Co-operative Home Energy Survey
Final Report

A Survey of Co-operative Housing Federation of British Columbia Properties to Assess Energy Efficiency Improvement Opportunities

October 2012

City Green Solutions
220-620 View Street
Victoria, BC, V8W 1J6
250.381.9995
manager@citygreen.ca

Table of Contents

Executive Summary

The CHF BC Co-operative Home Energy Survey (Energy Survey) was completed between June 2010 and October 2012 and consisted of the development and implementation of an online energy consumption and building characteristics survey, collection and analysis of utility data, and detailed energy assessments of selected housing complexes. The project had three main goals:

- determine the energy performance of survey respondents from utility consumption data provided by BC Hydro and FortisBC;
- ascertain common energy retrofit opportunities by building type through detailed energy assessments of selected high-consumption buildings; and
- utilize the above data to recommend the best approach(es) for engaging and prioritizing energy assessments and retrofits throughout all CHF BC housing complexes.

The Energy Survey provides a high-level overview of co-operative housing strategic and operational performance indicators related to energy performance and compared to provincial baselines for different building types. Analysis of the combined survey results, the energy consumption data and the detailed case studies provides information on which buildings and building types are consuming more energy than average, and follows with insights and recommendations on how all the surveyed buildings can reduce their energy consumption and costs.

Overview

Sixty-seven surveys were completed by 54 housing co-ops (some co-ops have more than one building type), representing almost one-quarter of all CHF BC member co-ops in the province. Of these, two main building types were represented within the analysis as follows: single-attached homes (including duplexes and triplexes): 63% and apartments (including mid and high rise apartments): 27%. The total estimated annual energy consumption of the 3110 housing units that responded to the survey, and for which complete energy data was available, is over 156,000 GJs. The annual cost of that energy consumption is over $2.8 million dollars per year, or $900/year/unit on average. A total of 2,900 tonnes of CO_2e, or approximately 0.95 tonnes/year/unit, were emitted annually as a result of the energy consumption of the surveyed co-op units.

Limited complete consumption data for natural gas consuming single-attached units was received, which limited the analysis on the substratum of units for this building type. Single-detached units represented only 1% of the total units within the survey and complete energy consumption data was not received for these units. As a result, single-detached units were excluded from the analysis. 9% of the sample is categorized as “mixed” building type, because the data we received from these co-op units represented more than one building type. As a result, these were also excluded from analysis because of a lack of provincial comparison figures.

Energy Consumption in Surveyed Co-ops and Provincial Averages

The total energy consumption for the combined co-op housing units surveyed was below the provincial average. Despite lower occupancy rates than both the provincial and the Energy Survey sample occupancy average, apartment units consumed more energy than the provincial average for apartments. Twenty-eight per cent of all co-op units surveyed were identified to be consuming more energy than their respective provincial averages:

- 26% were apartments units.
- 2% were single-attached units.

Above-average energy consumption in apartment building types resulted from two interrelated concerns.

- Space and water heating fuel type among apartments was predominantly natural gas with lower efficiency heating systems.
- Because most co-op members living in apartment buildings do not receive and pay their bills directly (units are not individually metered), they lack the incentives and feedback with regards to energy consumption that has been shown to contribute to higher energy consumption.

Despite the lower-than-average energy consumption among single-attached units the average energy cost for these single-attached units was higher ($939 per unit) than for the higher-than-average-energy consuming apartment units ($873 per unit). The higher energy costs for the single-attached units is caused by the fact that these units mostly use electricity whereas the majority of apartment units use less expensive natural gas for space and water heating.

Summary of Key Case Study Findings:

The following case study findings are highlighted here to provide an understanding of common energy upgrade options for single-attached and apartment complexes.

Single-attached units case study summary:

- Electricity as the exclusive energy source
- Located in the Lower Mainland/Vancouver Island climate zone
- Below provincial average modeled energy consumption: 41.19 GJ/unit/year
- Relatively high modeled energy costs: $1,030/unit/year
- If the combined upgrade recommendations were implemented for the single-attached case study, the units could realize a 38% reduction in energy consumption and costs.

Low-rise apartment units (fewer than 5 stories) case study summary:

- Natural gas space and water heating
- Located in the Lower Mainland/Vancouver Island climate zone
- Above provincial average modeled energy consumption: 64.62 GJ/unit/year
- Modeled energy costs: $830.23/unit/year

- If the combined upgrade recommendations were implemented for the low-rise apartment case study, including the windows, air sealing, baseload upgrades and new boiler, the building could realize a 59% reduction in consumption and a 53% reduction in energy costs.

High-rise apartment units (5 stories or more) case study summary:

- Natural gas space and water heating
- Located in the Lower Mainland/Vancouver Island climate zone
- Above provincial average modeled energy consumption: 73.00 GJ/unit/year
- Modeled energy costs: $1058.69/unit/year
- If the combined upgrade recommendations were implemented for the high-rise apartment case study the building could realize a 50% reduction in energy consumption and a 33% reduction in energy costs. Note: achieving a 50% energy reduction from current levels would only bring the building in line with provincial energy consumption averages for this building type.

Key Energy Survey Recommendations

The following four key Energy Survey recommendations provide a foundation for next steps for the CHFBC to reduce energy consumption for co-op members.

1. CHF BC should consider building organizational capacity to manage energy use in co-op housing by acquiring a co-op sector Energy Manager.
2. For surveyed apartment co-op units with above-average energy consumption CHF BC should use the list of high energy-consuming buildings generated by the Energy Survey to inform above-average energy consuming buildings of their consumption and connect those buildings with efficiency incentive programs (*e.g.* Fortis BC Efficient Boiler Program).
3. For electrically-heated single-attached units CHF BC should inform each of these buildings that there are opportunities for reducing energy consumption and energy costs and connect these building buildings with efficiency incentive programs (*e.g.* LiveSmart BC Efficiency Incentive Program).
4. CHF BC should consider setting a bold energy conservation reduction target. The target should be realistic but also inspirational so that the co-op housing sector realizes the multiple benefits of improved building energy performance and reduced energy consumption.

Introduction

The Co-operative Housing Federation of BC (CHF BC) is a progressive organization whose commitment to efficient and sustainable operations is evidenced by their "2020 Vision" program developed with CHF Canada. The CHF BC 2020 Vision includes standards for building maintenance and a commitment to environmental sustainability. In view of this commitment, CHF BC contracted City Green Solutions Society (City Green) to provide a "Housing Energy Inventory Analysis" of the co-op housing sector, which is referred to as the "Energy Survey" here after.

The Energy Survey provides an inventory and analysis of the energy performance and building characteristics of survey respondents. The Survey sought to answer the following questions:

- What is the current energy performance of the survey sample?
- What is the energy reduction potential for the survey sample?
- What is the best approach for engaging and prioritizing CHF BC housing complexes for energy efficiency retrofits?

The goal was to develop a high-level overview of the characteristics and energy usage of the sample CHF BC housing stock and to develop recommendations to prioritize and address energy efficiency retrofit opportunities. The approach used to satisfy the goal consisted of four integrated steps, as follows:

- Survey of building energy performance and characteristics: Co-op housing associations have the most up-to-date knowledge of the condition of their buildings, including issues and previously completed retrofits; these are the representatives to whom the survey was directed. The survey sought to establish a database of CHF BC buildings including characteristics such as regional distribution, building type, age of building, number of units, and space/water heating fuel type. The end results of this building survey have been made available to the CHF BC.
- Utility data collection: BC Hydro provided electricity data and FortisBC provided natural gas consumption data for survey respondent's buildings over at least the previous 4 years.
- Combined data analysis: Survey and utility consumption data were subsequently merged and analyzed. Resulting details on total consumption levels, average consumption and energy intensity were filtered to indicate energy performance trends by building type, billing structure and main heating fuel type; were compared with provincial baselines; and were used to inform energy retrofit recommendations.
- Detailed energy assessments: Energy assessments were performed on three complexes that would make good case studies in terms of identifying common energy saving retrofit opportunities by building type. These case studies would inform strategic energy management recommendations that can be implemented in the immediate and short term.

Project Partner Roles

The Energy Survey is an initiative of CHF BC which was funded by BC Hydro and FortisBC, supported by BC Housing, and implemented by City Green Solutions. The following is a summary of project partner roles.

Co-operative Housing Federation of British Columbia

- Provided overall Energy Survey project guidance including communication updates to stakeholders and task coordination.
- Provided FortisBC and BC Hydro with the addresses of the Energy Survey participants in order that the utilities could extract energy consumption and cost data for those buildings.
- Provided input to the survey content and information sought from respondents.

BC Hydro

- Provided funding for the Energy Survey.
- Provided seven years of energy consumption data and estimated cost data for survey respondent's buildings.
- Provided input to the survey content and information sought from respondents.

FortisBC

- Provided funding for the Energy Survey.
- Provided four years of energy consumption data and estimated cost data for survey respondent's buildings.
- Provided input to the survey content and information sought from respondents.

BC Housing

- Provided input to the survey content and information sought from respondents.

City Green

- Constructed the research methodology.
- Developed the final survey.
- Developed the benchmarking process for all building types.
- Developed privacy agreements with BC Hydro and FortisBC for the transfer of utility data to the CHF BC office and the transfer of the CHF BC housing list to BC Hydro and FortisBC.
- Received the utility consumption data from the utilities.
- Provided data analysis.
- Conducted detailed energy assessments on selected co-op complexes.
- Developed the final written report with conclusions and recommendations.

Overview of CHF BC Buildings

There are over 261 co-op housing associations comprising more than 14,500 housing units in British Columbia, and of these, 237 are members of the CHF BC.[1] The CHF BC does not currently maintain a database containing information about the energy consumption characteristics of their member buildings. The Energy Survey initiative is the initial step to gather such information.

The following table provides a summary of the average yearly energy consumption, related cost estimates, and greenhouse gas emission estimates for 3110 of the 3719 units surveyed.[2] The table indicates that in total 156,100 GJ of energy was consumed annually to power the units surveyed, or about 50.2 GJ/year/unit. This cost almost 2.8 million dollars, or about $900/year/unit on average. The table also shows that about 3,000 tonnes of CO2e/year were emitted as a result of the co-operative unit energy consumption, or about .95 tonnes/year/unit. The units surveyed used less energy on average than the average housing unit in BC. The exceptions are low-rise and high-rise apartment units, which will be discussed in more detail throughout this report.

Table 1: Surveyed co-operative units average yearly energy consumption and cost, and CO2e emissions

Building Type	Energy Use/Year (GJ)	Total CO2e (tonnes) (est.)	Total Costs (est.)
Single-attached Home	88,316	946.72	$1,732,801
Low-rise Apartment	14,001	454.26	$215,258
High-rise Apartment	39,268	1,336.36	$585,960
Single-detached Home[3]	790	5.60	$16,537
Mixed	13,775	224.15	$254,859
All types	156,152	2,967.09	$2,805,417

Strategic Benefits to Managing Energy in Co-op Housing

The primary strategic benefits to managing energy use in co-op housing include:

1. Improving the performance of aging housing stock;
2. Reducing utility costs to housing associations and co-op members;
3. Supporting provincial legislation to reduce GHG emissions;
4. Reducing the impact of uncontrolled variable costs on asset management and planning; and
5. Encouraging a co-op organizational culture that conserves and values energy.

[1] http://www.chf.bc.ca/what-co-op-housing and July 20, 2012 correspondence from F. Jackson.

[2] While some information was retained for all 3971 units, complete utility information was only received for 3110 units and as a result analysis was only completed on 3110 units.

[3] The data derived from the survey results suggested that the utility data for the 38 single-detached home units was incomplete. Whereas the survey data indicated that several housing units where heated with natural gas boilers, no natural gas data was identified for these homes.

(1) Improving the performance of aging housing stock
The co-op units surveyed are aging. The vast majority (94%) of co-op housing units were constructed prior to 1992, making almost all units surveyed at least 20 years old. BC Housing indicates in its Replacement Reserve Schedule and List[4] that heating, ventilation and cooling systems should be replaced every 15-20 years[5]. Older buildings represent opportunities for cost-effective energy efficiency upgrades during scheduled replacement of mechanical systems.

(2) Reducing utility costs to housing associations and members
Some co-op members live on fixed, low incomes and have limited capacity to adjust to fluctuating energy prices. Members that live in co-op housing and pay utilities in addition to housing charges will experience the most direct effects of rising home energy prices.

(3) Supporting provincial legislation to reduce GHG emissions
The Province has committed to reducing GHG emissions to 33% below 2007 levels by 2020.[6] The Province also aims to reduce energy demand per home by 20% by 2020.[7] Understanding the energy performance and energy efficiency opportunities in co-op housing can inform methods to reduce GHG emission from building energy use, thereby assisting the province to achieve GHG emission reduction targets.

(4) Reducing the impact of uncontrolled variable costs
Increasing utility costs pose a challenge to housing co-ops. Occupant behaviour, the physical state of buildings, and the efficiencies of the equipment that runs buildings can result in energy use orders of magnitude greater than highly efficient buildings occupied by members who have been educated about low-energy behaviours. Increases in utility costs exacerbate the existing energy use issues. Prioritizing energy upgrades and managing energy has the dual benefits of immediate cost reductions and dealing with deferred capital renewal facing housing associations as buildings age. Larger capital projects to improve building energy efficiency can represent significant long-term cost savings and provide a means to control and predict energy expenditures.

(5) Encouraging a co-op organizational culture that conserves and values energy
Developing a culture of conservation begins with the CHF BC and its member co-ops setting the tone that reducing the use of energy is a priority and that energy conservation has many benefits including increasing home comfort and providing for household financial savings. Given the relatively low energy use among co-op units surveyed, it may be that a culture of conservation already exists within the co-op housing sector. However, further analysis of the utility data indicates that apartment buildings consume more energy than the provincial average, which appears to be partially a result of occupant energy use patterns. As a result further actions to ensure that energy conservation is an organizational value and the provision

---

[4] Capital replacements are building components that wear out over time. The replacement reserve list includes capital items with estimated life years of 5 to 25 years, and a total cost greater than $2,500.
[5] BC Housing Standardized list of replacement items including estimated useful life.
[6] Province of BC. *Energy Efficient Buildings Strategy: More Action, Less Energy*. The Ministry of Energy, Mines and Petroleum Resources, 2007.
[7] Ibid.

of tools and information to assist co-op units reduce energy consumption may result in increased uptake of and support for energy conservation activities.

Challenges to Managing Energy Use in Co-op Housing

There are five main challenges to managing energy use in co-op housing:

1. Up-front capital costs associated with energy efficiency upgrades;
2. Limited administrative and operational capacity;
3. Co-op awareness of the benefits to managing energy use;
4. Competing core needs; and
5. Management systems for monitoring energy use and verifying energy savings.

(1) Up-front capital costs associated with building energy efficiency upgrades
Up-front costs associated with energy upgrades are one of the most significant barriers to energy management in co-op housing. Financing options need to provide two levels of assurance: (a) The projected energy savings can be verified and are reliable; and (b) The upgrades will provide a safe return on investment through the energy savings achieved and costs reduced.

(2) Administrative and operational capacity
The numerous responsibilities and varied operational activities within energy management are extensive. From the initial budgeting of capital costs and organizing energy assessments, to project oversight of building retrofits, and tracking and monitoring energy performance, the capacity required of housing providers is beyond the existing organizational resources of most associations. Co-operative members and co-op building managers, where they exist, are busy and typically have limited capacity to monitor and assess the applicability of the changing energy conservation programs, incentives and rebates that are available from utilities and government. Even when co-ops are informed about and eligible for existing energy conservation programs, co-op representatives may often find it difficult to find the time to engage with program delivery agents to complete energy assessments and installations.

(3) Co-op awareness of the benefits to managing energy use
Energy management is typically implemented by organizations when an individual with decision making authority is aware of the short and long-term benefits of reduced (and controlled) energy use. Although cost savings are not the only benefit to controlling energy use, it is a strong motivator for reducing energy use at the building level.

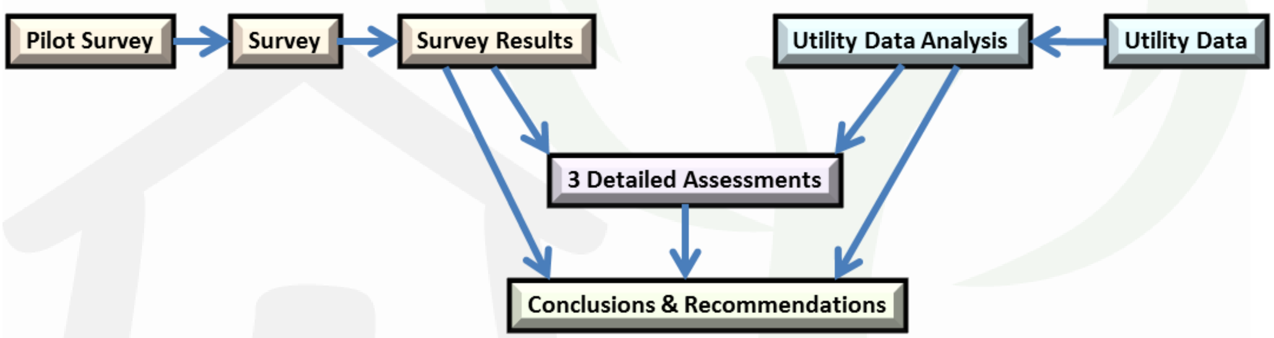
(4) Competing core needs
The core needs of housing co-ops are typically those related to providing and maintaining safe, clean and functional housing (maintaining building envelope, painting, replacing carpets and flooring, upgrading appliances, etc.). Recognizing that co-ops create budgets that have to account for numerous competing projects is an important element to understanding barriers to energy management in co-op housing.

(5) Managing and tracking building energy performance and prioritizing energy efficiency opportunities
No central energy performance monitoring system has been developed for the co-op housing sector. Along with gathering housing characteristics and baseline energy information, tracking ongoing building improvements and energy performance is an essential element of an effective energy management strategy. With limited funding available to co-ops for energy efficiency upgrades and varying levels of cost effectiveness for energy efficiency upgrades, the ability to identify energy performance and prioritize energy efficiency upgrade expenditures is critical. Without a process to prioritize energy efficiency expenditures, funding for energy efficiency upgrades may not achieve significant cost-effective energy savings or GHG emission savings for co-ops.

Methodology

The following diagram shows the relationships between the aspects of the Energy Survey research design, which is based on the combination of three streams of data: survey data, utility data, and detailed assessments.

Figure 1: CHF BC Energy Survey research design



Pilot Survey: An initial online pilot building energy and characteristics survey was developed as a means to gather input from program partners and a small group of co-op participants. The pilot survey included specific sections for each of the three main building types: apartments, single-attached building, and single-family detached homes. The pilot survey was distributed to ten selected housing co-ops who agreed to provide feedback on the survey design in addition to responding to the survey questions. The most significant change resulting from the pilot survey was the decision to create three separate surveys - one for each building type. Although it was acknowledged that this would require a small number of co-ops with multiple building types to complete multiple surveys, it was deemed to be much easier to administer and complete for the majority of single building type co-ops.

Survey: Both the pilot survey and the survey distributed were ambitious in the amount and scope of information being requested, including information about unit type, amount of Co-op live-space, building construction, location, upgrades performed, and co-op utility payment structures. However, only one survey was requested for each housing type that existed in a co-op. This meant that it was possible that several buildings of different vintages could be represented by a single survey and as a result some incommensurable differences between different buildings, like construction material, or construction year, were ignored. The survey was hosted online through a customized survey tool and was developed in collaboration with stakeholders, including BC Hydro, CHF BC, Fortis BC (then Terasen Gas Inc.), and the Co-ops who participated in the pilot survey.

The survey was distributed to all co-ops known to CHF BC as an attempt to engage with as many co-ops as possible. As such, no attempt was made to attain a statistically representative sample and this report cannot claim that the findings from the Energy Survey analysis precisely represent the co-op housing sector as a whole.

Utility Data: Utility data was provided by BC Hydro and FortisBC for all co-op associations that completed the survey. All addresses transcribed by the survey participants were extracted from the survey tool and delivered to the utilities. To protect the privacy of those individuals who lived in the co-op units surveyed, the data was provided only for addresses that had at least seven units represented in each piece of utility data. Up to seven years of data was requested to allow for some normalization of weather over a longer timeframe, and at least four years of data was provided by each utility. Both Fortis BC and BC Hydro delivered the data in monthly consumption figures, which provided a picture of the usage patterns over course of year, including the consumption differences between heating and non-heating season.

Survey Results and Utility Data Analysis: Through an overview of the data it was discovered that several buildings that should have filled out two different surveys filled out only one. This, in part, necessitated the creation of a mixed category. The review of the data also showed that many respondents did not completely fill out the address information for their co-op. Whereas the survey requested that respondents articulate each unit address that receives a BC Hydro bill, many respondents included only one address. This allowed for some ambiguity in the data provided by the utilities. In one example the consumption of a selection of co-op units was about 5 times the provincial average and about 10 times the average of the other co-op units surveyed. Lower consumption figures also resulted in the removal of two blocks of co-op units. The lowest consumer was 1.4 GJ per year, which is the amount of energy used to heat two square meters (or roughly 20 square feet) of an average BC residence in 2003. Those units on either end of the energy use spectrum, be it extremely high or extremely low, were removed from the analysis.

Results were then sorted by energy intensity per unit. A list of the ten buildings with the highest energy intensity was created and from this list three building complexes were targeted for detailed energy assessments. Analysis was also performed on the co-op units surveyed to compare these units against the provincial averages found in the most recent Statistics Canada Survey of Household Energy Use.[8]

---

[8] Natural Resources Canada's Office of Energy Efficiency. *Survey of Household Energy Use: Detailed statistical report*. 2007, pp. 162 – 191. Retrieved from: http://oee.nrcan.gc.ca/publications/statistics/sheu07/pdf/sheu07.pdf

Detailed Assessments: Three co-op building complexes were selected as good candidates for detailed energy assessments. The detailed energy assessments and case studies provided the following:

- Modeled energy consumption from baseloads, water heating and space heating;
- Modeled consumption and costs (per unit intensity);
- Building characteristics (type, size, insulation levels and year of construction); and
- A summary of energy upgrade opportunities that includes suggested upgrades, projected post-retrofit energy consumption, energy savings potential per upgrade, cost savings per upgrade, and upgrade costs and energy savings itemized as low/medium/high.

Summary of Limitations

There are a number of limitations with the methodology and approach that was utilized for this project. These are explained below:

- **Sampling**: No sampling technique was applied to the energy consumption and building characteristics survey. Instead, the survey was distributed to all co-ops by the CHF BC, including co-ops that were not members of CHF BC. This distribution method was employed to secure as much participation as possible. However, without sampling, this report cannot claim that the findings from the Energy Survey analysis precisely represent the co-op housing sector as a whole.
- **Combining data**: Each co-op was asked to fill out one survey for each unit type that existed in the co-op. As such, some building level data, like variation between construction material, and construction year, was lost. Further, in order to protect individual account holders' privacy utility data was collected into groupings of accounts with no fewer than seven units represented. This prevented building level analysis *per se* and as a result, unit type was used as the unit of analysis.
- **Inaccurate data entry**: Upon review of the completed surveys it was identified that some of the data entered was incorrect. These errors that occurred may have been a result of a misunderstanding or misreading of the question, an estimate being made on the response, or from the question not being clear enough. In some cases, where accurate data could not be secured through a follow up clarification, data was removed from the survey response.
- **Survey length**: The development of the survey was a process that incorporated input from multiple stakeholders which in the end resulted in a large number of questions being included within the survey, some more difficult to answer than others. Upon reviewing the survey data it became clear that much of the information provided will be valuable to the CHF BC for retaining information on individual member building characteristics. However much of the data provided was not directly incorporated into the larger analysis of the Energy Survey, which provides information on the survey respondents by unit type rather than by individual building. In short, a shorter survey would be recommended for future Energy Survey projects of this type. Future surveys should more closely mimic the questions found in the Statistics Canada Survey of Household Energy Use.

Timeline

The Energy Survey project implementation spanned more than two years, longer than anticipated. Several reasons can be noted for the longer than originally anticipated timeline:

- The energy performance and building characteristics survey was significantly modified following the pilot survey phase. Following the pilot phase, the survey was split into three separate sections by building categories: Single-detached home, single-attached home, and apartment buildings.
- After the survey was finalized and full participation was invited, the response rate was lower than desired. In an attempt to increase participation the survey was kept open roughly three times longer than originally planned.
- It took longer than initially anticipated to access the utility energy consumption data - over nine months from request for data to data being received.

Key points in the timeline of the project are shown below:

- May 2010 — Contract between CHF BC and City Green signed
- May 2011 — Pilot survey started
- July 2011 — Survey notification sent to all co-ops
- August 2011 — Initial utility data request sent to FortisBC
- August 2011 — Initial utility data request sent to BC Hydro
- November 2011 — Survey closed to further respondents
- May 2012 — BC Hydro utility data received
- May 2012 — FortisBC utility data received
- June/July 2012 — Analysis of survey and utility data
- July 2012 — Co-ops selected for detailed assessments contacted
- September 2012 — Assessments completed
- October 2012 — Energy Survey report completed

Results and Analysis

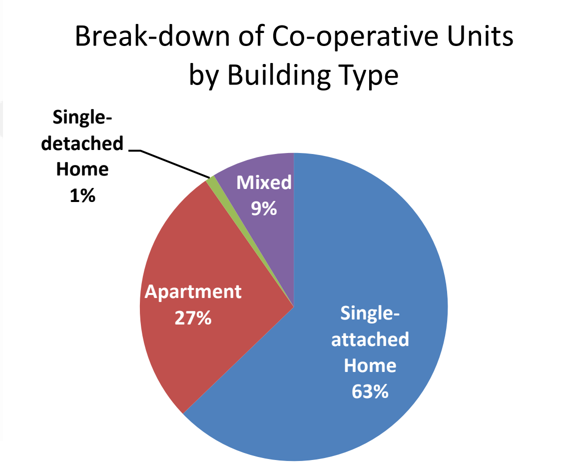
Co-op Unit Dwelling Characteristics

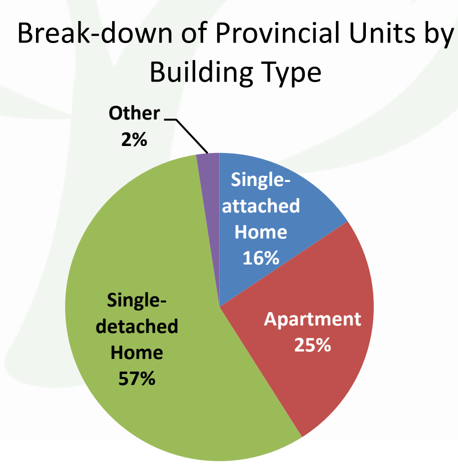
Sixty-seven surveys were completed by 54 housing co-ops, which is close to one-quarter of all 237 CHF BC member co-ops. In British Columbia, there are over 261 housing co-ops comprising more than 14,500 housing units, and of these, 3719 units are represented by the sixty-seven surveys completed, or roughly 26% of all co-op housing units in the province. While it is impossible to tell how representative the surveyed units are of all co-op housing units in the province, the information presented in the Energy Survey provides valuable insights into the energy use of a significant portion of the co-op housing sector.

The co-op units that responded to the survey were largely single-attached homes. The breakdown of units by building types is as follows (Figure 2): single-attached homes 63%, apartments 27%, single-family detached 1%, mixed 9%. The category named “mixed” was a result of re-identifying co-op units of two different housing types, but for which information, such as utility data, was mixed.

The building type breakdown of the provincial housing stock differs from that of the co-op units surveyed (Figure 2). In 2007 the housing in the province was largely made up of single-detached units and apartment units, whereas the co-op units surveyed are largely single-attached units and apartment units. Single-detached units comprised 57% of the dwellings in BC in 2007, but less than 1% of the co-op units surveyed, and these units were excluded from the energy analysis because of incomplete energy data. The exclusion of single-detached units from the analysis effectively lowers the average consumption of the co-op units surveyed in comparison to the provincial average, since single-detached buildings generally consume more energy per housing unit than do other building types. This is partially because single-detached units are larger: in 2007, housing units of this type in Canada were observed to contain 149 m^2 of heated area on average, which is roughly 16% greater than the Canadian average of all housing types. Single-detached units are also generally more energy intensive than most other housing types: in 2007, single-detached units in Canada consumed .93 GJ/m^2, which is 27% higher than the next-highest consuming building type, the single-attached units. The lower consumption patterns observed in the sample is partially a result of the particular type of buildings that made up the sample.

Figure 2: Co-operative housing units by building type and Provincial housing units by building type

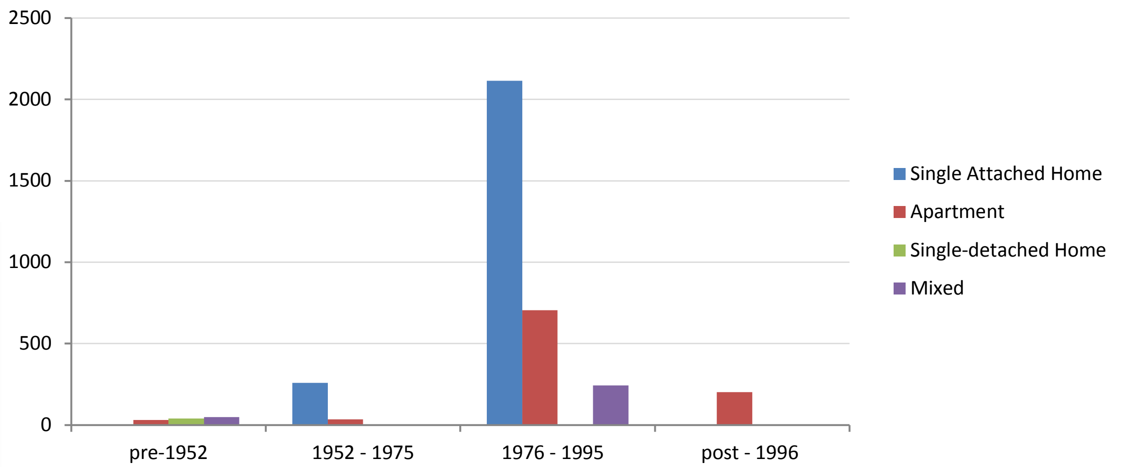




The construction year of the co-op units surveyed ranges from 1905 to 2002 (Figure 3). The extensive range in the age of the surveyed co-op units implies that co-op housing associations face challenges improving the efficiency of heritage buildings and older buildings, as well as maintaining and improving on the efficiency of more modern buildings. That said, the vast majority of co-op units surveyed were built between 1976 and 1996 when single-attached houses were less insulated than today, and when apartments were built using exposed concrete and more single-pane windows than today. There is an above-average representation of this age range in comparison to the average BC housing stock. The average age of the provincial housing stock is more evenly distributed, with 28% of units having been built before

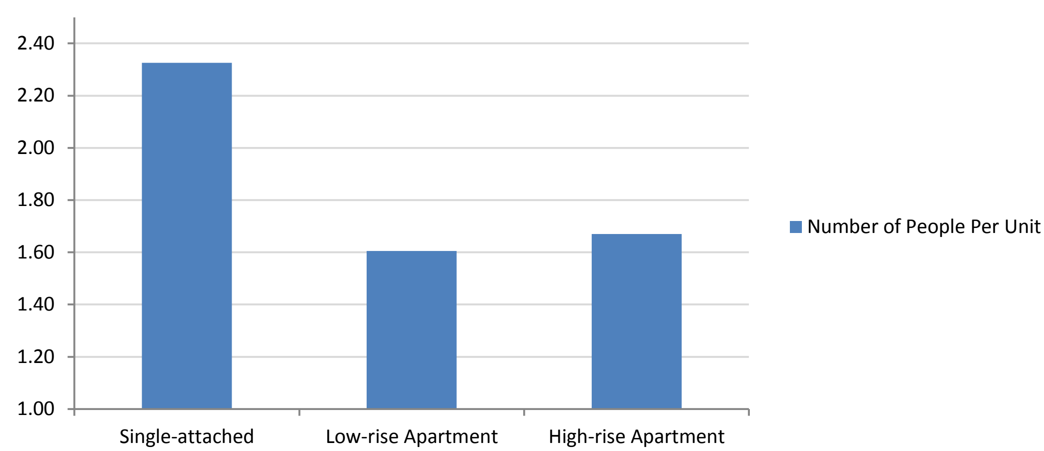
1970 (as compared to 11% of those units surveyed), and 27% built after 1989 (as compared to 11% of those units surveyed).

Figure 3: Co-op units by building type and year constructed



The occupant density (i.e. persons per unit) in the co-ops surveyed was 2.1 which is below the BC average, which according to the 2006 census conducted by Statistics Canada was 2.5 people per unit. All surveyed building types are below the Canadian average for occupancy, but the survey data shows that single-attached units contain more persons per unit than apartments. [9]

Figure 4: Number of people per unit by building type in surveyed co-ops



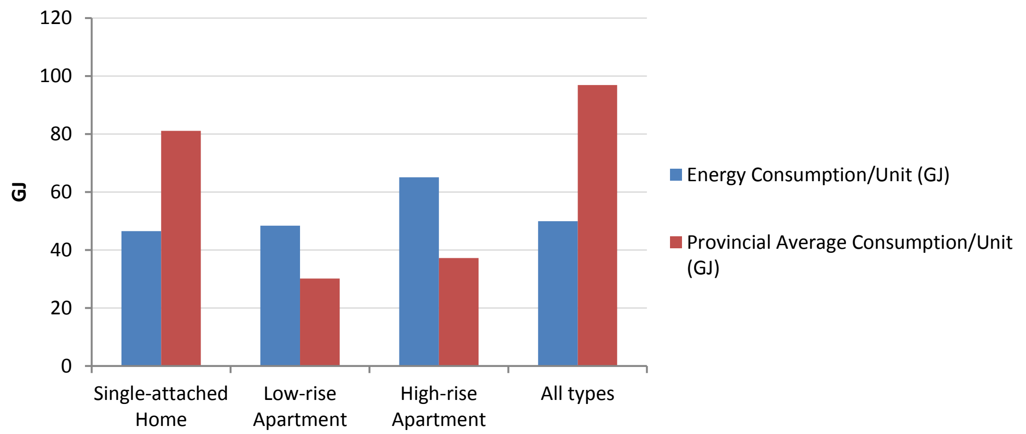
Co-op unit's energy consumption profile:

An analysis of energy consumption shows that the co-ops surveyed consumed less energy than the average BC dwelling (Figure 5). Single-attached units, which make up the majority of the sample, use less energy than average consumers, but low-rise (fewer than 5 stories) and high-

[9] It should be noted that the division between low-rise and high-rise apartment units is necessary here and in the much of the analysis below for the purposes of comparison to the provincial averages.

rise apartments (5 stories or more) consumed substantially more energy than the provincial averages for the respective building types. The low-rise apartment units surveyed consumed 24.3 GJ/unit more annually than the provincial average for that building type, and the high-rise apartment units surveyed consumed 27.8 GJ/unit more annually than the provincial average for that building type. It should also be noted that high-rise apartment units are the most energy intensive units surveyed overall, consuming 65.1 GJ/unit/year.

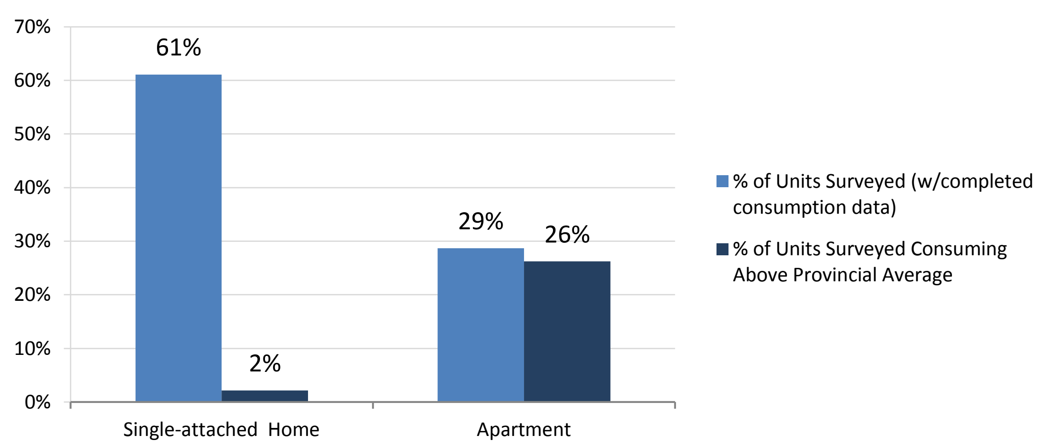
Figure 5: Co-operative units by building type: Measured consumption versus provincial averages



The figure below outlines the pattern of above-average energy consumption levels in the co-op housing units surveyed. Twenty-eight per cent of all co-op units surveyed were consuming more energy than their respective provincial averages:

- 26% were apartments units.
- The remaining 2% were single attached units.

Figure 6: Co-op Units Surveyed : Portion by Building Type vs. Portion Consuming Above-Average



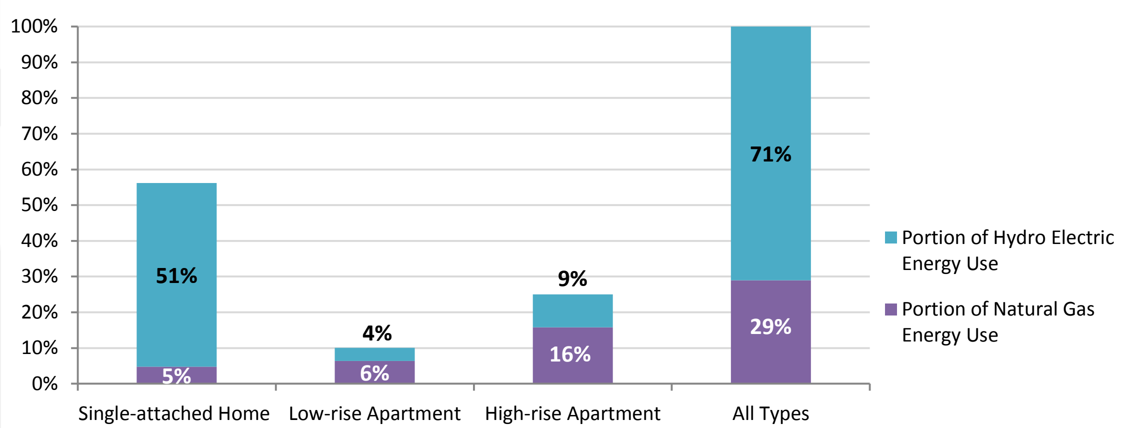
The factors that may account for this above-average energy consumption include:

1. **Water and space heating fuel types and system efficiency affect consumption.** Space and water heating fuel type among apartments was predominantly natural gas with lower efficiency heating systems. The 2% of single-attached units that were found to have above average consumption also used natural gas for space and water heating.
2. **Of those surveyed, apartments units face more occupant related energy use challenges than do single-attached units.** Real consumption is an entanglement of equipment efficiency with people's usage patterns. Because many co-op members living in apartment buildings do not receive and pay their bills directly (units are not individually metered), they lack the incentives and feedback with regards to energy consumption that has been shown to contribute to higher energy consumption.

Fuel Type

The data from co-ops surveyed indicates a higher percentage of electricity consumption than natural gas consumption. The pattern of above average electricity use is especially strong with the single-attached home units surveyed, 86% of which reported using electricity for space heating. In comparison, provincially the portion of natural gas consumed is higher at 52%, with electricity accounting for 36% and other energy sources such as wood or propane accounted for the remaining 12%.

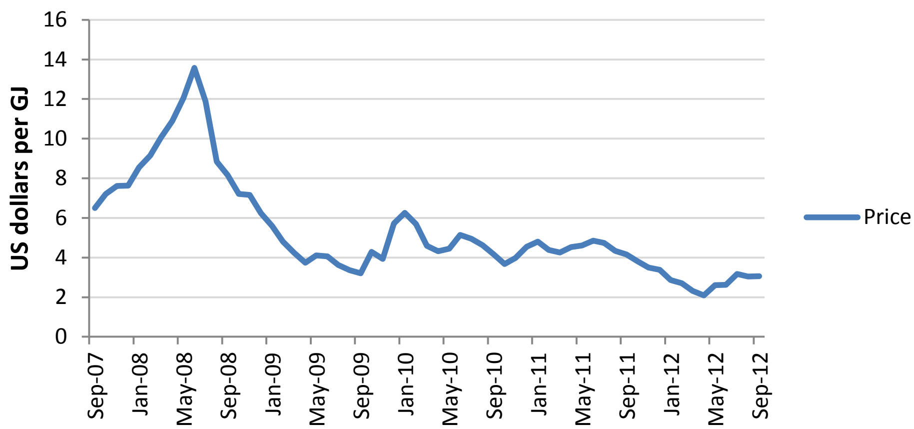
Figure 7: Relative electricity and natural gas consumption in surveyed co-op units



As a fuel, electricity is currently more expensive per unit of energy than natural gas. At current rates, BC Hydro electricity costs between $18.89 and $28.31 per GJ for residential customers, whereas Fortis BC natural gas costs between $9.21 and $17.79 per GJ. For the units surveyed, actual cost was between $19.90 and $22.13 per GJ for electricity and between $11.62 and $11.81 per GJ for natural gas. As a result, and despite the lower average energy consumption, the average energy cost for single-attached units was higher ($939 per unit) than for apartments ($873 per unit).

The major driver of the costs for consumers is the commodity price. The figure below shows that the cost of natural gas on the open market has failed to recover since the global financial crisis and the result has been lower prices for the consumer. The price of electricity, by contrast, has gone up over the same period, and is scheduled to increase further. The reason for the increase in electricity prices is the expanding demand for electricity in the province of BC and the relative cost of producing power. For example, in 2006 BC Hydro paid $24.31 per GJ on average, whereas in 2009 they paid $34.44 per GJ to increase the electricity supply created in the province. These costs are external to the costs of maintenance and the infrastructure used to distribute this new power to consumers. The high use of electricity in the co-ops surveyed is the primary reason that the cost per GJ paid to operate single-attached units is higher than apartments.

Figure 8: Natural Gas Commodity Price: 2007 to 2012

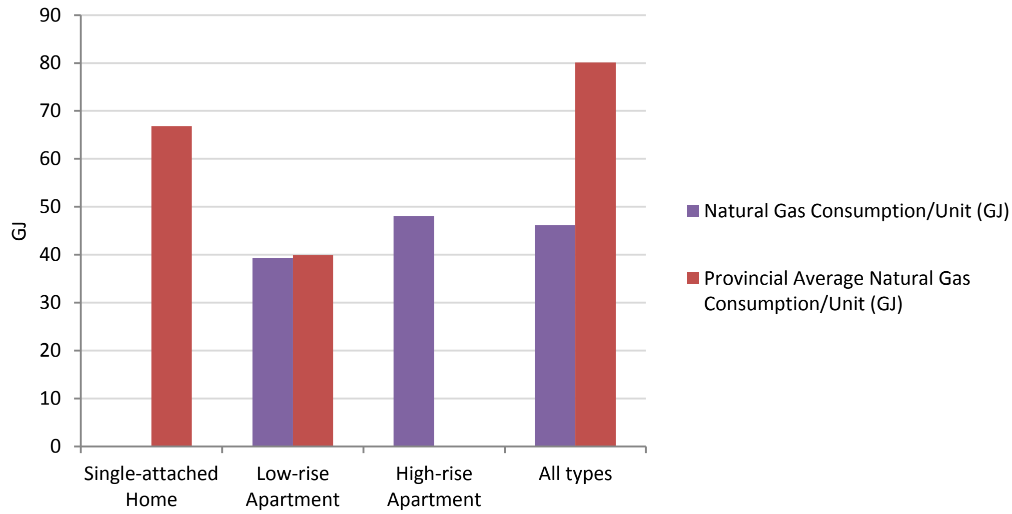


Adapted from www.indexmundi.com

The natural gas consumption in the co-op survey sample was roughly half that of the provincial average, but the exclusion of single-detached homes from analysis is likely drawing down the average of natural gas consumption (Figure 9). Unfortunately the natural gas consumption of single-attached units was largely unavailable: natural gas data was only provided for one building, representing 67 single-attached units. These units only account for 20% of the 337 single-attached units that reported using natural gas. This single block of units consumed 106 GJ of natural gas per unit, and was the only block of single-attached units that was identified to consume above the provincial average of either fuel type. As a result of the limited amount of data, it is difficult to draw any valid conclusions about the natural gas consumption of co-op single-attached units.

Co-op low-rise apartments surveyed consume more natural gas than the provincial average. Unfortunately there is no comparable provincial natural gas consumption average for high-rise apartments. The energy consumption for surveyed high-rise apartments is lower than the Canadian average (59.9 GJ/unit). That said, Canadian energy consumption averages are higher than the BC averages for all other building types.

Figure 9: Natural Gas Consumption per Unit by Building Type: Co-ops Surveyed vs. Provincial Averages

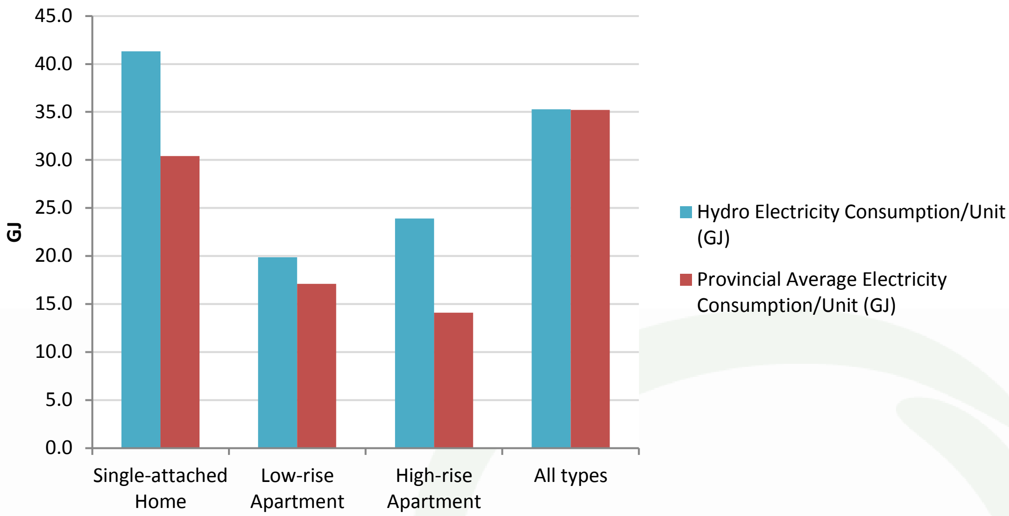


The electricity consumption of co-op units surveyed was roughly on par with the consumption observed throughout the province (Figure 10). The electricity consumption of the building types that comprised the majority of our sample, apartments and single-attached homes, was higher than the respective provincial averages. However, single-detached units, which comprise 57% of the housing stock in BC, consume more electricity than any other building type and are absent from the analysis. Single-detached units drive up the provincial average in comparison to the survey sample.

The analysis below suggests that high electrical consumption is contributing to the above-average energy consumption among the apartment units surveyed. This is surprising because of the above-average use of natural gas among the apartments surveyed. Among the low-rise apartments units surveyed, 74% reported using natural gas, whereas provincially only 34% of low-rise apartment units reported using natural gas in 2007. Above-average utilization of natural gas for space and/or water heating should translate into less electricity consumption than average, but it did not in the case of the surveyed units. The above-average electricity consumption among the apartment units suggests that apartment units surveyed face electricity-based energy challenges, which are likely related to occupant building use.

The single-attached units surveyed also showed above-average electricity consumption, but overall are below the provincial average in terms of energy consumption. The above-average electricity consumption shown below is largely due to the fact that only 13% of the of single-attached units surveyed reported using natural gas as an energy source. Provincially, 72% reported using natural gas as an energy source. This result indicates that electricity represents the main area for possible energy savings for single-attached units. For example, the survey data indicates that only 2% of single-attached units use heat pumps. Given the high level of electric heating in this building type, a substantial savings could result from wide scale installation of heat pump space and hot water heating systems.

Figure 10: Hydro Electricity Consumption per Unit by Building Type: Co-ops Surveyed vs. Provincial Averages



Occupant-Related Energy Use Challenges

The Energy Survey collected limited information about the occupants of the surveyed units, and instead focused on the building and equipment installed in the co-op. However, the analysis of electricity consumption above indicates that occupant building use contributes to the above-average consumption in the vast majority of apartment units surveyed. In this section we use the limited information collected about occupants to help analyze the consumption differences observed between apartment units and single-attached units surveyed. The major difference used as proxy for information about the occupants *per se* is billing structure.

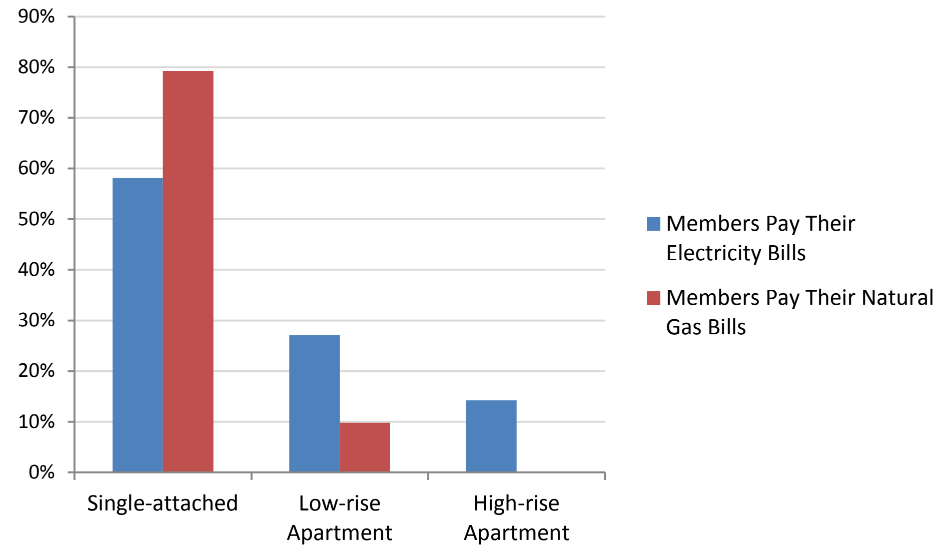
Metering and billing structure

Billing structures have been shown to have a large effect on consumption patterns. One study from the 1980s by Craig and McCann showed that buildings in which the units were not individually metered—meaning the individual occupants never saw the bills—consumed 35% more energy than individually metered units.[10] From this data we can suggest that different billing and metering structures can impact energy consumption per unit and the energy intensity of buildings. The figure below shows the difference in billing structures between the apartment and single-attached units. The survey results show that 58% or more of co-op occupants living in single-attached units pay their utility bills directly, but that 73% or more of occupants living in apartment units do not. Thus, the Energy Survey data indicates that for those co-op occupants who are not directly billed for their energy, there is no financial incentive to manage and measure consumption and therefore energy consumption tends to be higher than in buildings where financial incentives and methods to measure energy

[10] Craig, S., and McCann, J. 1980. Consumers without direct economic incentive to conserve energy. *Journal of Environmental Systems. 10*:1, 57-64.

consumption exist (payment of energy bills). However, this conclusion neglects important social factors involved in energy consumption.

Figure 11: Co-operative units in which utility bills are paid directly by the occupants



Receiving an energy bill constitutes an incentive structure, but high consumption does not necessarily result from the absence of such an incentive. One study observed a consumption difference of 300% between nearly identical units who were not paying directly.[11] The author of that study determined that factors such as income, cultural background, family size, and length of residence in the building were affecting this large variation. The units under study were eventually converted to individual unit meters, but one author reported that "Most residents responded to the conversion by virtually abandoning air-conditioning… a response that was far out of line with the modest price increases associated with the new billing arrangement." [12] The implication is that once the residents' attention was drawn to the financial effects of high individual consumption, they changed their behaviour.[13]

Individually metered units, with individual tenants paying the bills directly, may be the most expedient billing structure when trying to motivate a reduction in energy consumption. However, there are several issues limiting the ability of this approach to successfully address energy conservation in the context of the co-op housing sector.

- The co-op housing sector is typified by co-operation in the effort to create affordable housing. For some co-op members this means subsidized monthly housing fees and/or utilities rates.
- Installing individual meters is challenging and expensive in buildings where there was previously a single master-meter.

[11] Hackett, B., Lutzenhiser, L. 1986. Issues in the study of residential energy use: Ethnographic methods and models of behavior. *Proceedings from the American Council for Energy Efficient Economy. Summer Study 7*, 105-118.
[12] Lutzenheiser, L. 1993. Social and Behavioural Aspects of Energy Use. *Annual Review of Energy and the Environment*, *18*, 247-289. p.258.
[15] Ibid.

- Many buildings, especially those containing apartment units, share a single piece of equipment for space and/or hot water heating. In these cases, installing individual unit meters is difficult, if not impossible.

For many units in the co-op housing sector individual metering is not possible or practical. However, even without direct billing, co-ops could use incentives and feedback to help reduce consumption. For example, one study from the 1980s by Robert Slavin and his colleagues found that individuals living in master-metered apartments could be motivated to save energy if they were provided small incentives, which amounted to a percentage of the cost of energy they saved.[14] This study showed that the vast majority of tenants were discussing energy savings with each other as a result of the energy saving program, which helped to reinforce individuals' energy saving actions. A more recent study found that specific feedback about energy consumption could be delivered to building occupants through a website to motivate energy savings.[15] Vancouver-based Pulse Energy provides such an energy monitoring software that could be used for this type of energy saving program.[16] In cases where individual metering is not an option, a more socially-oriented program of incentives and feedback about energy consumption could be delivered to co-op members. Such arrangements should be based on the real consumption data available and should highlight the collective benefit associated with reducing energy consumption within co-op housing.

Case Studies

Three co-op building complexes were selected as good candidates for detailed energy assessments. They represent the major building types within the Energy Survey sample: single-attached units, low-rise apartments, and high-rise apartments. The case study analysis is a synthesis of the data derived from the assessments and of utility data received from BC Hydro and Fortis BC. Though we are aware of variation in consumption patterns between the individual units of multiple-unit buildings, the single-attached unit complex and the low-rise unit complex were modeled as a whole by treating each unit as if it had an identical consumption pattern. The high-rise unit complex was modeled to a greater level of detail to account for larger variations between the units based on the variable number of bedrooms.

The case studies provide the following information:

- Modeled energy consumption from baseloads, water heating and space heating;
- Modeled consumption and costs (per unit intensity);
- Building characteristics (type, size, insulation levels and year of construction);
- A summary of energy upgrade opportunities.

[14] Slavin, R. E., Wodarski, J. S., Blackburn, B.L. 1981. A Group Contingency for Electricity Conservation in Master-metered Apartments. *Journal of Applied Behavior Analysis, 14:*3, 357-363
[15] Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T. 2007. The Effect of Tailored Information, Goal Setting, and Tailored Feedback on Household Energy Use, Energy-related Behaviors, and Behavioral Antecedents. *Journal of Environmental Psychology 27,* 256-265.
[16] Pulse Energy Inc. 2012, Pulse Engagement Dashboard. Retrieved from: http://www.pulseenergy.com/pulse-platform/pulse-engagement-dashboard/

Single-Attached Unit Complex Case Study

The single-attached unit co-op chosen for the case study was representative of all single-attached co-ops surveyed:

- It used electricity as its exclusive energy source;
- Its consumption per unit was close to average among all co-ops surveyed; and
- It is located in the Lower Mainland/Vancouver Island climate region.

The results of the energy model show that a relatively small proportion of the overall energy consumption was being used for space heating, and almost half is estimated to power the baseloads in this complex

Despite the relative efficiency of this building type, the costs associated with operating single-attached buildings like the one in this case study is relatively high, and will continue to rise over at least the next several years as a result of the scheduled BC Hydro electricity rate increases. The costs and energy use information shown below is based on modeled data, which was adjusted based on the observed consumption to within 88% accuracy. The remaining 12% of consumption varied based upon unknown factors such as occupant lifestyle and appliance use.

Figure 12: Annual energy use and energy costs for the single-attached complex case study

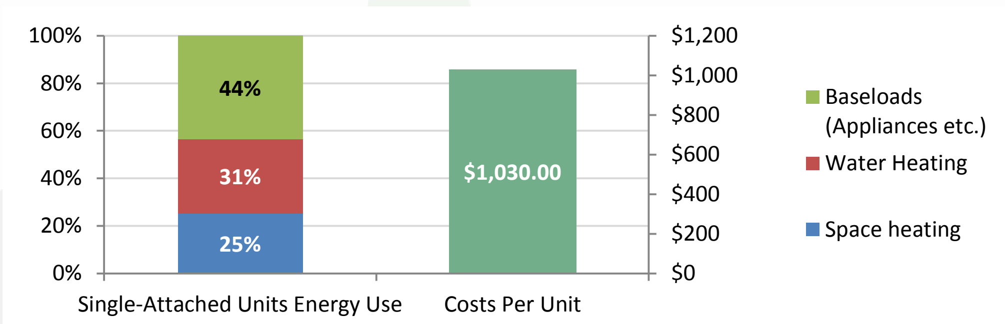


Table 2: Single-attached complex details

Building Details: Modeled single-attached unit complex		
Energy Use Intensity (GJ/Unit)		41.19
Building Type	Category	Single-Attached
	Stories	2
	Built	1991
Heated Floor Area		3522.4 m^2
Insulation	Ceiling	4.13 RSI
	Walls	1.6 to 1.97 RSI
	Foundation	1.4 RSI
Space Heating	Fuel	Electricity
	Equipment	Baseboards
	Efficiency	100%
Hot Water	Fuel	Electricity
	Tank	189.3 L
	Efficiency	73%
Lighting		Incandescent
Appliances		Conventional
Occupants/Units		107/34

The upgrade package shown below involves all major building components, including the building envelope, appliances, lighting, and the mechanical systems. Despite the relative efficiency of the single-attached complexes, there is room for improvement. The table provides categorized upgrade costs and energy savings to help contextualize these retrofits. The costs are categorized (low/medium/high) because contractor pricing could not be secured without access to the units. The low cost options are estimated to cost less than $1000 per unit, whereas high cost options are likely to cost $4000 per unit or more.

The total savings possible by implementing all upgrades is lower than the sum of the savings of the individual retrofits. This is because equipment in homes works as a system. One retrofit will affect the performance of other building components. For example, if a higher efficiency heating system is installed, then less energy is used to produce the heat, but if the air tightness of a unit is also improved, the heating system does not need to provide as much heat to maintain a constant temperature. The interaction between these two means that the heating system actually saves less energy as an individual upgrade than it would when combined with improved air tightness in the unit.

Table 3: Single-attached complex upgrade package

Upgrade	Upgrade Details	Annual Total Energy (GJ) Post-Retrofit	Annual Savings (GJ)	Annual Energy Costs ($) Post Retrofit	Annual Savings ($)	Upgrade Cost	Energy Savings
Ceiling Insulation	To R50	1383.8	17	$34,595.00	$445.74	Medium	Low
All Windows	ENERGY STAR	1271.6	129.2	$31,790.00	$3,681.18	High	High
Air Tightness	ACH 5.0	1383.8	17	$34,595.00	$486.54	Low	Low
Heating System	Mini-split air source heat pump	1186.6	214.2	$29,665.00	$6,060.84	High	High
Domestic Hot Water	Air source heat pump	1176.4	224.4	$29,410.00	$5,482.50	Medium	High
Base Loads	Stove, low-flow fixtures, and suite lighting	1298.8	102	$32,470.00	$2,586.04	Low	Medium
All Upgrades		**867**	**533.8**	$21,675.00	$15,957.90	**High**	**High**

The upgrade opportunity with the highest energy savings for the single-attached units case study was mini-split air source heat pump heating system, with the second being the installation of heat-pump hot water tanks. Windows also provide a high energy saving potential, but the replacement cost for windows reduces the cost effectiveness of this upgrade option. Baseload consumption, which includes lighting and appliances, can also be reduced through upgrades to more efficient products, perhaps even before the heating system upgrade. If the combined upgrade recommendations were implemented for the single-attached case study the units would realize a 38% reduction in energy consumption and costs.

Low-rise Apartment Complex Case Study

The low-rise unit complex chosen for the case study was a high energy consumer.

- It was a below-average electricity user, and used natural gas for space and water heating;
- It was built with largely un-insulated brick walls;
- It was the second-highest consumer among low-rise unit complexes; and
- It is located in the Lower Mainland/Vancouver Island climate region.

The results showed space heating as the major area of concern. Almost 70% of the energy consumed in this complex was used for space heating.

The building's high consumption was largely due to the unregulated loss of heat through the un-insulated building envelope and the correspondingly energy use by the heating system to maintain a constant temperature. Despite the relative inefficiency of this building type, the cost associated with operating this apartment building is the lowest among the case studies as a result of the low BC Hydro electricity use. The costs and energy use information shown below is based on modeled data, which was adjusted based on the observed consumption. This model was adjusted to 99% accuracy as compared to observed consumption.

Figure 13: Annual energy use and energy costs for the low-rise apartment complex case study

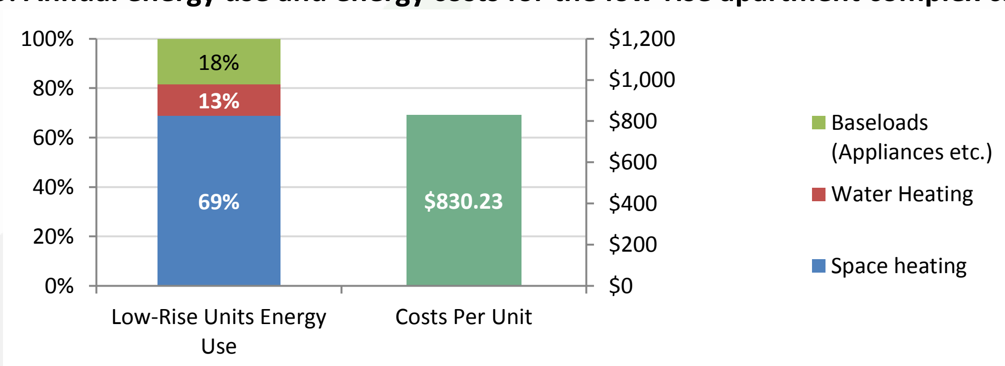


Table 4: Low-rise apartment complex details

Building Details: Modeled low-rise unit complex		
Energy Use Intensity (GJ/Unit)		64.62
Building Type	Category	Low-Rise Apartment
	Stories	3
	Built	1910-11
Heated Floor Area		1694.7 m^2
Insulation	Ceiling	4.44 RSI
	Walls	.8 to 1.11 RSI
	Foundation	.27 to .8 RSI
Space Heating	Fuel	Natural Gas
	Equipment	Boiler and Radiators
	Efficiency	80% Steady State
Hot Water	Fuel	Natural Gas
	Tank	302.8
	Efficiency	66%
Lighting		½ CFL - ½ Conventional
Appliances		Conventional and Natural Gas Ranges
Occupants/Units		36/32

The upgrade package shown below involves the major building components, including the building envelope, space heating, appliances, lighting, and the water heating system. The table provides categorized upgrade costs and energy savings to help contextualize these retrofits. The costs are categorized (low/medium/high). The low cost options are estimated to cost less than $1000 per unit, whereas high cost options are likely to cost $4000 per unit or more.

The total savings possible by implementing all upgrades is lower than the sum of the savings of the individual upgrades. This is because equipment in the building works as a system. One upgrade will affect the performance of other building components.

Table 5: Low-rise apartment complex upgrade package

Upgrade	Upgrade Details	Annual Total Energy (GJ) Post-Retrofit	Annual Savings (GJ)	Annual Energy Costs ($) Post Retrofit	Annual Savings ($)	Upgrade Cost	Energy Savings
Wall Insulation	Add R14	1889.5	200	$24,724.83	$1,842.66	High	Medium
Foundation Insulation	Add R14 to Basement walls; Add R28 to Crawlspace walls	1904.6	185	$24,863.67	$1,703.81	Low	Medium
All Windows	Argon, lowE	1763.8	326	$23,567.77	$2,999.71	High	High
Air Tightness	ACH 7.0	1715	375	$23,118.37	$3,449.11	Medium	High
Heating System	94% efficient boiler	1873.8	216	$24,841.30	$1,726.19	Medium	Medium
Hot Water	Solar 96 GJ	1929	161	$25,085.43	$1,482.05	High	Medium
Base Loads	Suite lighting	2088.9	84	$24,955.00	$1,612.48	Low	Medium
All Upgrades		865.8	1224	$13,694.11	$12,873.38	**High**	**High**

The upgrade opportunity with the highest energy savings is improving the air tightness of the building envelope. Windows also showed a high energy saving potential for this building, but because of the age and character of the windows in this 1910 building, the window upgrade cost would be especially high. Non-window related envelope retrofits should be addressed preferentially, starting with air sealing work and the foundation insulation. If the combined upgrade recommendations were implemented for the low-rise apartment case study, including the windows, air sealing, baseload upgrades and new boiler, the building would realize a 59% reduction in consumption and a 53% reduction in energy costs.

High-rise Apartment Complex Case Study

The high-rise unit complex chosen for the case study was a high energy consumer.

- It was an above-average electricity user, and used natural gas for space and water heating;
- It was built of structural concrete and contained minimal insulation in the walls;
- It was the highest consumer among high-rise unit complexes; and
- It is located in the Lower Mainland/Vancouver Island climate region.

The results showed space heating as the area of with the most energy use. Almost 50% of the energy consumed in this complex was used for space heating. The units were 68 m^2 on average, which is larger than the low-rise apartment complex units shown in the case study above. Natural gas represented 75% of this complex's modeled energy use, which resulted in low per unit the energy costs.

The costs and energy use information shown below is based on modeled data, which was adjusted based on the observed consumption. This model was adjusted to 89% accuracy as compared to observed consumption. The remaining 11% of consumption varied based upon unknown factors such as occupant lifestyle and appliance use.

Figure 14: Annual energy use and energy costs for the high-rise apartment complex case study

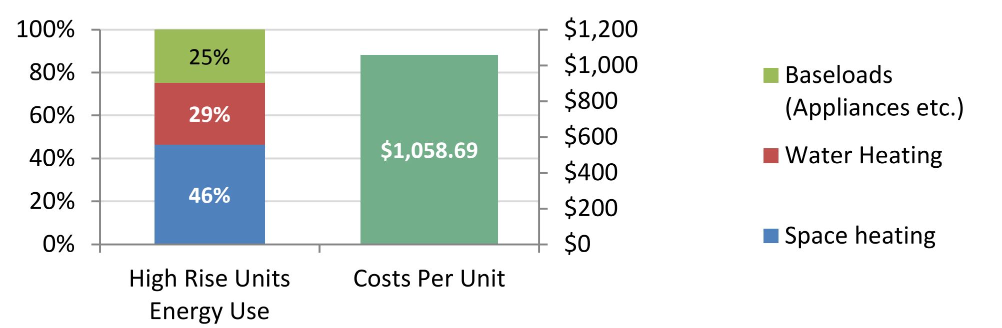


Table 6: High-rise apartment complex details

Building Details: Modeled high-rise unit complex		
Energy Use Intensity (GJ/Unit)		73.00
Building Type	Category	High-Rise Apartment
	Stories	7
	Built	1984-85
Heated Floor Area		3808 m^2
Insulation	Ceiling	2.8 RSI
	Walls	1.18 RSI
	Foundation	2.15 RSI
Space Heating	Fuel	Natural Gas
	Equipment	Boiler and Radiators
	Efficiency	80% Steady State
Hot Water	Fuel	Natural Gas
	Tank	Two 380L storage tanks
	Efficiency	66%
Lighting		Conventional
Appliances		Conventional
Occupants/Units		108/56

The upgrade package shown below involves all major buildings components including the building envelope, appliance, lighting, and the heating systems. This is the highest consumer among the three case studies and as such there is substantial room for improvement. The table provides categorized upgrade cost and energy savings to help contextualize the cost and savings associated with these retrofits. The low cost options are estimated to cost less than $1000 per unit, whereas high cost options are likely to cost $4000 per unit or more.

The total savings possible by implementing all upgrades is lower than the sum of the savings of the individual retrofits. This is because equipment in the building works as a system. One upgrade will affect the performance of other building components.

Table 7: High-rise apartment complex upgrade package

Upgrade	Upgrade Details	Annual Total Energy (GJ) Post-Retrofit	Annual Savings (GJ)	Annual Energy Costs ($) Post Retrofit	Annual Savings ($)	Upgrade Cost	Energy Savings
Wall	Increase by R12	3057.85	1029.85	$49,563.70	$9,722.96	High	High
Floor	Increase by R20	3941.40	146.3	$57,894.24	$1,392.41	Medium	Low
All Windows	Argon filled, lowE coating	3567.20	520.6	$54,354.58	$4,932.04	High	High
Air Tightness	Reduce Air Leakage to ACH 3.0	3813.45	274.25	$56,690.08	$2,596.58	Medium	Medium
Heating	High Efficiency boiler (≥94%)	3603.40	482.3	$54,700.18	$4,586.55	Medium	High
DHW	Solar 336GJ	3767.7	317.1	$56,283.51	$3,003.14	High	High
Base Loads	Suite lighting and Appliance	4073.9	13.1	$58,112.54	$1,124.29	Medium	Low
All Upgrades		2058.20	2027.4	$39,028.56	$20,258.28	**High**	**High**

The upgrade opportunity with the highest energy savings is increasing wall insulation. Windows and a solar hot water system also showed a high energy saving potential, but the upgrade costs would be high. High efficiency boiler installation would result in high energy saving if installed alone, but if installed in conjunction with the other retrofits the savings would drop to roughly ¼ of that shown above. This is because less energy would be required to heat the building if the building envelope was improved through wall insulation and window upgrades. If the combined upgrade recommendations were implemented for the high-rise apartment case study the building would realize a 50% reduction in consumption and 33% reduction in energy costs, which could likely be improved in conjunction with a conservation and awareness program focusing on baseload electricity savings. Interestingly, the 50% energy reduction shown above would bring the unit energy intensity down to 36.75 GJ/unit, which is only marginally below the provincial average for this building type (37.3 GJ/unit).

Conclusion and Recommendations

The Energy Survey provides a high-level overview of co-operative housing strategic and operational performance indicators related to energy performance and compared to provincial baselines for different building types. Analysis of the combined survey results, the energy consumption data and of the detailed case studies provides information on which buildings and building types are consuming more energy than average, and provides insights and recommendations on how all the surveyed buildings can reduce their energy consumption and costs.

Key Findings

- The total estimated annual cost of energy consumption for the 3110 surveyed co-op units is over $2.8 million dollars/year, or $900/year/unit on average.
- A total of 2,900 tonnes of CO_2e, or approximately .95 tonnes/year/unit, were emitted as a result of the energy consumption of the surveyed co-op units.
- The total energy consumption for the combined co-op housing units surveyed was below the provincial average. However, 28% of co-op units surveyed were identified to be consuming more energy than their respective provincial averages.
- The Energy Survey analysis identified that the higher energy costs for single-attached units versus apartment buildings is linked to exclusive use of electricity in that building type.
- The Energy Survey analysis identified that higher energy consumption in apartment units versus single attached units is linked to inefficient space and water heating systems and high occupant energy consumption.
- Moderate to significant energy consumption reductions can be achieved in all housing types in the co-op housing sector. For example, the single-attached unit case study demonstrated that even units consuming half the provincial energy consumption average can feasibly further reduce energy consumption by 40%. On the other hand, the high-rise case study demonstrated that achieving a 50% energy reduction from current levels would only bring the building in line with provincial energy consumption averages for this building type.

Recommendations

1. CHF BC should consider building organizational capacity to manage energy use in co-op housing by acquiring a co-op sector Energy Manager. A co-op sector Energy Manager could assist with the following:
    a. Lead the development and implementation of energy efficiency initiatives in co-op housing associations.
    b. Link co-op housing associations with existing energy incentive and rebate programs (see Appendix A).
    c. Develop and implement an energy conservation education and awareness program to realize low-cost energy savings, preferentially starting by targeting apartments where in-direct billing (the co-op member do not see the energy bills) is common.

   d. Explore financing options for the co-operative housing sector to reduce the capital cost barriers to energy savings retrofit opportunities that will benefit co-ops in long term energy savings.

2. For surveyed apartment co-op units with above-average energy consumption, CHF BC should use the list of high energy-consuming buildings generated by the Energy Survey to:
   a. Inform each of these buildings that they are above-average energy consumers with opportunities for energy bill savings including:
      i. Low-cost upgrades: Baseloads, specifically energy efficient lighting
      ii. Medium-cost upgrades: Foundation insulation and air sealing
      iii. Higher-cost upgrades: Boiler, wall insulation, windows, solar hot water systems
      iv. Note that not all upgrades identified in the case studies are appropriate for every low rise unit/complex.
      v. Note than while some retrofits are obvious, in-depth energy assessments are valuable tools to help co-op's identify and prioritize the best energy saving retrofits for their buildings.
   b. Connect each building with all relevant utility rebate and incentive programs.
   c. For buildings with gas heating, connect buildings with Fortis BC Energy Solutions managers to assess eligibility for the Efficient Boiler Program.
3. For electrically-heated single-attached units CHF BC should:
   a. Inform each of these buildings that there are opportunities for reducing energy consumption and energy costs including:
      i. Low-cost upgrade options: Baseloads and air sealing
      ii. Medium-cost upgrade options: Ceiling insulation and domestic hot water (heat pump) systems
      iii. Higher-cost upgrades: Windows, ductless mini-split air source heat pumps
      iv. Connect each building with relevant utility and provincial rebate programs, specifically the LiveSmart BC Efficiency Incentive Program (LSBC EIP). ecoENERGY home assessments employed by the LSBC EIP are valuable tools to help co-op's identify the best energy saving retrofits for their buildings.
4. Establish an energy consumption reduction target:
   To establish a framework for enhancing the energy performance of the co-op building sector in BC, CHFBC should consider setting a bold energy conservation reduction target. The target should be realistic but also inspirational so that the co-op housing sector realizes the multiple benefits of improved building energy performance and reduced energy consumption.

   Based on the findings of the case studies, building energy consumption reductions of 40 to 50% are achievable from building energy upgrades. Further energy consumption reductions can be achieved through energy educational initiatives to motivate energy reductions through behavior change. If the CHF BC was to establish an energy consumption reduction target for the co-op housing sector of 50% over the next 18 years, significant energy and cost savings and greenhouse gas emission reductions could be achieved. Based on the current energy consumption of the 3110 units that participated in the Energy Survey, a 50% reduction in energy consumption would be equivalent to an annual savings of ~80,000 GJs, 1.5 kilotonnes of CO_2e emissions, and at current utility rates $1,400,000 in fuel costs.

Closing Remarks

For the co-op housing sector, energy conservation represents a means to improve the performance of an aging housing stock, reduce energy expenditures to co-op members, improve the comfort and health of living spaces, support provincial legislation to reduce greenhouse gas emissions, and to take leadership in encouraging a co-op sector-wide organizational culture that conserves and values energy.

The Energy Survey provides a high level summary of the state of energy use in the sector and priority areas for immediate action. The Energy Survey also identifies where there is a lack about the energy performance of many co-op buildings in BC, most notably in the fact that only one quarter of CHFBC members participated. Based on the findings from the Energy Survey it is likely that there are a large number of co-op housing buildings that could significantly reduce their annual energy bill expenditures and environmental footprint.

All the stakeholders should take pride in taking this important step towards actively managing energy consumption in the co-op housing sector. The analysis and opportunity identification included in the Energy Survey was made possible by data sharing and cooperation among all stakeholders. Maintaining this level of commitment and participation will ensure that the energy and cost savings identified in this report are realized.

Lists of Tables, Figures, Acronyms & Glossary

List of Tables

List of Figures

List of Acronyms

CFL	Compact Fluorescent Lighting
LED	Light Emitting Diode
CHF BC	Co-operative Housing Federation of BC
CO2e	Carbon Dioxide equivalent
DSM	Demand Side Management
EMIS	Energy Management Information System
HVAC	Heating, Ventilation, Air Conditioning
GHG	Green House Gas
GJ	GigaJoule
NRCan	Natural Resources Canada
MEM	Ministry of Energy and Mines
PDAs	Program Delivery Agents
PPA	Power Purchasing Agreement
RSI	Thermal Resistance Properties

Glossary of Terms

Apartment Units
A housing unit located in a building originally designed to contain multiple dwelling units (apartments) within it.

Carbon Dioxide Equivalent (CO2e)
Whereas CO2e is usually defined as a static term of the various greenhouse gases in the atmosphere based upon their global warming potential (GWP), for the purposes of this report it is not defined as the amount, in terms of mass, of the various greenhouse gases flowing into the atmosphere expressed as the mass of CO2 with the equivalent global warming potential.

Demand Side Management (DSM)
Demand side management (DSM) is the development and implementation of policies and actions to control energy demand. The two main goals with DSM are to (1) Improve the efficiency of building systems and (2) reduce energy consumption. DSM is one of the best approaches to addressing climate change. Through reducing peak demand, additional infrastructure needs are minimized and less primary energy is used – reducing greenhouse gases responsible for global warming causing climate change.

Energy Intensity
Energy intensity refers to the energy used per unit of output or activity. The term is often used interchangeably with energy efficiency. In this report, the calculation used to determine a building's energy intensity (energy efficiency) is: total annual gas/electric/other fuel energy consumption per housing unit.

High-rise Apartment Units
A dwelling unit contained in an apartment building with five or more storeys.

Low-rise Apartment Units
A dwelling unit contained in an apartment building with fewer than five storeys.

Operating Agreements
An operating agreement is a contract that defines the roles and responsibilities between a non-profit housing society and BC Housing. Public funds are provided to societies through their operating agreement with BC Housing. Annual reports are provided to BC Housing to ensure the requirements within the operating agreement are being upheld.

Single-Attached Units
A house connected to at least one other dwelling, which together form a building.

Single-Detached Units
A house containing a single dwelling unit entirely separate from any other building or structure, generally known as a single family house.

Unit
Any set of living quarters that is structurally separate from the living quarters of other dwellings and has a private entrance outside the building or a private entrance from a common hall or stairway inside a building.

Appendix A: Primary and current incentive and rebate programs

The primary current incentive and rebate programs include:

1. BC Hydro ENERGY STAR® Appliance Rebate:
    a. BC Hydro provides rebates of up to $75 on ENERGY STAR® rated refrigerators, clothes washers, dishwashers, and freezers.
2. BC Hydro Product Incentive Program:
    a. BC Hydro provides incentives for high efficiency lighting upgrades in co-op building common areas.
3. Fortis BC ENERGY STAR® Water Heater Program:
    a. Co-ops with individual unit natural gas fired water heaters can access substantial incentives to replace old tanks with new high-efficiency storage tanks or tankless systems. Between $200 and $1000 can be accessed per unit installation.
4. FortisBC Efficient Commercial Hot Water Program:
    a. Fortis BC is offering up to $15,000 to commercial account holders who change out their domestic hot water system to a high efficiency system. This program has been popular with apartment complexes where the hot water equipment is aging, but who have difficulty paying extra for a high-efficiency system.
5. FortisBC Efficient Boiler Program:
    a. Fortis BC is offering up to $60,000 to commercial account holders who install a high-efficiency boiler used for space heating.
6. LiveSmart BC Efficiency Incentive Program:
    a. LiveSmart BC offers incentives and a subsidized energy assessment for single-attached and single-detached homes. The energy assessment helps identify the most relevant retrofits and provides access to incentives to help reduce the cost of major retrofit, including the installation of heat-pumps, high-efficiency hot water tanks, insulation, air sealing and more.

Appendix B: Additional Support Documents

Additional support documents have been provided to the CHFBC to inform future co-op housing energy conservation initiatives. These documents include:

1. CHFBC Energy Survey participant buildings list– prioritized by energy consumption (CHFBC Energy Survey_Prioritized list.xlsx)
2. CHFBC Energy Survey building energy and charateristics survey (APARTMENT.pdf, SINGLE-ATTACHED.pdf, SINGLE-DETACHED.pdf)