat	→	51%	
Total Consumption/Suite	→	25,229	kWh		% of Suite Elec used for Heat	→	59%	
Total Suite Consumption/Suite	→	21,815	kWh					
Total Common Consumption/Suite	→	3,414	kWh					

Energy Costs:

Gas: \$1.141/GJ Electricity: \$0.0829/kWh

Building - Annual Average

Total Energy	→	\$67,784	Total Space Heat Energy	→	\$34,256
Total Gas	→	\$856	Total Gas Space Heat Energy	→	\$113
Total Electricity	→	\$66,928	Total Elec Space Heat Energy	→	\$34,143

Per Suite - Annual Average

Total Energy/Suite	→	\$2,118	Gas Used for Heat Energy/Suite	→	\$4
Total Heat Energy/Suite	→	\$1,071	Elec Used for Heat Energy/Suite	→	\$1,067

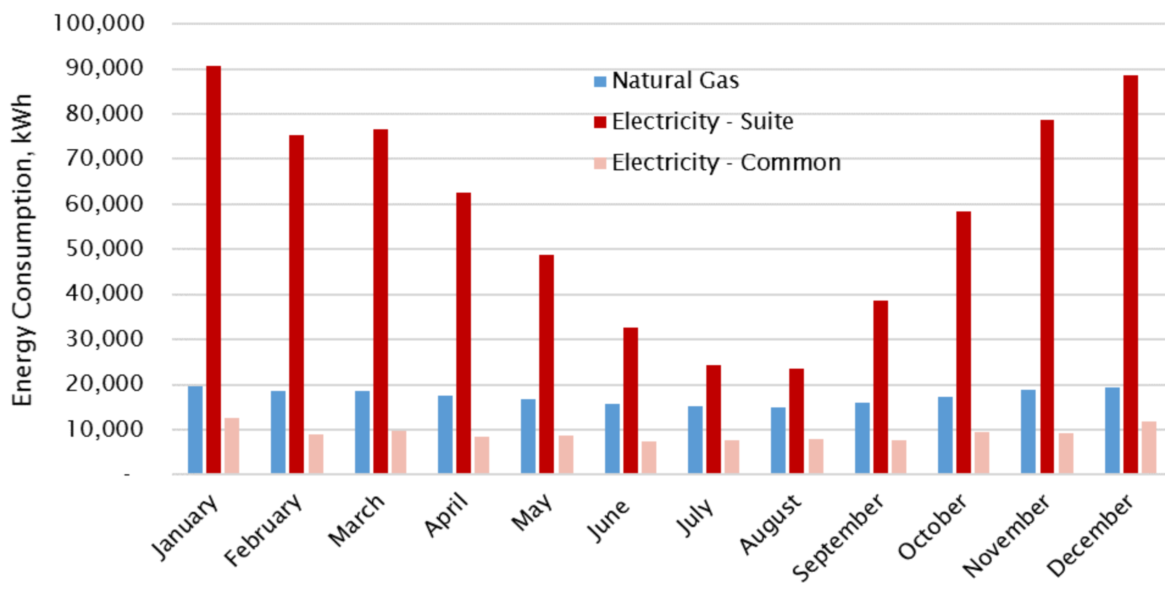
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

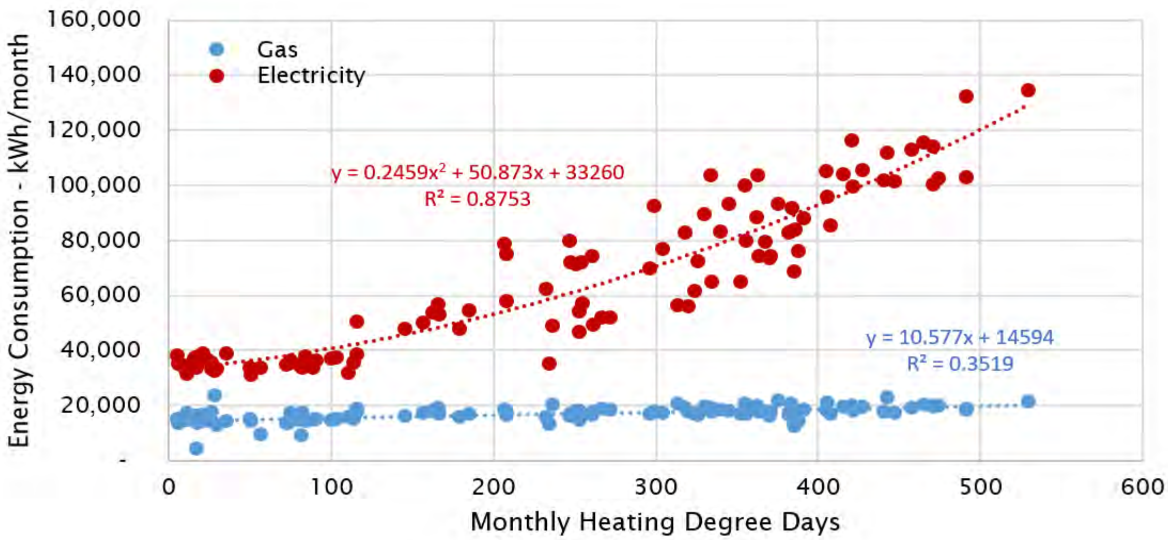
Building - Annual Average

Total CO_2	→	46	tons	Total CO_2/Suite	→	1.4	tons
Gas CO_2	→	37	tons	Gas CO_2/Suite	→	1.2	tons
Electricity CO_2	→	9	tons	Electricity CO_2/Suite	→	0.3	tons
Total CO_2/Floor Area	→	0.01	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Space Heat Consumption (Monthly)



Building Description:

Date of Construction	→	2005		
Number of Suites	→	24		
Number of Floors	→	3		
Gross Floor Area	→	3,318	m^2	(35,715 sqft)
Building Height	→	9	m	(27ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	37%		

Building 22

Consumption and Distribution Summary:

Gas and Electric Data From July 2005 to December 2013

Total Energy - Annual Average

Total Energy	→	380,326	kWh		% Total Energy is Space Heat	→	33%
Total Energy/Suite	→	15,847	kWh		% of Space Heat Energy is Gas	→	1%
Total Energy/Floor Area	→	115	kWh/m^2		% of Space Heat Energy is Elec	→	99%

Gas - Annual Average

Total	→	13,124	kWh	(47 GJ)	% of Total Gas Used for Space Heat	→	5%
Total Consumption/Suite	→	547	kWh	(2 GJ)			
Total Gas Used for Space Heat	→	655	kWh	(2 GJ)			

Electricity - Annual Average

Total	→	367,202	kWh	Total Suite Elec used for Space Heat	→	125,575	kWh
Total Suite Consumption	→	333,197	kWh	Suite Elec for Suite Heat/Suite	→	5,232	kWh
Total Common Consumption	→	34,005	kWh	% of Total Elec used for Suite Heat	→	34%	
Total Consumption/Suite	→	15,300	kWh	% of Suite Elec used for Heat	→	38%	
Total Suite Consumption/Suite	→	13,883	kWh				
Total Common Consumption/Suite	→	1,417	kWh				

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$30,495	Total Space Heat Energy	→	$10,413
Total Gas	→	$54	Total Gas Space Heat Energy	→	$3
Total Electricity	→	$30,441	Total Elec Space Heat Energy	→	$10,410

Per Suite - Annual Average

Total Energy/Suite	→	$1,271	Gas Used for Heat Energy/Suite	→	$0
Total Heat Energy/Suite	→	$434	Elec Used for Heat Energy/Suite	→	$434

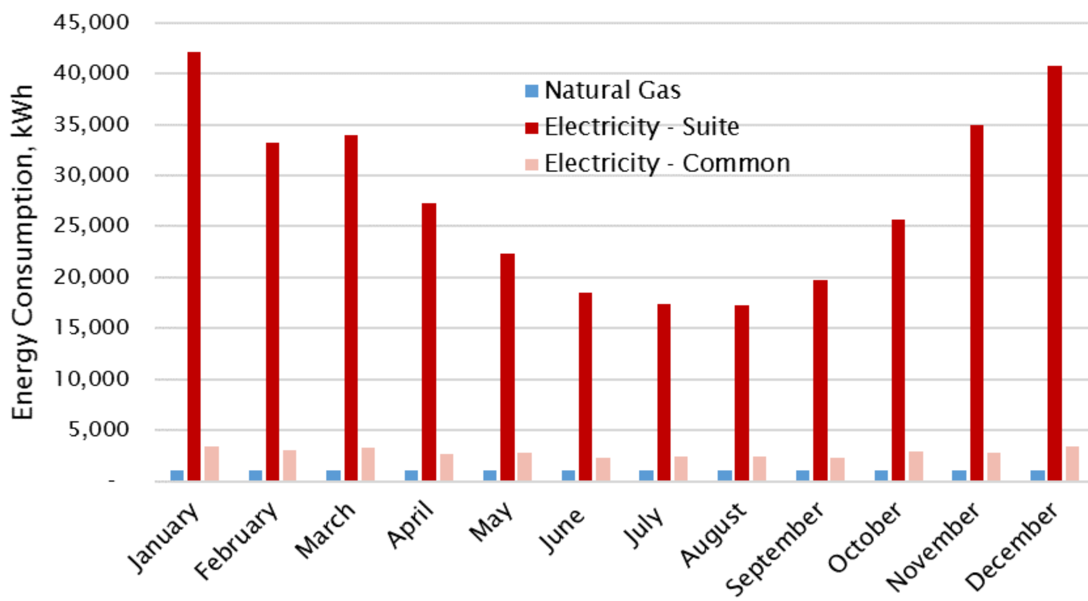
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

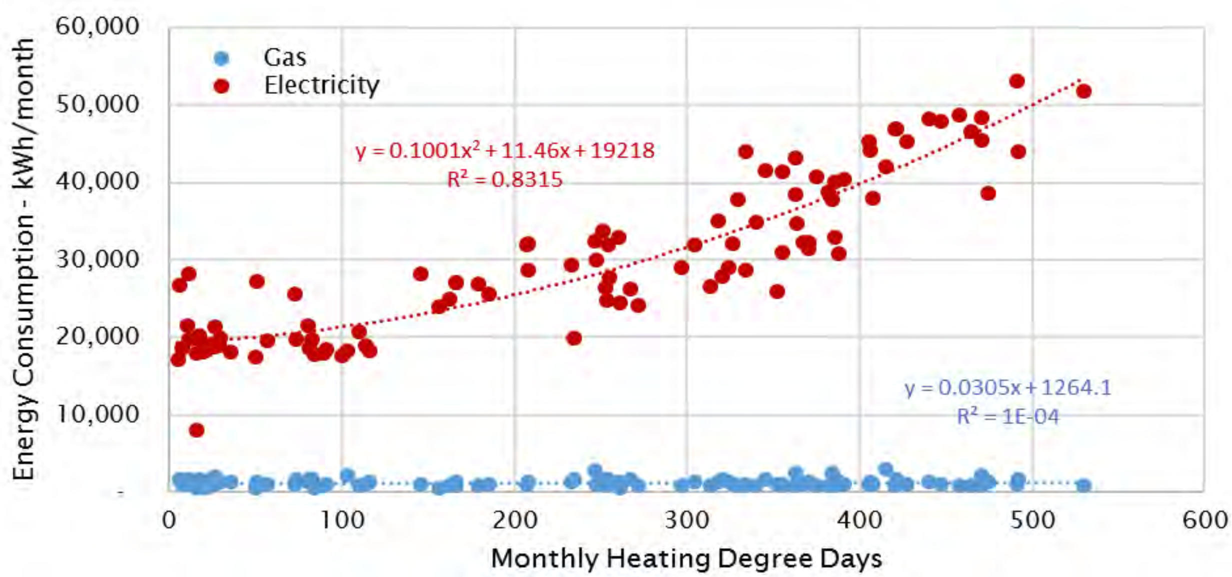
Building - Annual Average

Total CO_2	→	6	tons	Total CO_2/Suite	→	0.3	tons
Gas CO_2	→	2	tons	Gas CO_2/Suite	→	0.1	tons
Electricity CO_2	→	4	tons	Electricity CO_2/Suite	→	0.2	tons
Total CO_2/Floor Area	→	0.00	$tons/m^2$				

Average Monthly Energy Consumption Comparison

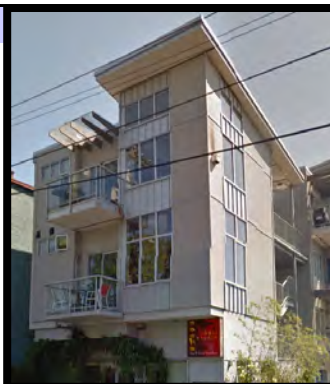


Heating Degree Days Versus Space Heat Consumption (Monthly)



Building Description:

Date of Construction	→	2006		
Number of Suites	→	44		
Number of Floors	→	3		
Gross Floor Area	→	4,180	m^2	44,993 ft^2
Building Height	→	9	m	(27 ft)
Floor Height (?)	→	3	m	(9 ft)
% Glazing Area	→	35%		



Building 23

Consumption and Distribution Summary:

Gas and Electric Data From July 2006 to April 2014

Total Energy - Annual Average

Total Energy	→	519,023	kWh		% Total Energy is Space Heat	→	38%	
Total Energy/Suite	→	11,796	kWh		% of Space Heat Energy is Gas	→	97%	
Total Energy/Floor Area	→	124	kWh/m^2		% of Space Heat Energy is Elec	→	3%	

Gas - Annual Average

Total	→	409,737	kWh	(1,475 GJ)	% of Total Gas Used for Space Heat	→	39%	
Total Consumption/Suite	→	9,312	kWh	(34 GJ)				
Total Gas Used for Space Heat	→	159,002	kWh	(572 GJ)				

Electricity - Annual Average

Total	→	109,285	kWh		Total Suite Elec used for Space Heat	→	5,596	kWh
Total Suite Consumption	→	109,285	kWh	(100%)	Suite Elec for Suite Heat/Suite	→	127	kWh
Total Common Consumption	→	N/A	kWh		% of Total Elec used for Suite Heat	→	5%	
Total Consumption/Suite	→	2,484	kWh		% of Suite Elec used for Heat	→	5%	
Total Suite Consumption/Suite	→	2,484	kWh					
Total Common Consumption/Suite	→	N/A	kWh					

Energy Costs:

Gas: $1.141/GJ Electricity: $0.0829/kWh

Building - Annual Average

Total Energy	→	$10,743	Total Space Heat Energy	→	$1,117
Total Gas	→	$1,683	Total Gas Space Heat Energy	→	$653
Total Electricity	→	$9,060	Total Elec Space Heat Energy	→	$464

Per Suite - Annual Average

Total Energy/Suite	→	$244	Gas Used for Heat Energy/Suite	→	$15
Total Heat Energy/Suite	→	$25	Elec Used for Heat Energy/Suite	→	$11

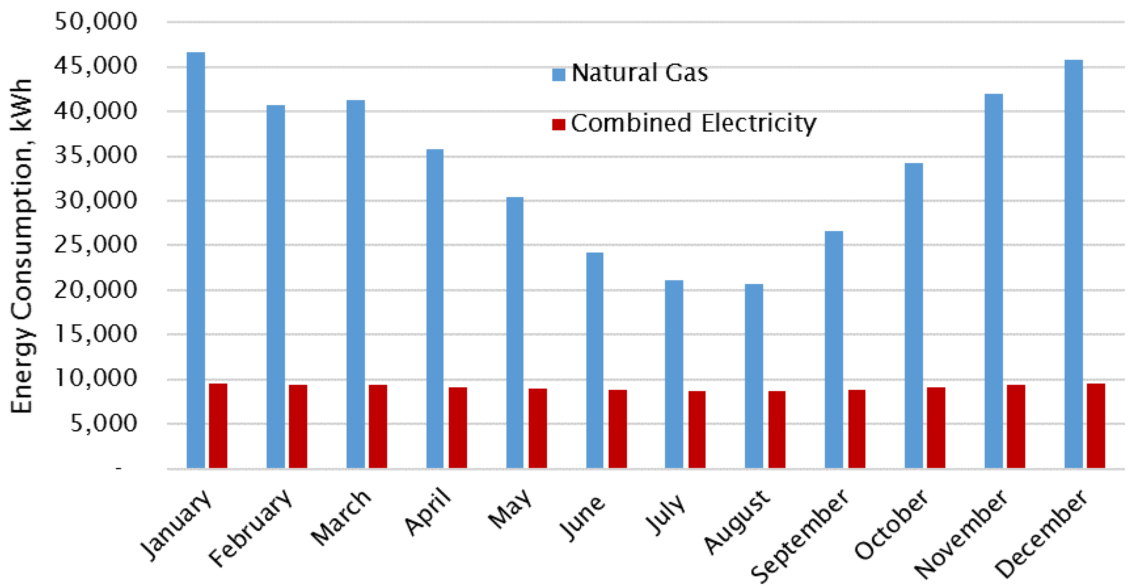
Greenhouse Gas Emission Analysis:

Gas: 49.87 kg CO_2 /GJ Electricity: 2.964 kg CO2 /GJ

Building - Annual Average

Total CO_2	→	75	tons	Total CO_2/Suite	→	1.7	tons
Gas CO_2	→	74	tons	Gas CO_2/Suite	→	1.7	tons
Electricity CO_2	→	1	tons	Electricity CO_2/Suite	→	0.0	tons
Total CO_2/Floor Area	→	0.02	$tons/m^2$				

Average Monthly Energy Consumption Comparison



Heating Degree Days Versus Space Heat Consumption (Monthly)