Cornerstone Building

Energy Assessment

Summer 2007-Winter 2008-09

Prepared for: Fernwood NRG

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By: BlueMap Sustainable Solutions

Susan Pratt, Colin Rankin and Forrest Smith

Victoria, B.C.

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Assessment Summary

The vision and commitment of Fernwood NRG and Fernwood community members has resulted in a restored heritage building that serves residential and commercial needs, while providing an example of the cost and greenhouse gas (GHG) emission savings possible through energy conservation and use of renewable energy sources. The present energy system of the Cornerstone building provides an annual saving of about 18.4 tonnes of GHG emissions and $6,450.00 relative to conventional space heating systems. Additional energy cost and GHG emission savings could be realized through reducing energy demand, completing solar hot water heating, and/or improving system controls and the building's space heating/air distribution system.

Building Description: Cornerstone Building, mixed use (residential/commercial) brick construction, built in 1909, natural gas boiler and ground source heat pump (geo exchange) space heating, natural gas on-demand and storage tank hot water heating, utility-provided electrical services. Note: See appendices for data sources and calculation methods.

Energy Type and Use Note: annual use is estimated using data from summer 2007 through winter 2008-09	**Annual Amount (megajoules)**	**Annual Energy Cost ($$)**	**Annual GHG emissions (tonnes)**	**Savings associated with use of ground source heat pump (geo exchange)**	
				GHG Emissions Reduced (tonnes)	**Cost Savings (Estimated $$)**
Electrical – Space Heating	74,302	1,280	1.99	18.4	6,450.00
Natural Gas – Space Heating	81,500	1,340	4.24	-	-
Electrical – Other Uses	528,986	9,110	14.1	-	-
Natural Gas – Hot Water Heating	346,400	5,700	18.01	-	-
Solar (Passive) – Hot Water Heating	Potential to reduce natural gas use – (GHG emissions reduction and cost savings)				
TOTAL	**1,031,188**	**17,430**	**38.34**	**18.4**	**6,450.00**

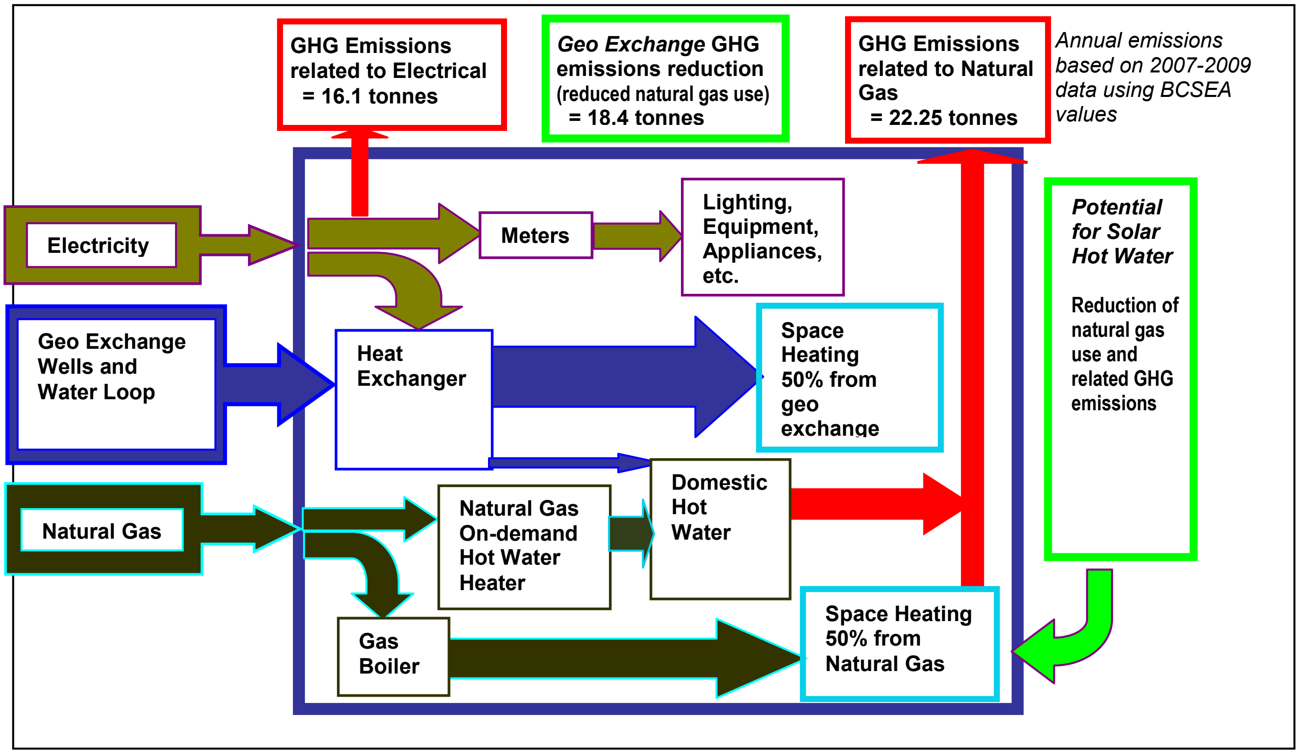
Fernwood NRG Values and Objectives – context for energy management

In 2005 the Fernwood Neighbourhood Resource Group (Fernwood NRG) purchased the Cornerstone Building. The building, located on the 1300 block of Gladstone Avenue (and Fernwood Drive) in Victoria BC, is a two-storey heritage structure built in 1909 that had been boarded up for several years prior to its purchase by the community group. Fernwood NRG renovated the building over a two year period, creating four 3-bedroom affordable housing suites on the top floor and converting the main floor to commercial space. Total capital cost of the project was $1.6 million – with half of that amount obtained through grants and partner funding. Volunteer labour (including families, school groups, professionals and seniors who provided expertise, skilled trades and helping hands) lowered construction costs, and local businesses donated materials, further reducing project costs. In 2008, the project received a national award from Canada Housing and Mortgage Commission (CMHC) for best practices in affordable housing.

The Cornerstone Building is intended to serve as a living demonstration of neighbourhood revitalization and sustainability – renewing heritage, serving community interests and broadening social and environmental understanding. Energy management for the Cornerstone Building has to be undertaken in the context of Fernwood NRG operating principles and resources, including:

- **Community (social) values and objectives** – maintaining heritage character, providing community gathering places and services, providing affordable family rental housing
- **Environmental considerations** – demonstrating efficient use of energy and innovation in use of renewable energy, documenting and reducing emissions of greenhouse gases (carbon footprint)
- **Economic and human resource considerations** – recognizing the limited capital pool of the organization and the involvement of community volunteers and building residents and users

The Cornerstone Building's Energy System



System Description:

The energy system of the Cornerstone Building includes three hot water storage tanks (two for domestic hot water and one for space heating), a ground source heat pump (GSHP) and two geo exchange wells, a natural gas boiler (supplementing the geo exchange heat source), an on-demand gas hot water unit and an air distribution system to eight areas (four second-floor apartments and four main-floor commercial areas). Solar fittings (for hot water heating) are roughed in to the roof. Electricity provided by the provincial utility is used for residential and commercial lighting, appliances and air cooling.

Design and commissioning of the energy retrofits for the Cornerstone Building involved a team coordinated by Fernwood NRG staff that included Wilf Scheuer of Pro Star Mechanical Technologies (geo exchange and project coordinator), Houle Electric (electricians), Victor Procter of Blue Mountain (engineering) and Solarcrest (solar installations).

Two geo exchange wells (including a water well with pump in place capped for future use) provide renewable energy for heating the building. There is one loop system to the heat exchanger from these two wells. The ground source heat pump system for heating is supplemented by natural gas fired hot water boilers, providing about 50% of the building's heating. During the heating season some heat (approximately 10,000 BTU/hr) is diverted from the ground source heat pump to preheat domestic hot water.

System Design Constraints

The major constraints in the design and retrofitting of the energy system involved:

- **Building condition and heritage features** – maintaining heritage character with intended functions
- **Site limitations** – building and lot footprint, underlying geology of the site
- **Budget –** capital, operating

Cost and site constraints limited the number of geo exchange wells that could be sunk, and consequent capacity of the ground source heat pump system from this source. Solar panels (for hot water heating) have not been installed due to cost relative to return on investment.

The heritage features, condition and intended functions of the building limited air distribution system options. As well, additional changes to the original design were made through the retrofitting process due to budget constraints and interior design considerations. The coffee shop (corner commercial unit) air distribution unit is mounted on the ceiling instead of the wall (which would be the functional preference). There is currently no fresh air make up provided in this unit – only exhaust. Modifications were also necessary to accommodate return air for this unit.

The system does not include a "smart" direct digital control (DDC) and optimization system (the only controls are "basic" thermostats in each of the conditioned spaces). As a result, there is no electronic interface between the ground source heat pump (GSHP) and the gas boiler. Heat source controls are set up so the boiler is "stage 2" heating and the heat pump "stage 1" – a more sophisticated DDC could, for example, lockout the boiler altogether based on demands for heat , the capacity of the system and the ability of the system to respond.

Commissioning and Operations

The building and energy system was commissioned in November 2006, reaching full occupancy (including a restaurant, coffee shop, gallery and residential units) over the following year. The ground source heat pump is "switched on" from mid to late September until early June. Our energy assessment confirms that the GHSP provides about 50% of space heating for the building (in line with design estimates). The GSHP is not used for cooling in the summer months although the system could provide cooling if desired. The occupant of one commercial unit (a restaurant) has installed a supplemental conventional air conditioning unit.

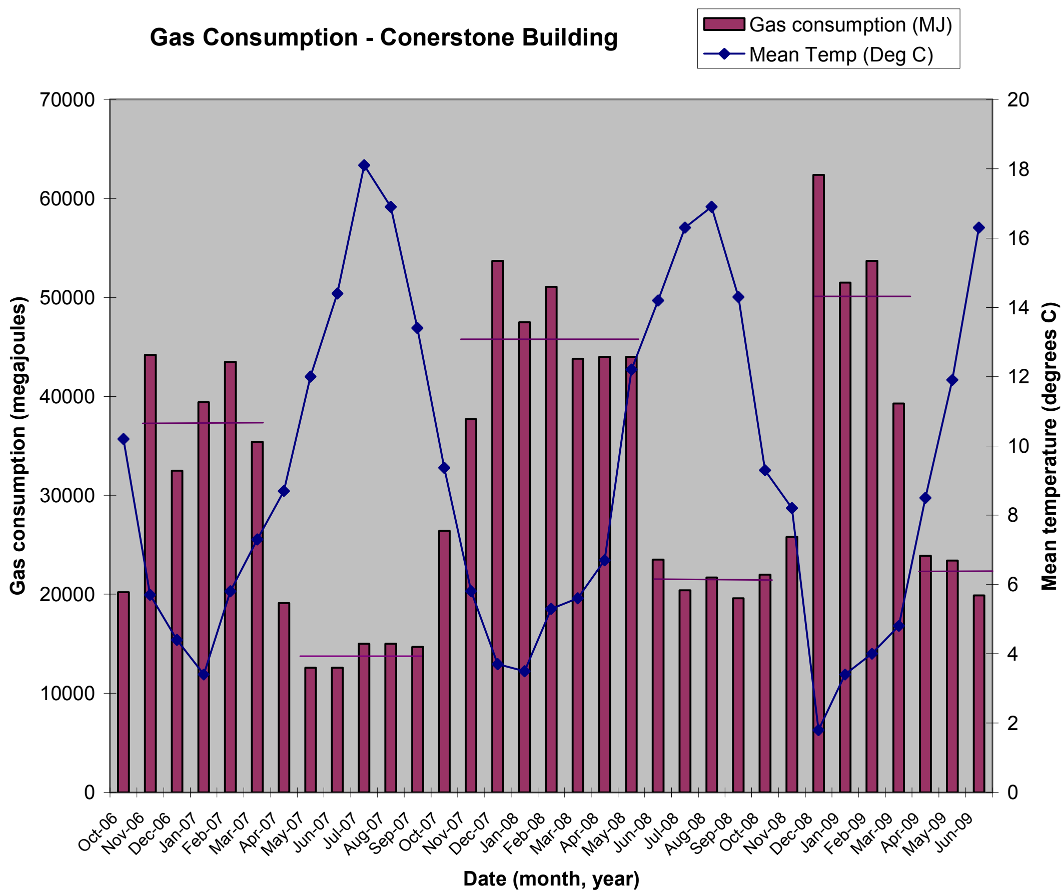
Annual maintenance of the heating system and briefing of building employees on routine maintenance tasks (as well as start up and shut down of the GSHP) is performed by Pro Star Mechanical under contract.

Detailed interviews with residential and commercial building users were not conducted. Fernwood NRG building managers feel that, with occasional exceptions, the energy system satisfies user needs. The most significant air heating and conditioning concerns are associated with the commercial coffee shop and restaurant units. In the coffee shop, single pane glass windows and high humidity from the steam system for coffee (as well as high occupancy) cause condensation on the glass in the winter and heating challenges. A mechanical dehumidifier was installed in the past year resulting a significant reduction in humidity. Additional modifications to the heating and ventilation system with particular consideration of the fresh air needs of this space would further improve the air quality. When addressing this issue, the scope of work should also include fresh air, ventilation and heating of the basement space.

Pattern of Energy Use

The following three charts – showing: (1) natural gas consumption; (2) electrical energy consumption; and (3) total energy consumption – have been prepared using billing information from BC Hydro (electricity) and Terasen (natural gas). Energy consumption has been converted to common units (megajoules – MJ) and is shown as solid bars by month between October 2006 and March or June 2009 based on available data. The mean temperature (degrees Celsius) for each month is also plotted as a solid line against gas and electricity consumption. The total energy consumption chart includes gas and electricity consumption by month, as well as total consumption and the trend line (least square average) for the three elements. Data and calculation methods used for comments and analysis are provided and described in the final appendices of this document

Gas Consumption and Geo Exchange Energy Savings

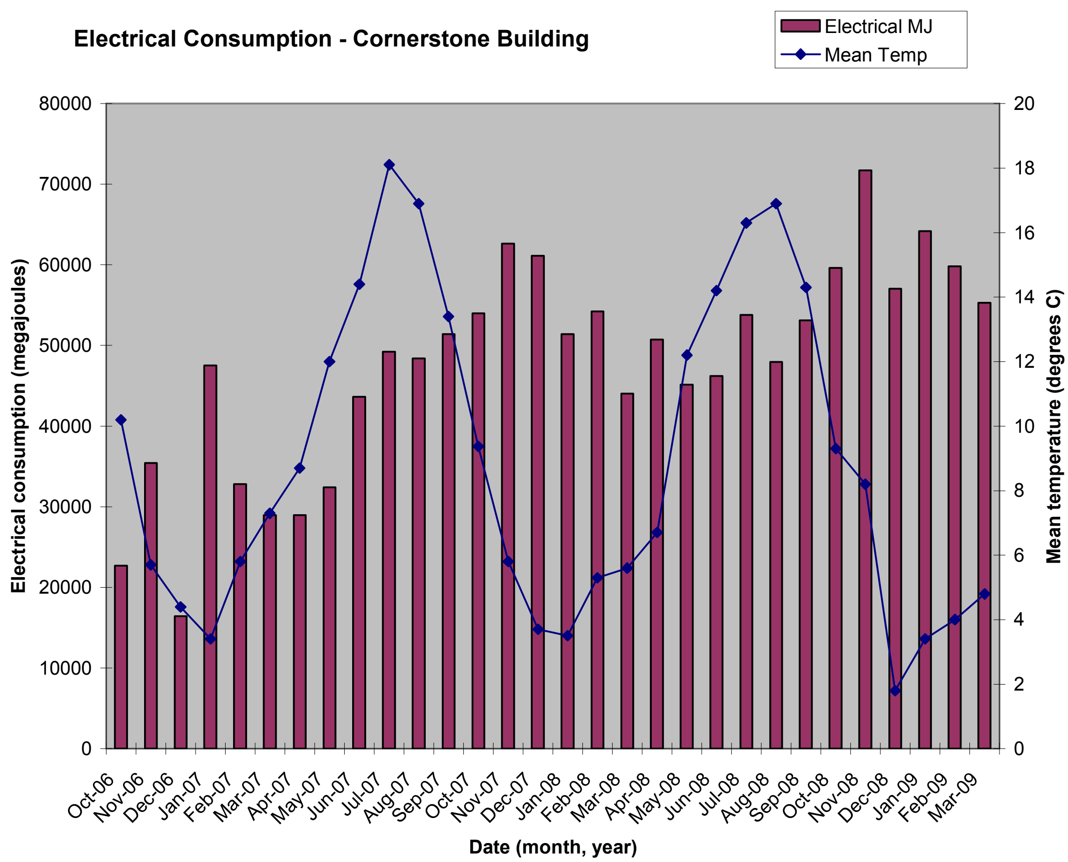


Comments and Analysis

The Cornerstone Building uses natural gas year-round for hot water heating and in winter months (October-April) for space heating (supplementing the ground source heat pump). The consumption graph shows a clear relationship between low mean temperature and higher gas consumption. In the winter of 2008-09, an average of 42,450 MJ/month was consumed, with a peak consumption of 62,400 MJ in December 2008. Consumption in the summer of 2008 averaged 28,867 MJ/month with a low in July of 20,400 MJ. Gas consumption in both summer and winter has increased year-by-year since October 2006 – as shown by the six horizontal (seasonal average) lines across the x-axis of the graph.

Cost of space heating by natural gas (gas-fired boiler) for the Cornerstone Building is estimated using this data to be $20.56/gigajoule (one gigajoule = one thousand megajoules). This compares with a cost of $3.91/gigajoule for space heating using the ground source heat pump (GSHP). This assessment confirms that at least 50% of the building's space heating requirements are met by the GSHP. Use of the GSHP rather than "conventional" natural gas boiler only heating results in a savings of up to $6450.00/year depending on design and capacity considerations and a reduction in greenhouse gas (GHG) emissions of as much as20.4 tonnes/year (based on 2007-09 usage and cost data and assuming an average of 4.4:1 efficiency for the GSHP – as compared to the lower 0.8:1 efficiency of the gas boiler).

Electricity Consumption



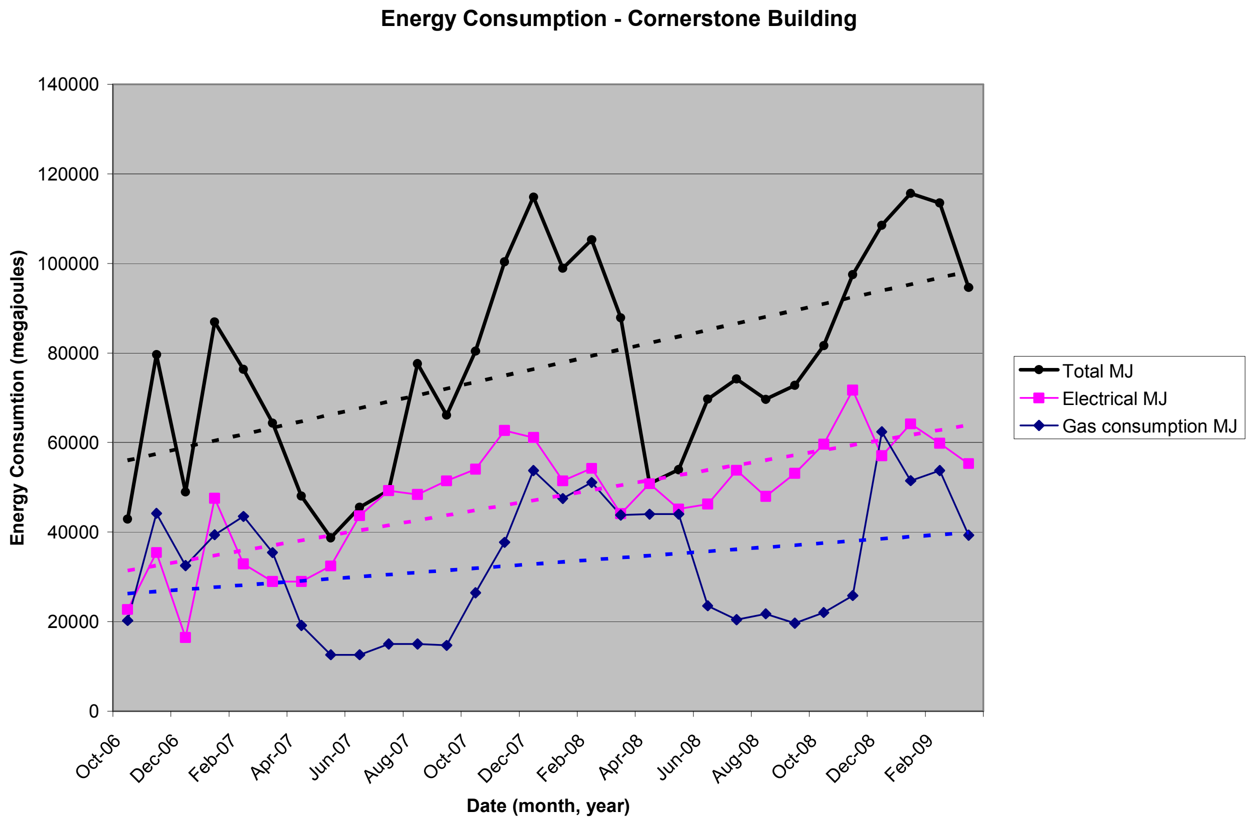
Comments and Analysis

Electrical usage in the Cornerstone Building includes appliances and lighting, as well as supplemental air conditioning and space heating by commercial and residential building tenants. Electricity consumption in the summer of 2008 averaged 49,500 MJ/month while in the winter of 2008-09 it averaged 61,272 MJ/month. Compared to the summer and winter of 2007-2008 the correlation between mean temperature and electricity consumption is not as strong. It is reasonable to assume that this is due to the significant change in loads as result of new tenants and their activities and the addition of an electric air conditioning unit in the restaurant space. Consumption does appear to peak from year to year in the months between November and January (corresponding roughly with the lowest monthly mean temperatures of each year).

Electricity consumption of each building space and tenant is metered, however the available individual meter data is not sufficient to determine and compare monthly and daily usage patterns and/or significant seasonal variation in usage for individual tenants.

Total Energy Consumption

This chart shows gas, electrical and total energy consumption for the Cornerstone Building between October 2006 and March 2009. Month-by-month consumption is plotted by data point and solid lines (blue diamonds for gas consumption, large violet squares for electricity and small black squares for total energy consumption). Running average ("least-square") consumption for each data series is shown in dotted lines (blue for gas, violet for electricity and black for total consumption).



Comments and Analysis

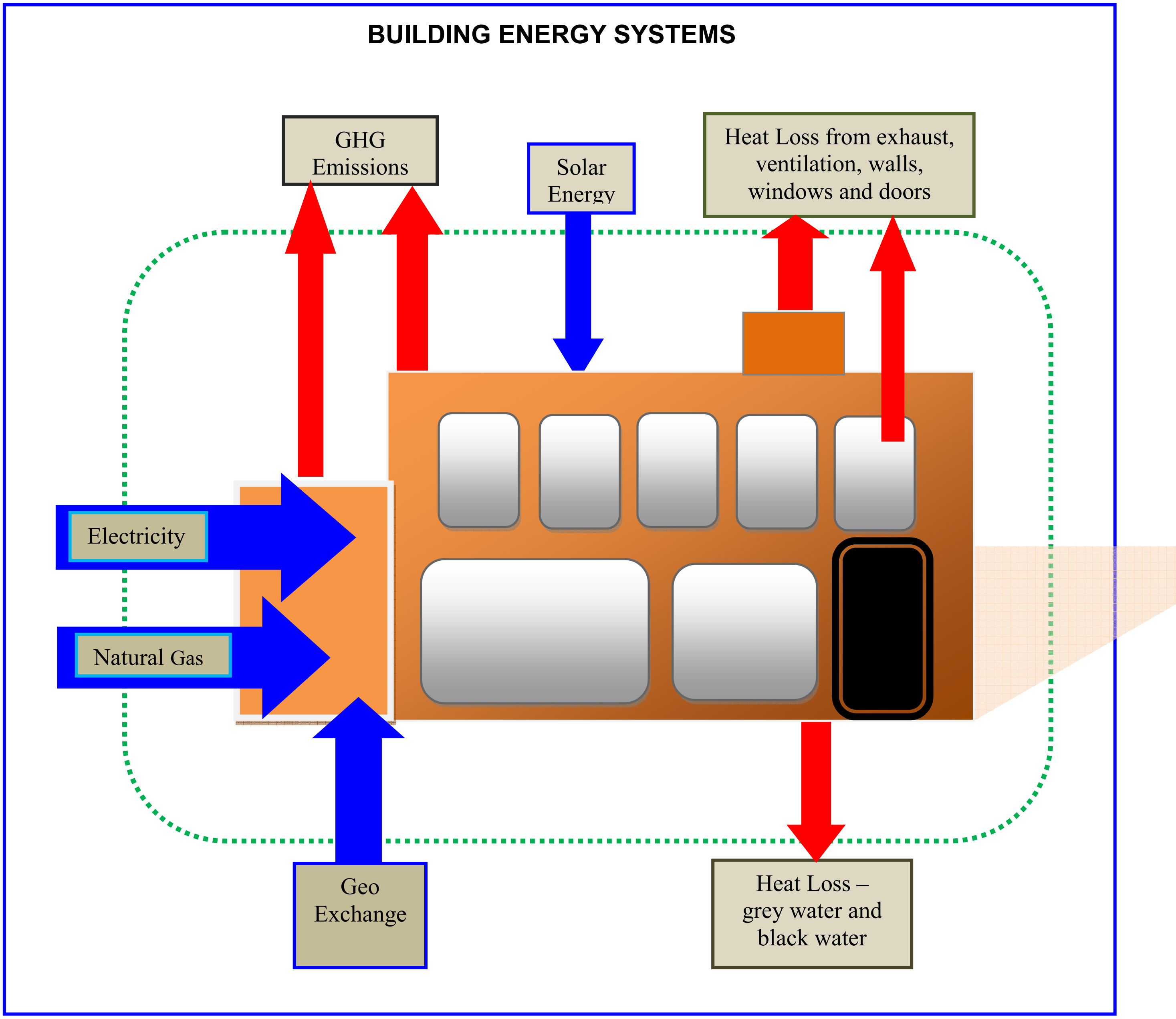
Energy consumption of both natural gas and electricity for the Cornerstone Building has increased consistently between October 2006 and March 2009. Total energy consumption increased, for example, from 42,880 MJ in October 2006 to 80,400 MJ in October 2007 and 81,616 in October 2008. A significant component of this increase in energy use may be due to the fact that the building was not fully occupied through 2006 and 2007. Comparisons of energy consumption based on longer-term analogous data (i.e., consumption figures for a fully occupied building and/or specific building spaces using temperature corrected use data) will provide more insight into consumption patterns.

A more detailed comparison of energy consumption on a month-by-month and seasonal basis shows natural gas use for the building decreasing slightly between the winter of 2007-08 and 2008-09 and the summers of 2008 and 2009. In comparison, electricity use increased by about 10% from the winter of 2007-08 to the winter of 2008-09. Further assessment of electricity use (in particular) may identify factors behind this increase and potential opportunities for conservation.

Opportunities for Energy Conservation and GHG Emissions Savings

Energy consumption and GHG emissions for a building are related, however have important distinguishing differences. Energy conservation can support both cost and GHG emissions savings – depending on the cost and effectiveness of the conservation measures and the type and price of the energy sources involved. GHG emissions for heating and powering a building are closely tied to the burning of fossil fuels – with renewable sources having the lowest GHG emission factors.

The figure below provides a generic summary of the elements of a building's energy system and the flows of heat and moisture through a building (depicted in the schematic diagram on the first page of this assessment). Energy conservation and GHG emissions savings opportunities can be realized through close examination of each of these elements – individually and collectively – in relation to the nature of the Cornerstone Building and the way in which occupants and visitors use it.



1. Energy Conservation

The amount of energy consumed in a building (and potential for energy savings) is related to four factors:

A. Conversion – the energy used/lost in the conversion of a raw source of energy into a useful service (e.g., boilers, heat pumps, cooling plant)

B. Distribution Loads – those associated with energy lost (unproductively) in transferring the energy from the source (e.g., boiler) to the point of use in the useful space

C. Functional Loads – the energy needs/demands of the occupants or equipment in the building (e.g., temperature, light, fresh air)

D. Building Envelope – everything that separates and protects indoors from out, including exterior walls, insulation, roofing, foundation, flooring, windows and door

Looking at each of these factors in turn, the following possibilities are offered for further investigation or consideration by Fernwood NRG.

A – Conversion

- Take further advantage of the superior conversion efficiency of the ground source heat pump over the gas boiler (4.4:1 versus 0.8:1) – installation of a digital switching system (between the heat sources) could increase utilization of the GSHP (from present 50/50 to up to 80/20).
- Completion of the solar hot water project would add another renewable energy source to the system, further reducing consumption of natural gas and associated costs.
- Confirm roles and responsibilities for periodic and annual maintenance tasks between Fernwood NRG and contracted technicians (e.g., Pro Star Mechanical Technologies), with clear "help line" and "emergency contact" provisions.

B – Distribution Loads

- The domestic hot water distributions lines and storage tanks are not currently insulated. There may be some energy savings that could be realized by effective insulation of this equipment.
- Train personnel and establish protocols for routine maintenance and review to optimize efficiency of distribution system (e.g., filter checks and changes, thermostat settings, monitoring comfort and satisfaction of building users).

C – Functional Loads

- Some concerns were reported regarding less than ideal adjustments of the thermostats in some areas. Guards or electronic controls could be installed to prevent random adjustments to the settings. Steps to improve occupant comfort should be considered. Consult with a mechanical engineer to review and redesign the current air distribution system to include fresh air input, improved air mixing and heat distribution.
- Develop an information/education tool and provide building users with regular "energy management reviews" summarizing energy use and carbon footprint data to build understanding, shared ownership and cooperation in the managing of energy use in the Cornerstone Building.

D – Building Envelope

- Addressing these issues is generally expensive and is best incorporated in major maintenance and updating projects. Given the heritage values of the Cornerstone Building features, care must be exercised when considering changes to the building envelope – for example, moisture and provision for "breathing" of the building are important considerations. A specialist could be engaged to ensure that energy conservation measures respect the heritage values that Fernwood NRG wishes to retain and are within engineering parameters of the building envelope. With these considerations in mind however, it would be worth investigating as a priority window and door upgrades for the coffee shop to improve user comfort and control condensation in this space.

2. GHG Emissions Savings

GHG (greenhouse gas) emissions from buildings are dependent on:

A. **Level of Activity** – e.g., hours of use, types of use, controls and set-points, behaviour of building users.

B. **Efficiency of the Energy System** – e.g., efficiency of heat production, heat loss in distribution system.

C. **Types of Fuel Used** – emission factors of fossil fuel sources (e.g., fuel oil, natural gas) relative to renewable sources (e.g., hydro-electric generation, geo-exchange, solar).

A – Level of Activity

Key considerations are the duration of use and the amount of use – energy conservation measures will also likely reduce GHG emissions. Make sure that the system operates in a way that matches the requirement of the users – no more and no less. Is energy being wasted because:

- There is an increase in heating or cooling related to poor building envelope – windows, doors, wall, roof insulation and structural air leakage. See: 1D – Building Envelope above.
- There is high humidity in some areas. Air that is moist has a higher heat capacity than dry air requiring more heat to increase its temperature.
- Unoccupied areas are being heated. Thermostats are not being set back during unoccupied hours. Space temperatures have not been lowered in storage areas. Develop an educational program for users. Install controls where necessary.
- Control set-points have in the past been adjusted incorrectly by operators (e.g., thermostat temperatures too high). An error of 1-2 degrees C can make a significant difference in heating costs and GHG emissions. In public spaces consider controls with lock out features. In private areas engage and educate users.
- Building users are not engaged in GHG reduction measures and targets. Develop strategies to engage and educate all building users (tenants, employees, service providers, visitors, suppliers and management). Create an atmosphere or shared ownership and responsibility in the Cornerstone community. Make it possible for everyone to engage in GHG reduction initiatives and share in successes as goals are reached.

B – Efficiency

When the system is functioning at optimum efficiency the use of fuel is more efficient, thereby controlling GHG emissions.

- Preventative maintenance – Create and implement a maintenance plan to ensure optimal function of burners, heat exchangers, filters, ducts, pipes, dampers and moving parts.
- Design of system does not meet the requirement of an area. Address the air make up and heat distribution in the coffee shop system. Consider installing a ceiling fan to move accumulated heat at ceiling level to floor level.

C – Fuel Type

- GHG emissions vary depending on the type of fuel used to create energy for the building. The emissions from the Cornerstone Building could be further reduced by relying more on renewable sources of energy and less on fossil fuels.
- Maximize use of the ground source heat pump – currently the GSHP is responsible for about 50% of space heating. Explore options for more sophisticated interface controls to reduce use of the natural gas boiler.
- Complete the solar hot water project to further reduce natural gas use for the building.

Summary of Potential Energy Conservation and GHG Emission Saving Measures

Potential Action	Potential for Energy Conservation Savings	Potential for GHG Emission Savings	Estimated Cost[1]	Comments
1. Building user education program	High	Medium	Low	Orientation and information to build shared awareness, "ownership" and goals.
2. Building operations and maintenance program	High	Medium	Low	Program would increase system efficiency and minimize maintenance and repairs.
3. Fernwood community awareness program	Medium to High Will depend on the size of the ripples you generate...	Medium to High	Low	Community program could be developed using information gained from Cornerstone Building experience to encourage residents and businesses in developing energy and GHG reduction strategies.
4. Electrical assessment (lighting, equipment, appliances)	High	Medium	Low	Not undertaken in this assessment – BC Hydro incentive programs could be accessed to minimize costs.
5. Completion of Solar Hot Water project	High	High	High	Project would likely yield long term energy and GHG emission savings.
6. Electronic interface control between GSHP and Gas boiler	High	High	Medium	Very good value, assuming that efficiency of existing heating system is improved.
7. Upgrade thermostats to control set-points in occupied areas and minimize heat delivered to unoccupied spaces	High	High	Low-Medium	Cost would vary with extent of digital control system and thermostats used.
8. Retro-fit of air distribution system in the coffee shop to improve air circulation and fresh air return	Low	Low	Medium	While this action would most likely increase energy consumption, the changes would improve comfort for the users of the space – improve working conditions and reduce the risks associated with high humidity posed to the building envelope.
9. Building envelope upgrades (windows and doors in coffee shop)	High	High	Medium-High	Related to item 8 – this action alone will not solve the fresh air and high humidity problems. New thermal windows would however result in less condensation and fogging.

Notes:

[1] Estimated capital or program initiation costs: **Low:** $1-5,000 **Medium:** $5-10,000 **High:** Over $10,000

Appendices – Energy Consumption Data and Calculation Notes

Cornerstone Building – Energy Consumption Data

Month and Year	Natural Gas Consumption MJ	Electricity Consumption MJ	Total Energy Consumption MJ	12 Month Energy Consumption (Running Total) MJ	Mean Temp Degrees C	Heating Degree Days (HDD)
Oct-06	20,200	22,680	42,880		10.2	241.3
Nov-06	44,200	35,424	79,624		5.7	369.7
Dec-06	32,500	16,416	48,916		4.4	422
Jan-07	39,400	47,520	86,920		3.4	452.4
Feb-07	43,500	32,832	76,332		5.8	341.4
Mar-07	35,400	28,944	64,344		7.3	332
Apr-07	19,100	28,944	48,044		8.7	278.3
May-07	12,600	32,400	38,700		12	185.2
Jun-07	12,600	43,632	45,532		14.4	107.9
Jul-07	15,000	49,248	49,328		18.1	25.6
Aug-07	15,000	48,384	77,584		16.9	40
Sep-07	14,700	51,408	66,108	724,312	13.4	138.7
Oct-07	26,400	54,000	80,400	761,832	9.37	267
Nov-07	37,700	62,640	100,340	782,548	5.8	367.2
Dec-07	53,700	61,128	114,828	848,460	3.7	444.7
Jan-08	47,500	51,408	98,908	860,448	3.5	448.4
Feb-08	51,100	54,216	105,316	889,432	5.3	368.9
Mar-08	43,800	44,064	87,864	912,952	5.6	384.6
Apr-08	44,000	50,760	50,760	915,668	6.7	339.3
May-08	44,000	45,144	53,944	930,912	12.2	180.3
Jun-08	23,500	46,224	69,724	955,104	14.2	123.6
Jul-08	20,400	53,784	74,184	979,960	16.3	53.7
Aug-08	21,700	47,952	69,652	972,028	16.9	55.4
Sep-08	19,600	53,136	72,736	978,656	14.3	110.6
Oct-08	22,000	59,616	81,616	979,872	9.3	269.9
Nov-08	25,800	71,712	97,512	977,044	8.2	293.2
Dec-08	62,400	57,024	108,524	970,740	1.8	503.1
Jan-09	51,500	64,152	115,652	987,484	3.4	454
Feb-09	53,700	59,832	113,532	995,700	4	392
Mar-09	39,300	55,296	94,596	1,002,432	4.8	409.7
Apr-09	23,900	no data			8.5	284.8
May-09	23,400	no data			11.9	190.6
Jun-09	19,900	no data			16.3	64.6

Notes:

1. Natural gas consumption figures for some months (May-June 07, July-August 07 and April-May 08) interpolated from two month billing period
2. 12 month energy consumption figure is total consumption for the 12 month period ending that month (e.g., Oct 06-Sept 07)
3. Mean temp figures from Environment Canada data for Victoria BC
4. Heating degree days from Environment Canada data for Victoria BC

Calculation Notes

Calculation of Gas Use

Step 1	Determine the total gas use of one heating season: (e.g., Oct 08-March 09) six month total = **254,700 MJ**
Step 2	Determine the total gas use of one non-heating season: (e.g., April 08-Sept 08) six month total = **173,200 MJ**
Step 3	Calculate annual gas use for space heating: 254,700 (step 1) - 173,200 (step 2) = **81,500MJ/year**
Step 4	Calculate annual gas use for operations other than space heating (i.e., domestic hot water): [254,700 (step 1) + 173,200 (step 2)] - 81,500 (step 3) = **346,400MJ/year**

Data source: Fernwood NRG – Terasen billings (monthly or bi-monthly readings)

Calculation of Electrical Use

Step 1	Determine the total electrical use of one heating season: (e.g. Oct 07-April 08)[1] seven month total = **378,216MJ**
Step 2	Determine the total electrical use during one non-heating season: (e.g. May 07-Aug 07)[2] Four month total = 173,416MJ /4 months = **43,416 MJ/month**
Step 3	Calculate electrical use for space heating over one heating season (7 months) 378,216 (step 1) - [43,416 MJ/month (step 2) x 7 months] = **74,302MJ**
Step 4	Calculate annual electrical use for operations other than space heating: 603,288MJ (12 month May 07-April 08 total from data table) - 74,302 (step 3) = **528,986 MJ**

Data source: Fernwood NRG – BC Hydro billings (monthly or bi-monthly readings)

Calculation of Costs Related to Space Heating

Step 1	**Natural Gas Boiler:** Gas boiler used 81,500MJ (Calculation of Gas Use – Step 3) to provide 65,200 MJ or 65.2 GJ of heat (operates at 0.8 efficiency). Cost of Boiler heat per GJ = ($16.45/GJ[3] x 0.8 efficiency factor) = **$20.56/GJ[4]**
Step 2	**Electricity related to Ground Source Heat Pump (GSHP):** Heat pump used 74,304 MJ or 74.304 GJ of electricity to provide 222.912GJ heat (operates at 3:1 efficiency). Cost of GSHP per GJ = ($0.062/kWh[5] / 0.0036 kWh/GJ) /4.4 efficiency factor) = **$3.91/GJ[6]**

Notes:

[1] Data indicated an abnormally low use in March 08 which may have been due to meter reading scheduling rather than usage, so to establish a baseline figure the entire heating period of seven months was used (rather than a portion of the season), to obtain a more accurate reflection of the monthly average of electrical use.

[2] This four month period was considered as the most representative use period for establishing a non-heating electrical baseline (as the installation of an electrical air conditioning (AC) unit in the restaurant commercial spaces in summer '08 increased electrical usage in subsequent summer months).

[3] Cost of natural gas per GJ (as charged by utility).

[4] Cost is provided in $/GJ as gigajoules are the units used in utility billing

[5] Cost of electricity per kWH (as charged by utility).

[6] Cost is provided in $/GJ to enable comparison with natural gas cost.

Calculation of Greenhouse Gas (GHG) Emissions

Emissions factors and rationale derived from BC Sustainable Energy (BCSEA) website:
www.bcsea.org/solutions/citizens-and-homeowners/calculate-your-carbon-footprint

Emissions related to electricity. Electrical energy from BC Hydro is 88% "clean" (i.e., from renewable sources). The remaining 12% is imported from out of province and is generated by burning coal and gas. The GHG emission factor for this portion of electrical power is 800 grams CO_2/kWh. GHG emissions for electricity used in the Cornerstone Building were derived by calculating 12% of electrical use, multiplying those kWh by 800 grams CO_2/kWh and converting the resultant to metric tonnes:

Step 1: Calculate total annual electrical use = 603,288 MJ / 3.6 kWh/MJ = 167,580 kWh

Step 2: Calculate portion of electricity associated with emissions: 167,580 kWh x 0.12 = 20,110 kWh

Step 3: Calculate GHG emissions: 20,110 kWh x 0.8 kg/kWh = 16,088 kg or **16.1 tonnes**

Emissions related to natural gas. This figure was calculated by multiplying the amount of gas used (in GJ) by the emission factor for domestic use of natural gas – 52 Kg/GJ of natural gas – and converting the resultant to metric tonnes.

Step 1: Calculate total annual natural gas use (heating + non-heating) = 427,900 MJ or 427.9 GJ

Step 2: Calculate GHG emissions: 427.9 GJ x 52 kg/GJ = 22,250.8 kg or **22.2 tonnes**

Emissions savings associated with use of ground source heat pump (geo exchange). This figure was calculated by first multiplying the electrical load for heating (in GJ) by the efficiency factor of the heat pump (4.4:1), accounting for the inefficiency factor of the natural gas boiler (0.2:1), multiplying the resultant by the GHG emission factor for natural gas (52Kg/GJ) and then subtracting the emissions associated with the electrical load.

Step 1: Convert electrical load of heat pump to GJ: 74,302MJ/1000 = 74.302GJ

Step 2: Calculate amount of natural gas required an equal amount of heat: 74.302GJ x 4.4 = 326.93GJ

Step 3: Add inefficiency factor of gas boiler: 326.93 + (326.93 x 0.2) = 392.32GJ

Step 4: Calculate GHG emissions: 392.32GJ x 52 Kg/GJ =20,400Kg or 20.4 tonnes

Step 5: Calculate difference in emissions: 20.4 tonnes - 1.99 tonnes (existing electricity GHG emissions) = **18.4 tonnes**

Tips for Utilizing Utility Bill Data to Assess Energy Usage

Date – When entering the data be sure that the energy use being recorded corresponds to the time period when the energy was actually used and not the date of billing (e.g., the date of the bill is usually the month following the date of use).

Electrical Usage – BC Hydro records and charges users in kilowatt hours (kWh). One kilowatt hour equals 3.6 mega joules (MJ) (or 0.0036 gigajoules GJ). Energy use should be converted to common units to enable comparison of energy sources.

The length of billing period (time between meter readings) can vary. To approximate the use per month divide the total number of kilowatt hours by the total number of days for a daily average. Multiply the daily average by the number of days in that month. When the meter reading (billing) period ends or begins part way through a calendar month look for the remaining days on the previous or next bill. Use the daily average strategy to complete the energy profile for each month.

Natural Gas – Terasen bills are often estimated and corrected on later bills. The number corresponding to the "Present reading" will have "Est" written beside it. When calculating the information from these bills look forward and backward through the billing history to be sure that you are entering the data for each month correctly.

Average Monthly Temperature – Terasen records the average daily temperature for each billing period.

Average daily temperatures for each month are also available from Environment Canada.

Another common method for building energy use comparisons uses "Heating Degree Days" (HDD). HDD = (Base Temperature - Average Daily Temperature) x number of days (in the month). The "base temperature" for heating is the temperature at which a "typical" building requires no heating. The standard base temperature for heating is 18° C.

Monthly temperature records for identified locations (e.g., Victoria International Airport) are available from Environment Canada – see, for example, the link below:

www.climate.weatheroffice.ec.gc.ca/climateData/dailydata_e.html?timeframe=2&Prov=XX&StationID=118&Year=2009&Month=9&Day=1