Balmertown Fire Station

Energy Efficiency Evaluation, 10044

FINAL REPORT - JULY 2012

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consulting engineers & architect

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1. Introduction

1.1 Objectives

Keewatin-Aski Ltd. was retained to identify energy saving opportunities (ESO's) in various buildings operated by The Corporation of the Municipality of Red Lake (the Municipality) including the Balmertown Fire Station. Reports for each facility reviewed are bound under separate cover. The Municipality proposed a straight-forward goal: *"Identify ESO's to achieve a target of 20% overall reduction in energy usage."*

1.2 Methodology

The building was initially reviewed on September 23, 2010 by Kelly Merke, P.Eng. (Keewatin-Aski Ltd.) to screen potential candidates and develop a scope of work for future energy assessments. The review consisted of a walk-through of the building to compile an inventory and evaluate the current condition of the buildings enclosure (walls, roof, windows and doors), lighting and HVAC equipment. Access to the building was facilitated by Walter Scarrow, the fire-chief for the Municipality.

Separate reviews to obtain infrared imaging were conducted on December 1st and 3rd (2010).

As-built construction drawings were not available at the time of the visit; however, a preliminary floor plan provided basic reference (see Appendix "A"). On site measurements were obtained such as areas and volumetric data. A blower-door apparatus (Minneapolis Blower Door, Model 3 + DG700 differential manometer) was also utilized to determine the air leakage characteristics in the 'as-operated' state. The data collected, filed for future reference and later incorporated into energy modelling software. Software utilized for this energy evaluation was "Hot2000 ver. 10.51" developed by Natural Resources Canada.

The base model was calibrated utilizing historical energy consumption data provided by the Municipality for the calendar years 2007 to 2010. Where building data was not available assumptions were made on discussions with site personnel or based on other local knowledge for similar building types.

During the blower door testing, a qualitative review of the thermal performance of the building enclosure was reviewed from the interior with a thermal imaging camera (Flir Model: InfraCAM). A separate review (static) was conducted from the exterior on December 1st, and December 3rd of 2010.

ESO's are presented and prioritized observing fundamental building science control principals as follows:

Priority 1 - Water / Drainage Control
Priority 2 - Air / Leakage Control
Priority 3 - Vapour Control
Priority 4 - Thermal Control

1.3 Date & Weather

The review of the facility was conducted on September 23, 2010. Interior temperature was recorded at 18°C and outside air temperature at time of visit was approximately 10°C. On December 1st and 3rd (2010) the exterior temperatures were -12 °C and -17 °C respectively.

1.4 Limitations and Assumptions

Discussions within this report relate to the visible elements of the building that remain installed at the time of visit. No sampling, destructive testing or disassembly was made during the visit. Appliances and ancillary equipment such as refrigerators and stoves were not reviewed. Costs analyses presented herein are based on the best available information, local experience and approximations where appropriate. Results and actual costs/savings will vary from estimates provided.

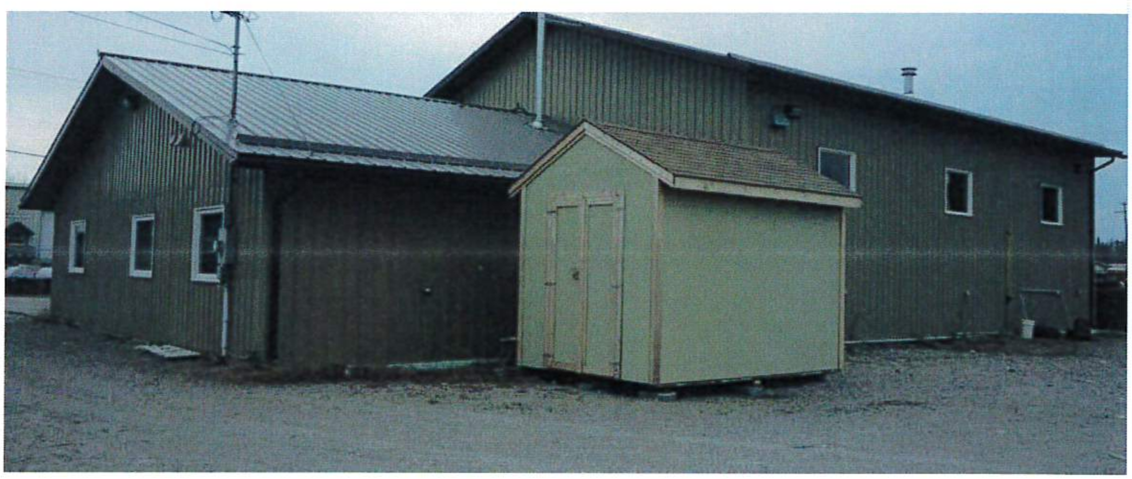
2. Observations

The Balmertown Fire Station was constructed approximately 26 years ago (est. 1986). The building is pre-engineered steel-frame, single-storey, slab-on-grade with a specified Gross Floor Area of 3,200 sq.ft. (298 sq.m.). Construction is generally considered to be as-original with no upgrades to the architectural or structural systems. No maintenance history was available at the time of the review.

Site

The building is located at Fifth Street, Balmertown, ON. The street elevation faces east. The main entry to the building is located on the east elevation. Three (3) overhead garage doors (14' x 14') face the street. A second man-door is located on the south elevation. The lot is generally flat with moderate grading away from the building in each direction.

Southeast Elevation View



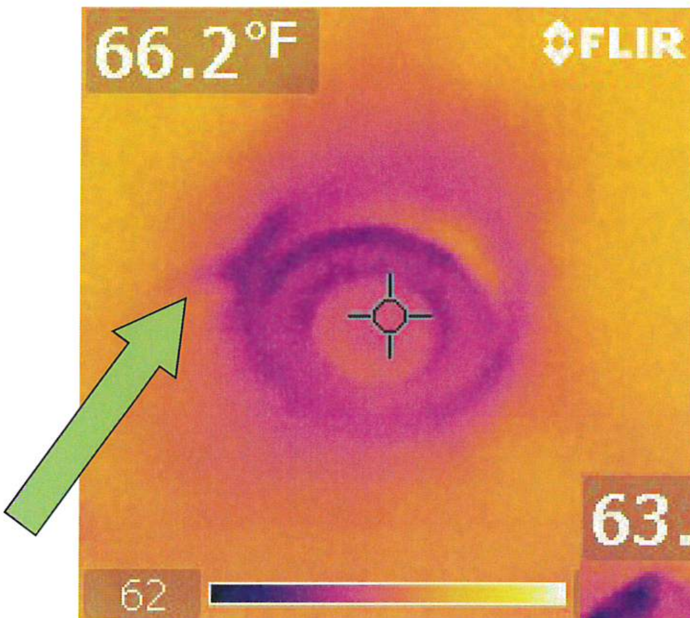
Northwest Elevation View

Foundation

Rigid insulation is present, however, exposed and unprotected at the slab perimeter (photo below). Fitment of insulation is also poor. Nominal insulation value for 1" thick XPS is R5. It is not known if the insulation extends horizontally, however, it is assumed that it extends vertically downward from grade to a depth of 2' (The depth of the thickened edge slab noted on drawing).

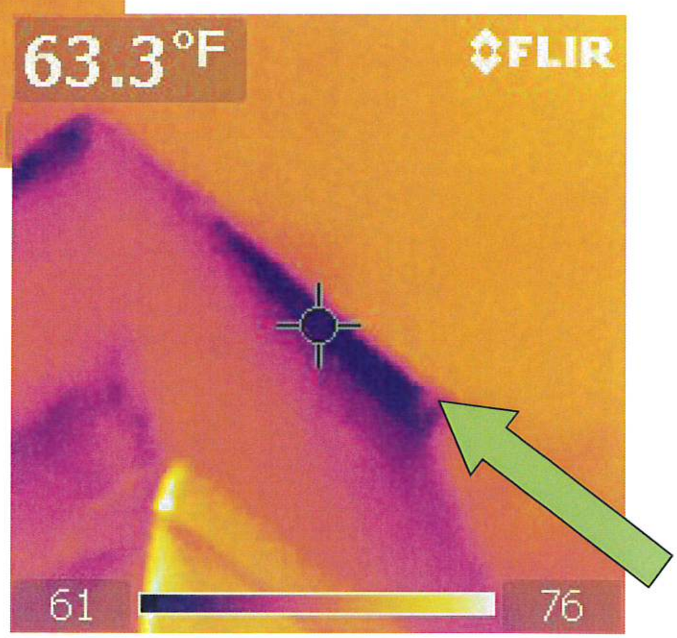
Exterior Walls

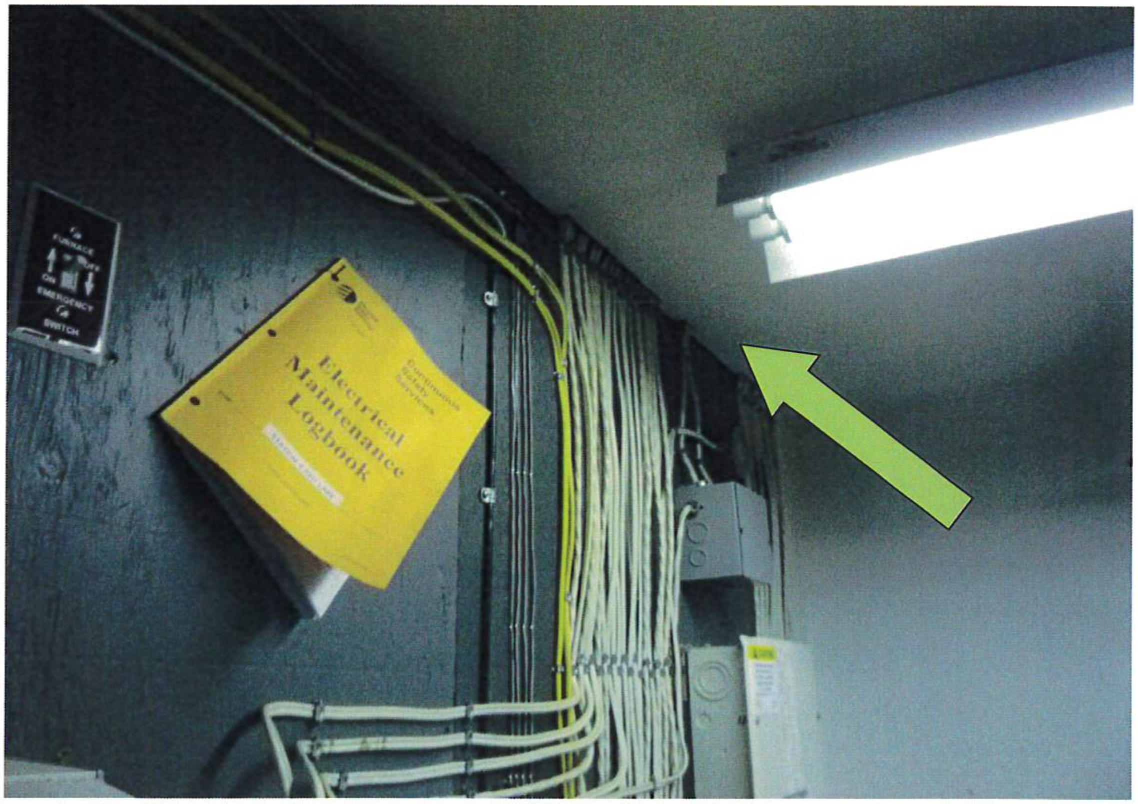
The exterior walls are 2x6 wood-framed with fiberglass batt insulation with nominal insulation value of R20. The effective insulation value is estimated at R15. Interior finishes are gypsum board or plywood. Exterior sheathing is corrugated metal siding.



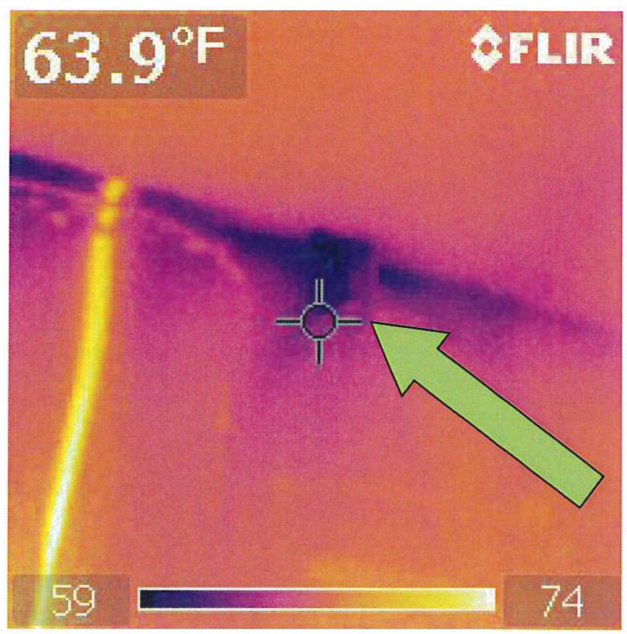
Air leakage was observed at locations where services (wiring, piping, ducts, etc.) penetrates the exterior wall and ceiling planes

Air leakage around detector (infrared image left). Air leage at duct penetration (infrared image below).



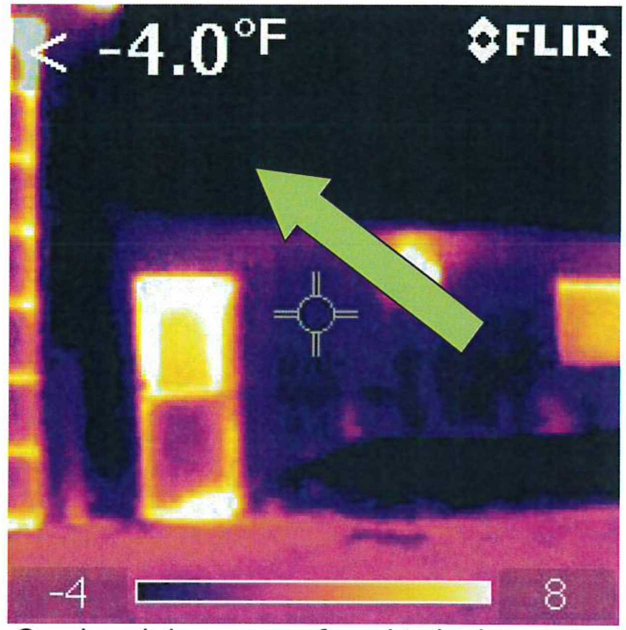


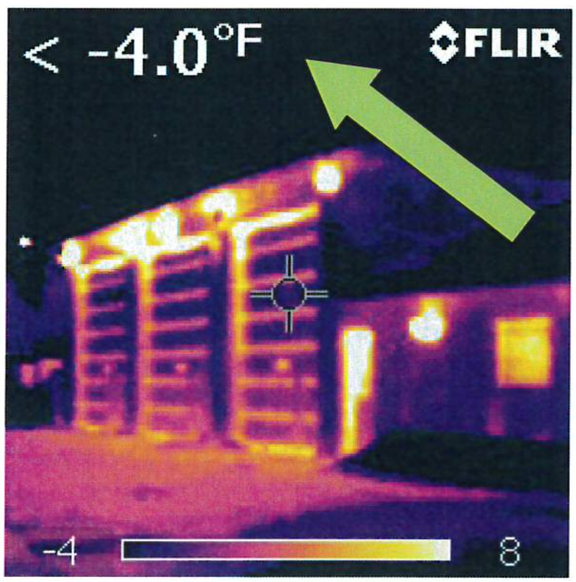
Air leakage observed at ceiling penetrations around wiring (photo above and image right)



Doors & Windows

Exterior man-doors are insulated steel units (commercial). Weather stripping is worn and due for maintenance/ repair. Air leakage evident in the infrared images (photo right). Estimated nominal insulation value is estimated at R2.



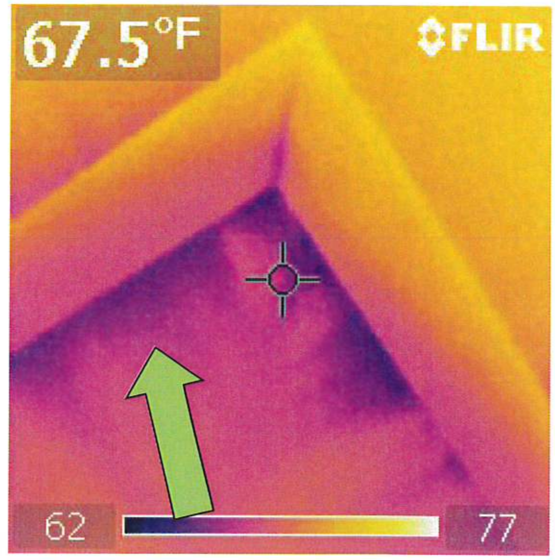


Overhead doors were found to be in need of adjustment at the head and sill locations. Past attempt to correct this condition were previously made, however, with limited success. Additional investigation into cause is recommended. Discontinuities in the air/vapour barrier system is suspected along the front garage wall. Significant leakage is evident in the infrared images (photo left).

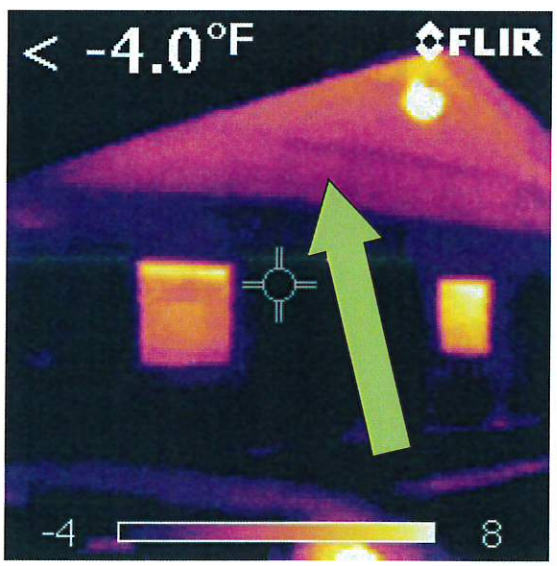
Exterior windows are vinyl frame, dual-glazed sealed units. There are seven (7) windows in total. No significant performance issues were noted. Estimated effective insulation value of these units is R3.

Roof / Attic Space

Access to the lower attic space was obtained through an interior access through the ceiling. The attic access does not fit the opening tightly and lacks weather-stripping. Air leakage is evident in infrared imaging (image right).



The roof/attic assembly consists of engineered wood trusses with metal sheathing over strapping. The attic floor is insulated with blown cellulose. The bottom chords of the trusses are visible (photo below right) and the average depth of insulation is approximately 6" resulting in a nominal insulation value of R20 The effective insulation value is estimated at R19.



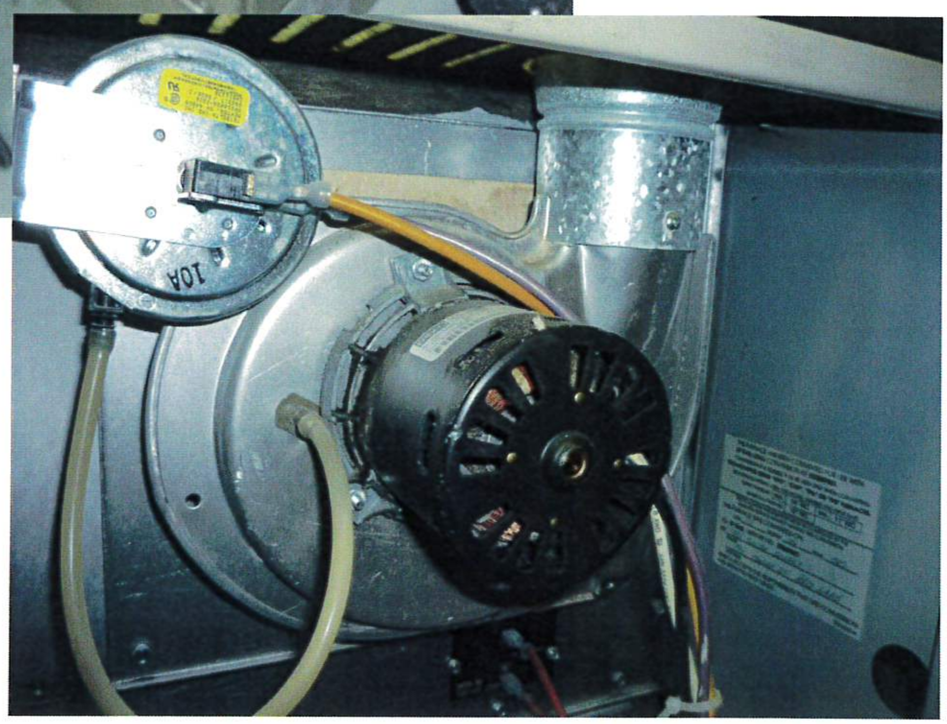
Heat loss from the attic is evident in infrared imaging (photo above).

Ductwork and HVAC

All primary air distribution and exhaust ducts are present in the lower attic space (photo right). Exposed ductwork is located above the insulation in the unheated zone outside the building thermal control layer. Minimal duct insulation is present at some locations; however, does not provide appreciable benefit or resistance to heat-loss. The ductwork is poorly supported/fastened and not sealed. Generally, for the given climate zone, placement of ducting in the unheated attic space, especially heating, should be avoided wherever possible.

Separate heating systems are provided for the garage bays and the office/admin/training room areas. The garage bays are heated with two (2) ceiling suspended propane-fired fan/coil (1/30hp) unit heaters (photo left). These units are naturally aspirated and vent to a common flue. Each unit has an input rating of 100,000 Btu/h (Model F100-3 by Reznor). These units have an estimated steady-state efficiency rating of 75%.

The admin area is heated with a propane-fired forced-air furnace rated at 100,000 Btu/h with an induced draft flue (Model NPGA100BA by Ducane, photo left and below). The flue is shared with the hot water tank. The estimated steady state energy efficiency rating of this unit is 82%.



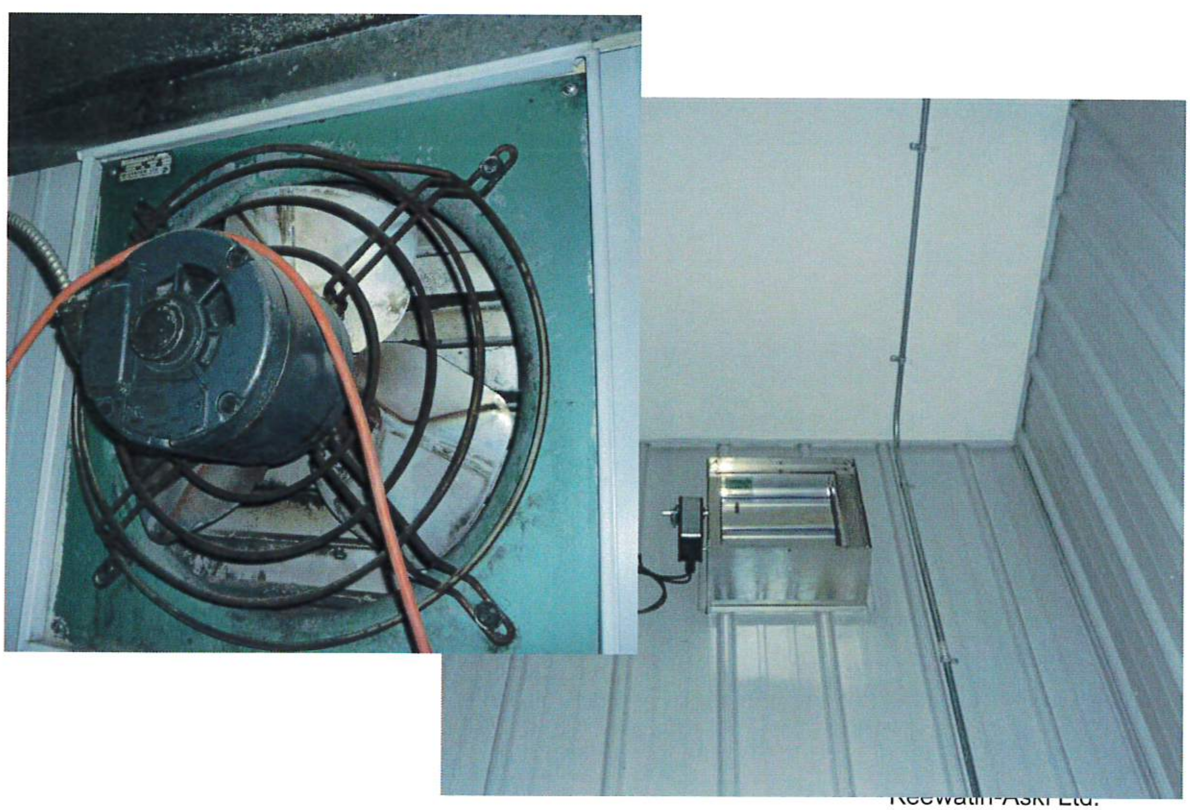
Domestic Hot Water

Domestic hot water is provided via a propane-fired, naturally aspirated storage-type hot water tank (41.6 Imp. Gal. by Giant, Model UG50-41LE-P, photo below). The existing hot water tank has an estimated Energy Factor (EF) of 0.55.

Exhaust Fans

Carbon monoxide sensors are present in the garage area and automatically engage an exhaust fan to eliminate fumes after vehicles enter/exit the space. The exhaust fans (photo below, top) are interconnected with motorized dampers (bottom photo) to allow fresh air in and minimize or eliminate back-drafting of the fuel-fire appliances.

Exhaust depressurization revealed that the building pressure can be reduced to -25Pa when all exhaust fans are activated. The pressure is maintained for a short period while the motorized damper opens. Given the presence of naturally aspirated heating and hot water appliances in the facility it is probable that, at times, the exhaust fan can cause back-drafting condition. As a result, the rising carbon monoxide levels may trigger the CO sensor and cause the exhaust fan to operate for extended periods resulting in a further energy penalty.



Lighting

Lighting throughout the facility is by commercial grade fluorescent tube light fixtures (T-12).

Air Leakage Rate & Area Estimates

The air leakage rate, in air-changes per hour at 50Pa pressure, for the building is estimated to be 5.02 ACH^{50} in the 'as-operated' state. Air leakage accounts for 28% of the total energy consumption (heat loss) for this building.

This is a measurement of the number of complete air changes per hour that occurs in the building when a pressure difference between the inside and the outside of the building is set at 50 Pascals (Pa). A 50-Pa pressure difference simulates wind blowing at 56 kilometers per hour on the building. A larger ACH value represents a leakier building.

The Equivalent Leakage Area (ELA) for the building is estimated to be 2.15 ft^2. This represents the total air leakage area. The total leakage area includes the cumulative area of all cracks, holes, gaps, etc. in the building combined. A larger the ELA value represents a leakier building.

3. Energy Usage Analysis

Electricity

The average annual hydro usage is 20,300 kWh (72.9 GJ) based on a three-year consumption history (2007 to 2009). Generally usage is consistent through the year with a moderate peak annually in March. Average monthly hydro usage[1] is approximately 1700 kWh as shown in Figure 1 below. Key electrical consumption loads are lighting, ventilation, fans/motors, battery chargers, business/admin equipment.

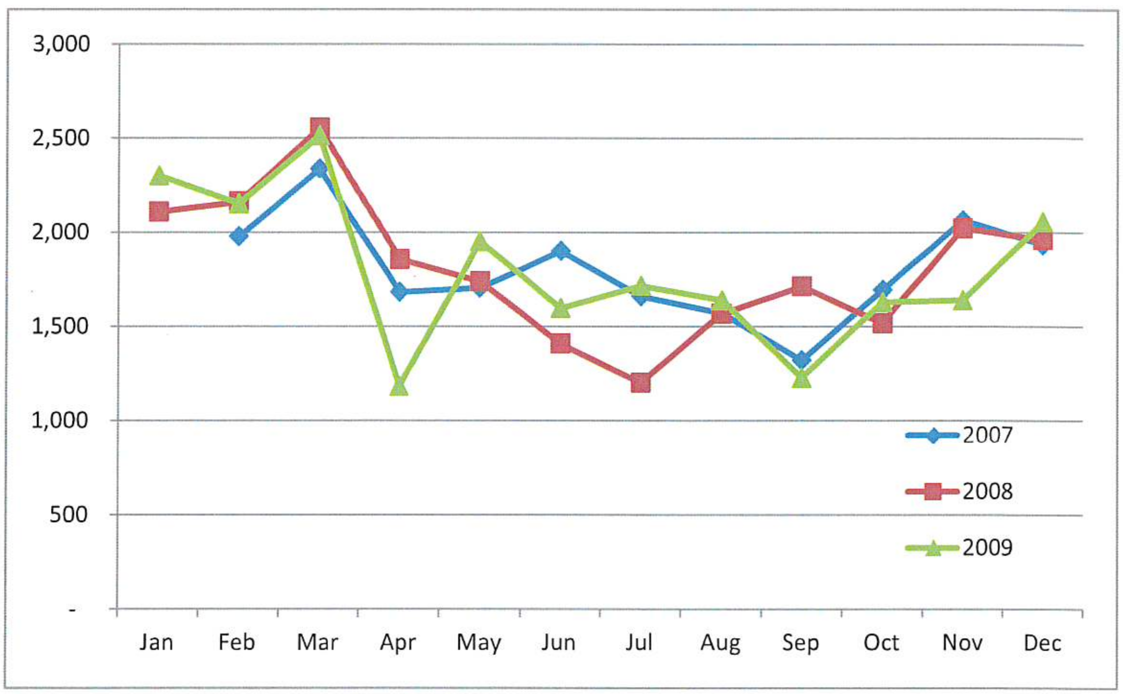


Figure 1 - Monthly HYDRO Consumption Data (kWh)

[1] Data for March 2009 was estimated due to missing or suspect data.

Propane

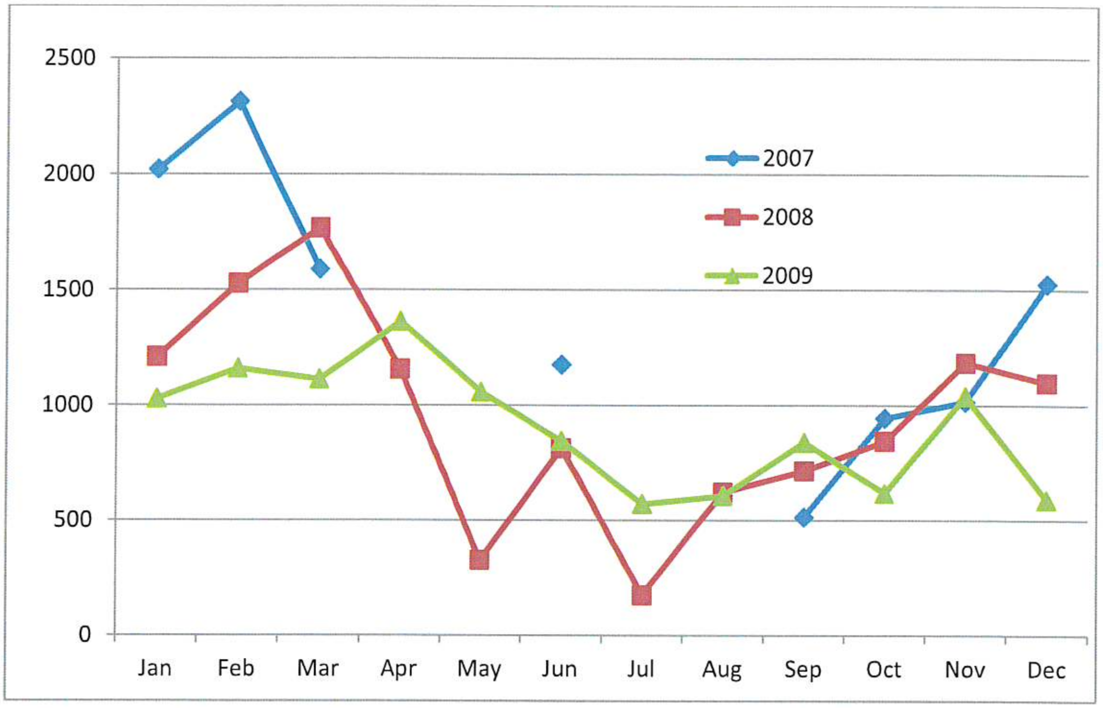


Figure 2 - Monthly PROPANE Consumption (litres)

The average annual propane usage is 11,127 litres (281.6 GJ or 78120 ekWh[2]) based on a three-year consumption history (2007 to 2009). Key propane consumption loads are heating and domestic hot water.

[2] ekWh = equivalent kilowatt hours

4. Energy Intensity Calculation

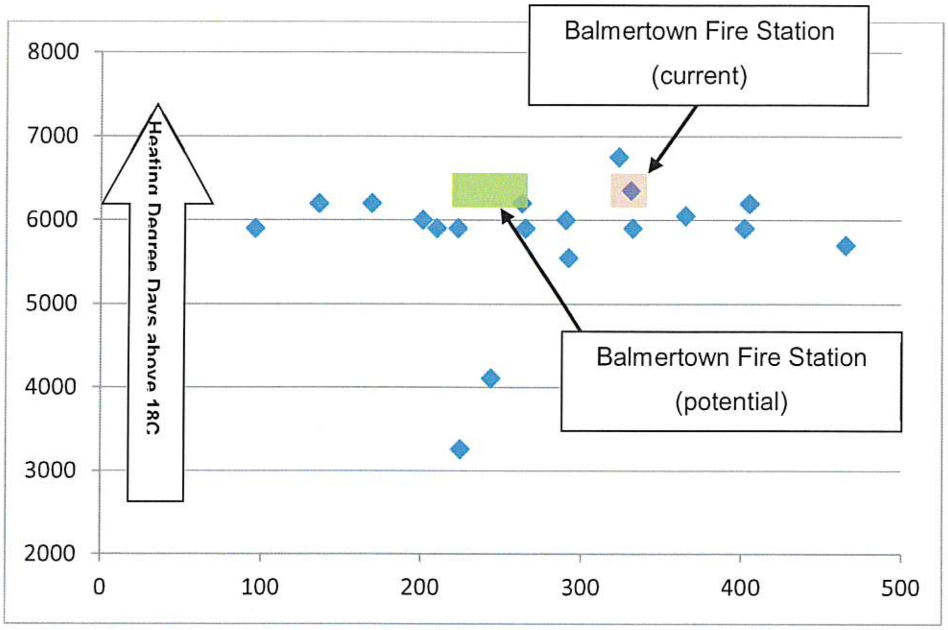


Figure 3 - Energy Intensity (ekWh/m2) Comparison of Similar Facilities[3]

The total energy consumed annually is 354.5 GJ and the building area is 298 m^2 which equates to an Energy Intensity of 1.19 GJ/m2 (330.8 ekWh/m^2). Approximately 14% higher than the average intensity of 290 ekWh/$m^{2.}$

Figure 3 above illustrates a comparative ranking for a representative sample of similar facilities (Municipal Fire Halls) in Ontario and Manitoba based on pre-retrofit conditions.

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[3] From combined 2007 data by AMO (Assoc. of Munipalities of Ontario) and AMM (Assoc. of Manitoba Municipalities).

Figure 4 on the next page represents the estimated relative energy losses for the primary building enclosure and mechanical assemblies or systems comprising the Balmertown Fire Station.

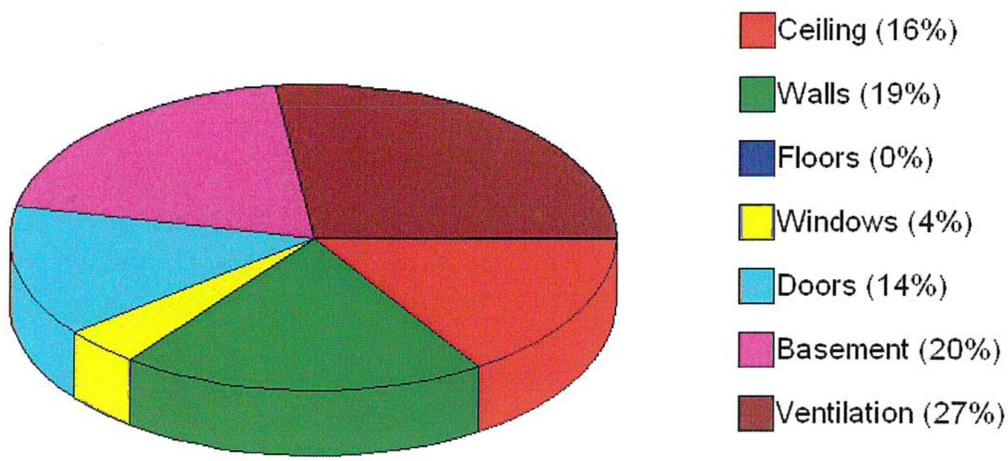

Figure 4 - Components of annual heat loss.

Figure 5 below indicates the represented amounts of energy consumption between space heating, hot water and lighting loads.

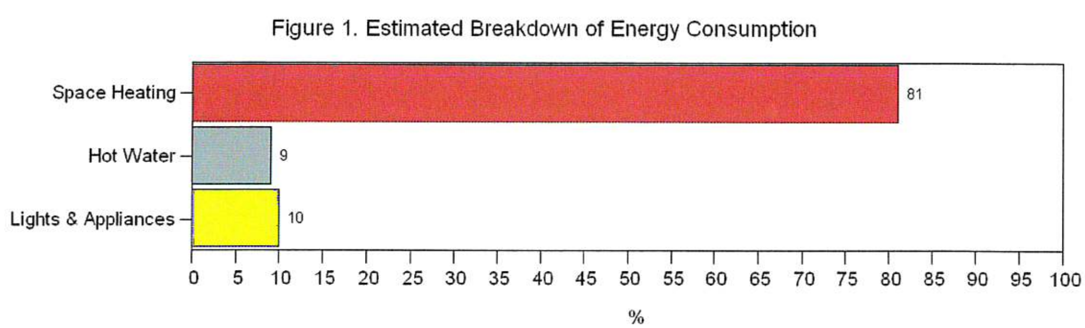

Figure 5 - Estimated Breakdown of Energy Consumption

5. Energy Savings Opportunities (ESOs)

a. Improve Air Sealing
    a. Replace, install or adjust weather stripping:
        i. Overhead Doors
        ii. Man Doors
        iii. Attic Access Hatch
        iv. Vent Stack Penetrations (in attic)
        v. Duct Ceiling Penetration (in attic)
        vi. Wire Penetrations (in attic)

b. Add Attic Insulation
    a. Add cellulose blown in insulation to achieve R60 nominal insulation value.
    b. Note that only after all measures have been made to ensure that the attic floor and any penetrations are sealed can additional insulation be added. Prerequisites also include determination of the scope of ductwork revisions (per above) and preparations for ensuring proper eave ventilation are maintained. A significant gain in energy savings is expected with this upgrade.

c. Add Exterior Wall Insulation
    a. Add R10 rigid XPS wall insulation to the exterior walls and air-barrier if not already present. Provide strapping to ensure adequate drainage control layer is maintained.
    b. Note that the existing cladding may possibly be re-used which makes this measure more cost effective.

d. Add Foundation Perimeter Insulation
    a. Add minimum R10 rigid XPS foundation insulation Note that the extent and depth of horizontal insulation should be confirmed and, if required, be supplemented to achieve nominal R20 or greater insulation value.

e. Replace Heating Systems
    a. Install a new natural-gas-fired condensing, direct-vented, forced-air furnace that is sized appropriately for the entire facility based on post-upgrade heat-loss analysis with an AFUE rating of 96.0 or greater.
    b. Install complete side-wall exhaust and intake flues (direct vents) for sealed combustion to eliminate back-drafting potential.
    c. Eliminate all vertical flues and ceiling penetrations.
    d. Revise Ductwork
        i. Option 1 - Relocate ductwork to interior (preferred option).
            1. Design new ductwork to suit airflow requirements based on and in conjunction with proposed heating systems upgrade (see below).
        ii. Option 2 – Seal and insulate attic ducting.
            1. Less than optimum performance will be achieved with this option and the risk of moisture related issues which may occur in the future will increase and may be detrimental to occupant safety/comfort and/or building durability/performance. This option should only be considered if Option 1 cannot feasibly be implemented. If so, then stringent standards for implementation must be followed to ensure serviceability and durability of the structure.

f. Replace Domestic Hot Water System
    a. Install a new DHW system with a condensing, direct-vent tank-less natural-gas-fired hot water heater with an Energy Factor of 0.90 or greater.
    b. Install complete side-wall exhaust and intake flues (direct vents) for sealed combustion to eliminate back-drafting potential.
    c. Eliminate all vertical flues and ceiling penetrations.

g. Upgrade Lighting
    a. Install LED lighting.
    b. Install motion/occupancy sensors/timers.

6. Effects of Implementing Energy Savings Measures

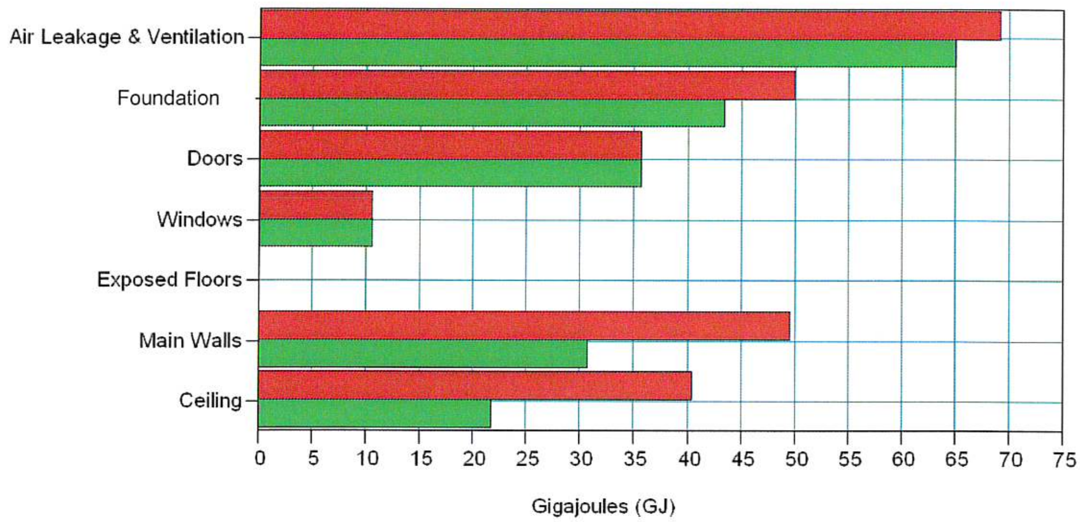

Figure 6 - Breakdown of Heatloss Through Building Enclosure

In Figure 6 above, the various components of heat loss are presented. The air leakage component is added to illustrate the separate impact of the combined air leakage (convective heat loss) characteristics from the remaining assemblies. Pre-retrofit values are indicated in *red (top bar)* while post-retrofit values are shown in *green (bottom bar).* The effects of the proposed energy saving measures, if implemented as whole, are illustrated. It is noted that air leakage is the single highest factor responsible for 28% of the estimated total energy loss, followed by losses through the foundation and walls at 17% and ceiling at 14%.

As shown in Figure 7 below, the overall potential of energy savings is 20% (after non-heating upgrades) and a further 12% for a total of 32% by implementing the recommended upgrades.

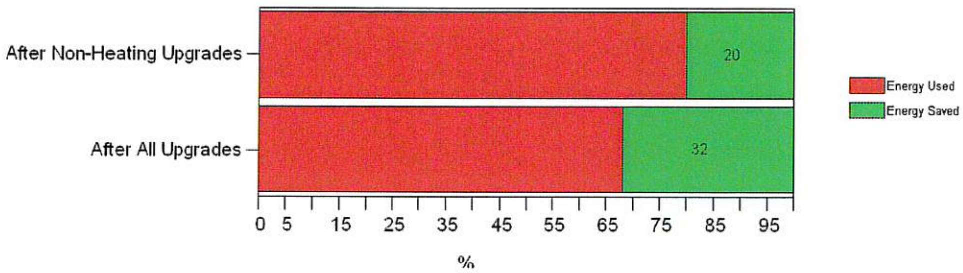

Figure 7 - Estimated Percentage of Potential Energy Savings

7. Cost Analysis

A summary of the estimated project costs and estimated annual savings are presented in Figure 8 below. Simple payback for the individual upgrades range between 3.3 years to over 29.2 years, however, when combined average out to 10.8 years. The total estimated cost of upgrades is $73,500. The average annual savings with all measures implemented is estimated at $6,800.

It is noted that the simple payback method does not fully account for escalated costs of materials and rising costs of energy. Furthermore, the added capital equity of the investments and resulting extended life of the facility and reduced maintenance costs is not fully accounted using the simple payback method. Other benefits that may be realized by implementing the recommended measures include improved occupant comfort, health, safety and reduced environmental impact, none of which are easily measured financially. Where appropriate, a life-cycle cost assessment may be advisable where the Municipality deems this to be appropriate.

ESO Description	Annual Energy Savings (GJ)	Cost Saving Per GJ	Estimated Annual Savings*	Estimated Project Cost	Simple Payback Period (yrs)
Air Sealing	5	$45	$300	$1,000	3.3
Add Roof Insulation	25	$45	$1,200	$35,000	29.2
Add Wall Insulation	58	$45	$2,700	$25,000	9.3
Replace Heating System	42	$38	$1,600	$6,000	3.8
Replace DHW System	18	$38	$700	$3,500	5.0
Upgrade Lighting	6	$42	$300	$3,000	10.0
Totals	**154**	**$44**	**$6,800**	**$73,500**	**10.8**

* Estimated annual savings based on all ESO measures implemented.

Figure 8 - Cost Analysis of Energy Saving Opportunities (ESOs)

8. Conclusion

Generally, the building is considered a valuable asset and worthy of improvements that will extend its serviceable life and reduce its footprint, whether that is measured in dollars or environmental benefits.

The reader is cautioned, however, that few measures will stand alone and deliver satisfactory and significant improvements to health, safety and energy efficiency if implemented individually and without regard for their impact on the building. In some cases, doing so may pose increased risks, adverse results and even failures. An example of this is to tighten the building enclosure without regard for the combustion air requirements of the naturally aspirated appliances which can have negative and even harmful effects. Any renovations or modification to the building and its related systems should be applied with appropriate advice and guidance of knowledgeable professionals and qualified tradesmen.

The building, for its age of only 10 years, is under-performing its peers using 14% more energy than average (which includes several buildings over 70 years old). This is mainly due to several key issues such as air leakage, inadequate attic insulation levels and an inefficient heating system. With the recommended upgrades presented in this report there is potential to exceed the target of 20% reduction in energy consumption by a considerable margin.