Energy Study and Net Zero Strategy

Prepared for

Village of Midway Community Hall

Attention

Penny Feist, CAO

Prepared by:

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Executive Summary

This report presents the finding of an ASHRAE Level 1 energy study for the Community Hall, located at 692 Seventh Street in Midway.We have identified strong opportunities for leadership in the field of energy conservation and sustainability by achieving carbon neutrality and net zero energy consumption.

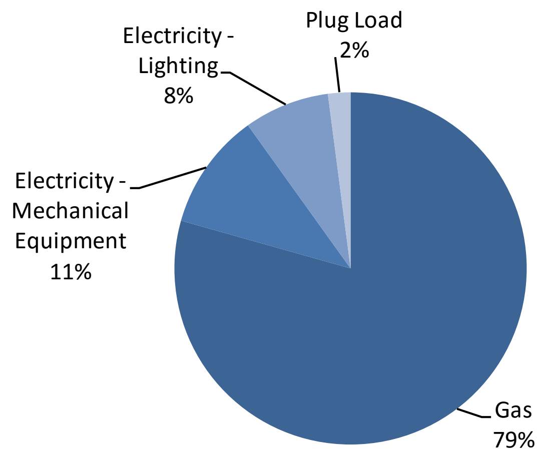
The as-found condition of the lighting and HVAC systems at the building in this report were at the end of life or relied on obsolete technology. These systems will perform more economically and have their life cycle extended by implementing the measures recommended in this report.

2016 updates to this report continue to use the conditions observed in 2013 as a baseline for project analysis. Provisions have not been made to accommodate future expansions on the facility affecting the heating, lighting, or ventilation systems.

I. Consumption and End Use

With a high level analysis of utility bills and facility equipment, the following breakout of energy consumption is produced:

Annual Utility Consumption



II. Recommended Energy Projects

This report presents the steps Midway Village can take to make its Community Hall a Net Zero facility. The overlying approach taken here is to apply the following three sequential steps:

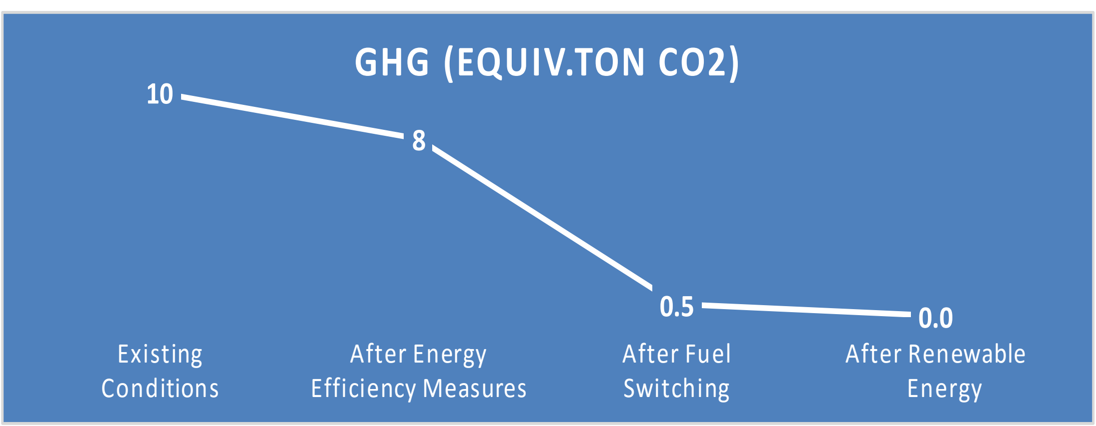
1. Implement Energy Efficiency Measures to minimize the existing energy demand. Also known as "Demand Side Reductions". Measures in this category will represent the best immediate value. Installing a start-of-the-art Building Automation System (BAS) should be considered a paramount priority. A web-enabled BAS accompanied by a modern Fault Detection and Diagnostic (FDD) service, building equipment, energy, and maintenance needs are monitored remotely and automatically, enabling powerful tools for system optimization and automated performance monitoring and reporting. Lighting Upgrades primarily revolve around replacing the obsolete T12 fixtures with new, TLED technology. These new lighting technologies are not only more efficient, but also offer improved light quality and controllability. Minor mechanical and water measures are also included here. Triple pane window technology represents the most advanced option for fenestration upgrades.
2. Eliminate fossil fuel consumption with fuel-switching strategies. This step has the most drastic impact on environmental metrics though is also likely to be the most capital intensive. Given the use of this facility, the climate of Midway, and the new technologies available, we recommend using an air-source heat pump as a primary means of space heating to replace the end of life gas furnaces.
3. Offsetting remaining electrical consumption with renewable energy generation. This step is made possible by the elimination of fossil fuels and brings the facility into true sustainability. For the scale and environment of this project, we recommend Solar PV as a means of energy generation.

Identified Opportunities toward Net Zero Operation

			Annual Savings					
Measure Description	Cost ($)	Payback (years)	Utility Cost ($)	Natural Gas (GJ)	Demand (KW)	Electricity (KWh)	GHG (tons CO_2)	BEPI (MJ / m²)
Energy Efficiency	$16,300	17.7	919	39		5,068	2.0	86
Fuel Switching	$105,000	119.3	880	148		-13,500	7.1	149
Renewable Energy	$85,000	31.5	2,700		5.0	32,400	0.7	175
Project Total	**$206,300**	**45.9**	**4,499**	**187**	**5.0**	**23,968**	**9.8**	**409**

III. Potential Results

The facility currently produces 10 tonnes of equivalent annual CO_2 emissions. The following chart demonstrates how emissions can be brought to zero, saving the complete energy utility cost of $3,300 annually plus $1,200 in potential additional revenue from surplus onsite electricity generation.



ACKNOWLEDGEMENTS

SES Consulting Inc. would like to acknowledge the valuable assistance of the following personnel in providing the necessary information for this report.

The 2013 energy audit and report upon which this 2016 revision is based was created and written by Brian Miltimore, AScT, with the assistance of Angie Weddell, EIT, Sean Crowley, EIT, and Justin Blanchfield, P.Eng. Brad White, P.Eng, was Senior Engineer for the project. The audit was conducted with the assistance of Tami Peters Deputy Clerk and John Bolz, Public Works Foreman for the Village of Midway and Dale Littlejohn and Megan Lohmann of the Community Energy Association. Their enthusiasm, cooperation and many contributions to the project are greatly appreciated.

The 2016 revisions are provided by Brad White, P.Eng, and Steffen Trangeled, EIT.

The cooperation and contributions by all are greatly appreciated.

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List of Acronyms

BAS: Building Automation System

BEPI: Building Energy Performance Index

BOMA: Building Owners and Managers Association

CFL: Compact Fluorescent Lamp

CNK: Carbon Neutral Kootenays

DDC: Direct Digital Control

DHW: Domestic Hot Water

DX: Direct Exchange

ECM: Energy Conservation Measure

EMIS: Energy Monitoring Information System

ESCO: Energy Service Company

GHG: Greenhouse Gas

HDD: Heating Degree Day

HID: High Intensity Discharge

HRV: Heat Recovery Ventilator

HVAC: Heating, Ventilation, and Air Conditioning

IRR: Internal Rate of Return

LED: Light-Emitting Diode

MH: Metal Halide

MUA: Make Up Air

NPV: Net Present Value

NTSB: Night-time Setback

OAT: Outdoor Air Temperature

OS: Occupancy Sensor

PHT: Predicted High Temperature

1. Overview

The Community Hall is located 692 Seventh Street, Midway, BC. The building appears to be about 40 years old. There have been few interior changes and renovations over time and the building is maintained on a breakdown basis. The building is an older 7,182 square foot, wood frame construction, public assembly building. The Community Hall has a 3,268 sqft. main floor with a foyay entrance way, office space and a large hall with a stage at one end. The basement has a full kitchen, activity areas, washrooms, and storage space. There is also a small mezzanine that provides space for storage and mechanical rooms.

1.1 Physical Condition

The building envelop, roof and foundation systems are in poor condition from an energy conservation perspective. There is limited window area, single entry front doors, single paned glass and no thermal breaks in the exterior wall framing. The absence of these features greatly reduces the insulation value of the building and increases the need to maintain the exterior walls for air infiltration.

1.1.1 Mechanical Systems

The building has two heating zones and no mechanical cooling. There are many electric baseboards in the individual rooms that are controlled by internal thermostatic controls only.

1.1.1.1 Heating System

There are two natural gas furnaces located on the mezzanine that serve the main floor and basement. The furnaces are well past their expected life and should be replaced. Many of the individual rooms have locally controlled electric baseboards to provide additional heating; these units are not interlocked with any of the other systems leading to the occurrence of overheating in all the zones visited on the day of the site tour.

These gas furnaces are past the expected service life. They are about 40 years old and present a risk to catastrophic failure. The efficiency of a furnace of this age is less than 60%.

Figure 1: Low Efficiency Furnaces

1.1.1.2 Ventilation System

Minimum ventilation is provided by an axial fan in the wall of the main floor hall. This fan is inadequate to provide any cooling effect if the space is occupied. Each of the washrooms has a separate exhaust fan.

1.1.1.3 Domestic Hot Water

The Domestic Hot Water is supplied by a two electric water heaters about 187 litre, 3,000 W each. The DHW piping is exposed and can be insulated; also a heat trap could be installed to reduce convection losses.

Figure 2: Un-insulated piping

1.1.2 Control Equipment

The building has residential style thermostats for controlling the 2 heating zones. The electric baseboard is controlled by internal thermostats that are not interlocked. The functionality of the control system can be expanded and improved.

The building was in heating mode because of the low night time temperatures that frequently occur during the summer months in mountain regions. The furnaces and electric baseboard come on at night when the outdoor air temperature is at 11ºC, which is about 5 ºC below the setpoint for bringing on the heating systems. This causes the building to be preheated on a day when day-time temperatures are going to be in the high 20 to low 30ºC range. This gap in the control system sequence of operations is making the building uncomfortably warm during the day.

Figure 3: Indoor and Outdoor Temperature, Heat ON in Summer

1.1.3 Lighting System

Lighting systems in the building is predominantly obsolete fluorescent T12 with magnetic ballasts, and screw in CFLs or incandescent lamps. The lighting is controlled by room wall switches.

Figure 4: T12 Lamps Requiring Replacement

The main floor would be over lit if the lamps were not degraded by being at the end of their life. When these lamps are replaced the light levels will be excessively high for the area, so delamping is recommended in conjunction with a lighting upgrade.

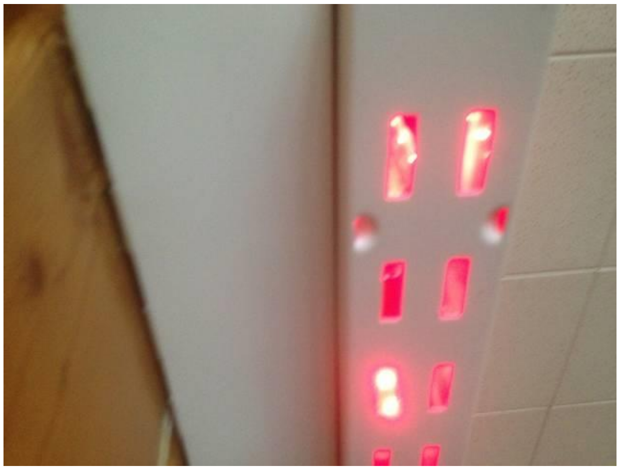


Figure 5: Existing LED Upgraded Exit Lights

The exit lights have been upgraded to LED, as have some exterior lights.

1.1.4 Plug Load

Major plug loads consist of the kitchen refrigeration equipment being left on when not in use.

Figure 6: Plug Load in Basement Kitchen

1.1.5 Water Consumption Systems

Water fixtures in the building are not equipped with low flow devices. Although water conservation measures were not within the scope of this report, we recommend installing faucet aerators (0.03 l/s) to reduce heat and water consumption, as well as new low flow toilets (6 litres/flush).

2. Energy Analysis

2.1 Energy Use

Table 1 presents the annual average estimated energy consumption based on the historical billing data from 2011 and 2012.

Table 1: Community Hall Historical Energy Consumption

	Energy Use (GJ)		BEPI (MJ/m2)		Cost ($)		Cost ($/ft2)	
Utility	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**
Gas	186	159	278	238	$2,495	$2,135	$0.35	$0.30
Electricity	37	45	55	68	$834	$1,031	$0.12	$0.14
Total	**222**	**204**	**333**	**306**	**$3,329**	**$3,166**	**$0.46**	**$0.44**

This facilities in 2012 cost $3,329 per year for electricity and natural gas utility services. This is about $0.46 per square foot per year and is low energy intensity. This is a consequence of the very low number of weekly scheduled events. However, the heating equipment operates more than necessary and there are many good conservation opportunities that should be implemented.

Five years of cost data was available at the time the report was written and this has been used to estimate the consumption. The consumption increased by 8% and rate based costs increased by 5%. The utility costs for energy are increasing at about 3.5% per year and are predicted to continue at this rate. Combining this rate of increase with either the consumption or the cost increases will have a dramatic effect on the budget planning for the community. This cost increase can be turned around by implementing the recommended conservation projects

2.3 End Use Breakdown

The estimated percentage of electricity consumption by building system is presented in Figure 7. This ballpark breakdown is based on very rough estimates based on a thorough site visit and our past experience with similar facilities. These values have been used to estimate savings from measures associated with these systems.

We estimate that largest end uses of electrical energy in the building are lighting, domestic hot water heating, ventilation, and electric heating, using 38%, 15%, 7% and 30% of consumption each. Plug load makes up the remainder of the load at 10%.

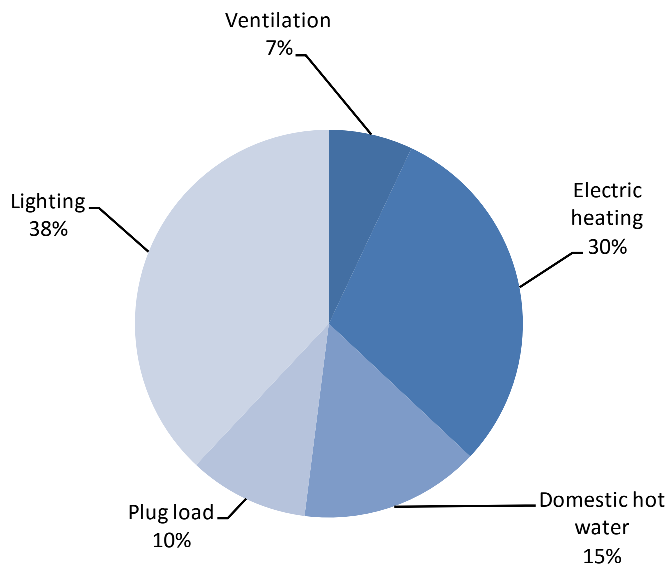


Figure 7: Community Hall Electricity Consumption

The estimated percentage of total energy consumption by building system is presented in Figure 8. Gas heating energy consumption makes up the majority of energy use in the building at 79% of overall energy consumption, followed by electric lighting at 8%. Mechanical Equipment followed by plug load make up 11% and 2% respectively.

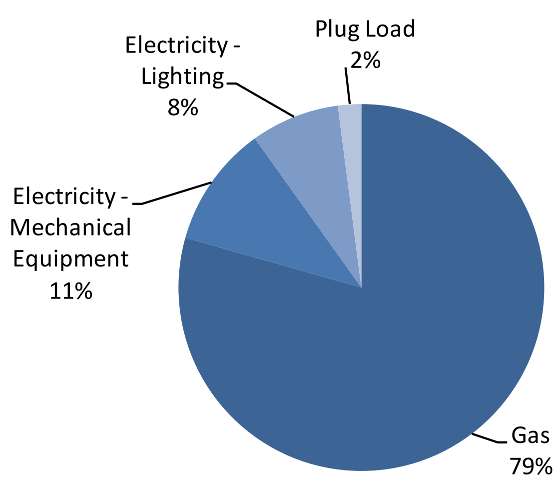


Figure 8: Community Hall Electricity and Gas Consumption

3. Energy Opportunities

A number of measures to eliminate the carbon footprint of the Community Hall and bring it inline with the communities aspirations of sustainability of have been analyzed and are summarized in Table 2.

Savings calculations should be considered as estimates as the scope of this study did not include a detailed energy balance against an inventory of building equipment. The savings estimates are based industry accepted methods for a Level I energy assessment. Please note that any incentives that may be available from government or utility incentive programs have not been included in our financial evaluation.

This report presents the steps Midway Village can take to make its Community Hall a Net Zero facility. The overlying approach taken here is to apply the following three sequential steps:

1. Implement Energy Efficiency Measures to minimize the existing energy demand. Also known as “Demand Side Reductions”. Measures in this category will represent the best immediate value.
2. Eliminate fossil fuel consumption with fuel-switching strategies. This step has the most drastic impact on environmental metrics though is also likely to be the most capital intensive.
3. Offsetting remaining electrical consumption with renewable energy generation. This step is made possible by the elimination of fossil fuels and brings the facility into true sustainable operation.

A full description for each ECM is available in the Overview Report, new or unique ECM’s for this building have their details included below.

Table 2: Community Hall Project Summary

			Annual Savings					
Measure Description	**Cost ($)**	**Payback (years)**	**Utility Cost ($)**	**Natural Gas (GJ)**	**Demand (KW)**	**Electricity (KWh)**	**GHG (tons CO_2)**	**BEPI (MJ / m²)**
Energy Efficiency	$16,300	17.7	919	39		5,068	2.0	86
Fuel Switching	$105,000	119.3	880	148		-13,500	7.1	149
Renewable Energy	$85,000	31.5	2,700		5.0	32,400	0.7	175
Project Total	**$206,300**	**45.9**	**4,499**	**187**	**5.0**	**23,968**	**9.8**	**409**

3.1 Energy Efficiency Measures

The first step towards reducing a building’s environmental footprint is reduce its existing demand load. To accomplish this, the application of modern efficiency strategies and equipment are recommended.

Several low-cost and easily implemented measures are available to improve energy efficiency and reduce energy demand at the Community Hall. An analysis of recommended projects is presented in Table 3 below.

Table 3: Energy Efficiency Measures Summary

			Annual Savings				
Description	**Cost**	**Payback**	**$**	**GJ**	**kWh**	**GHG**	**MJ / m²**
Building Automation System	$9,200	21.4	$430	26	1,022	1.3	44
Lighting Upgrades	$1,650	5.5	$300	-	3,600	0.1	19
Mechanical Upgrades	$300	6.3	$48	3	111	0.1	5
Faucet Aerators	$50	2.5	$20	-	200	-.0	1
Occupant Engagement	$100	9.1	$11	-	135	-.0	1
Window Upgrades	$5,000	45.5	$110	10	-	0.5	15
Total	**$16,300**	**17.7**	**$919**	**39**	**5,068**	**2.0**	**86**

3.1.2 Building Automation System

Installing a start-of-the-art Building Automation System (BAS) should be considered a paramount priority. Not only will a BAS realize immediate savings from efficiently controlling the heating and ventilation equipment, but will allow proper integration of any future upgrades. It is the first step toward modernizing the building as a whole. With a web-enabled BAS, building equipment and performance is monitored remotely and often automatically, maintenance and service can be performed easily and remotely. We recommend implementing a BAS product with long-term storage capacity and accompanying it with a Fault Detection and Diagnostic online service – powerful tools for system optimization and automatic maintenance monitoring. In additional to operating the facility more efficiently, the enhanced controllability will contribute to improved occupant comfort and satisfaction.

Specific strategies to be implemented with the BAS upgrade include reduced schedules with weather prediction and optimal start, advanced warm-up, outdoor air lockout, nighttime setback sequences, and eliminating heating and cooling conflicts. This will address the chronic over heating of some of the offices.

3.1.3 Lighting Upgrades

Lighting Upgrades primarily revolve around replacing the obsolete T12 fixtures with new, TLED technology. Also replacement of existing incandescent and CFL lamps with LED screw in lamps. Additionally, de-lamping should be done in areas where the current lighting levels are in excess of those required for the space.

We recommend the installation of occupancy sensors for washroom lighting. In addition, in the absence of automated lighting system upgrades staff should be encouraged to manually turn off lights and close window coverings during un-occupied periods.

3.1.4 Mechanical Upgrades

Mechanical Upgrades include air infiltration sealing and hot water pipe insulation. Ensuring that building envelop penetrations are sealed and water tight will reduce loss of heated air in winter. Replacing door seals and window caulking on a regular basis will improve the overall performance of the heating system and reduce drafts in the occupied spaces. The exposed DHW piping should be insulated to minimize unwanted heat loss into the surrounding space.

3.1.5 Faucet Aerators

Water fixtures in the buildings are not equipped with low flow devices. We recommend installing faucet aerators (0.03 l/s), kitchen sink aerators, and new low flow toilets (6 litres/flush). Water use in most facilities can be reduced by 45% or more if these simple, low cost measures are implemented.

A low cost demonstration of conservation and GHG reduction is water conservation. The less water that is heated, pumped and flushed the less cost to the local government for transportation, service piping and treatment charges. Also, the requirement for operating funds and capital funds decreases as water use decreases.

The water conservation measures are an example of leadership in conservation ethics that have many co-benefits for Municipalities. Conserving water reduces demand for potable water on the distribution system and reduces the amount of water required during peak seasons. In addition, the load sent to the Sewage Treatment Plant will be reduced. The major co-benefits of water conservation are dramatic cost savings in terms of capital renewal and expansion for Municipal Water and Sewage Treatment Systems.

3.1.6 Occupant Engagement

Occupant Engagement involves social campaigning to reduce unnecessary electrical plug load. Energy efficiency strategies will be far more effective if building occupants are included in the process in a series of communications to encourage energy awareness behavior. We highly recommend an occupant engagement strategy be put in place in order to educate building occupants on the ideas and options for energy conservation in this facility, such as closing window blinds when leaving a room as well as turning out the lights. Research highlights that occupant engagement enables positive outcomes and culture change that encourages energy efficient behavior.

3.1.7 Window Upgrades

The existing single-pane windows present a significant source of energy loss for the building. Triple pane windows are relatively new to our commercial market but provide outstanding thermal insulation. The existing windows could potentially be upgraded to a larger size of triple-pane type while saving energy compared to existing conditions.

3.2 Fuel Switching

After the energy demand of a building has been minimized, the next key step toward becoming net-zero is eliminating the consumption of fossil fuels. In British Columbia, this translates to an all-electric heating system. The recommended method of fuel switching is presented in Table 4.

Table 4: Fuel Switching Measure Summary

Description	Cost	Payback	Annual Savings				
			$	GJ	kWh	GHG	MJ / m²
Air Source Heat Pump	$105,000	119.3	$880	148	(13,500)	7.1	149

3.2.1 Air Source Heat Pump

Heat pump technology can surpass 600% efficiency in ideal conditions, and never falls below 100%. For comparison, a new condensing gas boiler operates at 80-95% efficiency while the existing gas furnaces are estimated to operate around 65% efficiency. Air source heat pumps are rapidly gaining traction in the Canadian HVAC industry. They use an outdoor evaporating unit to capture heat and reject it to a condensing coil indoors. The latest generation of this technology is rated to outdoor temperatures of minus 30 Celsius. For the Midway Village climate, we recommend coupling the heat pump system with an electrical booster (resistance heating) to ensure full heating capacity is available during the coldest times of the winter.

A geothermal exchange system using a water-to-air heat pump was also analyzed but not recommended due to the extremely high cost of implementation and modest efficiency gains relative to the air source option.

3.3 Renewable Energy Offsetting

The recommended method of renewable energy generation is presented in Table 5 below.

Table 5: Renewable Energy Measure Summary

Description	Cost	Payback	Annual Savings				
			$	GJ	kWh	GHG	MJ / m²
Solar PV	$85,000	31.5	$2,700		32,400	0.7	175

3.3.1 Solar PV

A solar photovoltaic system represents the most cost effective method of renewable electrical generation at this scale. Our analysis budgets for 180m^2 of roof coverage, accounts for experimentally observed system losses, and uses the National Resources Canada (NR Can) published annual horizontal solar irradiation value of 3.65 KWh/m^2/day for the Village of Midway. This can be compared to other nearby cities in Figure 9.

A system of this size will generate approximately 50% more electricity than required by the facility assuming the proposed efficiency and fuel switching measures are implemented and there are no major changes in the operation of the facility. This would allow for considerable leeway in reducing the size of the solar system or more intensive use of the facility while still achieving “Net Zero” energy use. The proposed system configuration should be eligible for certification as a Net Zero Energy Building.

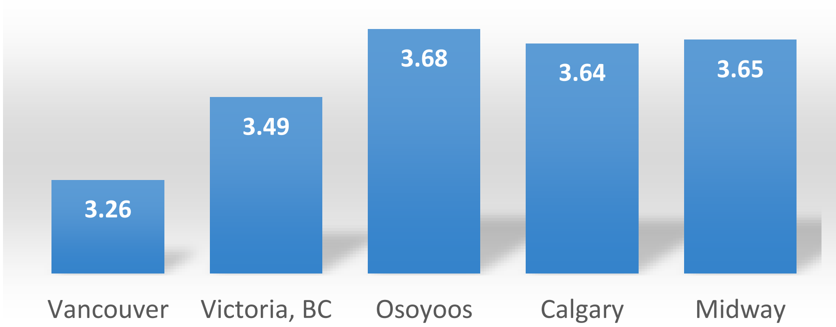


Figure 9: Horizontal Solar Irradiation (KWh/m2/day)

4. Financial Analysis

Financial analysis is challenging in smaller facilities as the economies of scale will not apply, and fixed costs for project design and construction are carried fully by the ECM as it is evaluated. These fixed costs are spread out over more components in a project taking place in a larger building, thereby reducing the impact on larger projects of fixed costs.

Table 6 presents a financial analysis of the energy and water conservation measures presented above.

Table 6: Community Hall Financial Analysis

Description	Cost	Payback	Annual Savings	Life Expectancy	NPV	IRR
Energy Efficiency Measures						
Building Automation System	$9,200	21.4	$430	15	($4,800)	(2%)
Lighting Upgrades	$1,650	23.1	$300	20	$2,000	20%
Mechanical Upgrades	$300	12.6	$48	15	$200	16%
Faucet Aerators	$50	2.5	$20	10	$100	41%
Occupant Engagement	$100	9.1	$11	5	($100)	(15%)
Window Upgrades	$5,000	45.5	$110	10	($4,162)	(19%)
Fuel Switching						
Air Source Heat Pump	$105,000	119.3	$880	25	($92,949)	(8%)
Renewable Energy						
Solar PV	$85,000	31.5	$2,700	25	($48,024)	0%
Total for all ECM Projects	**$206,300**	**45.9**	**$4,499**	**24.1**	**($145,900)**	**(3%)**

Our financial analysis is based an annual fuel cost escalation rate of 2.1%, and a conservative discount rate of 7.5%. In the event municipal borrowing costs are lower than assumed here, project economics will improve.

We recommend that a longer simple payback and the lower NPV and IRR be considered in light of possible capital project upgrades to the buildings and that strict business case analysis be suspended when considering the merit of any individual project.

This report has been prepared to include demonstration and leadership projects to make the Community Hall Net Zero – producing significantly more energy than it consumes.

Please note that any incentives or grants that may be available from government or utility incentive programs have not been included in our financial evaluation.

6. Conclusion

This report has identified a number of excellent opportunities for energy conservation and recommends a path toward Net Zero status by means of eliminating fossil fuel consumption and generating electricity on-site.

Should all the measures identified in this report be implemented, to a total of approximately $206,000 , the following graphs present the progression of energy savings and improvement of environmental performance.

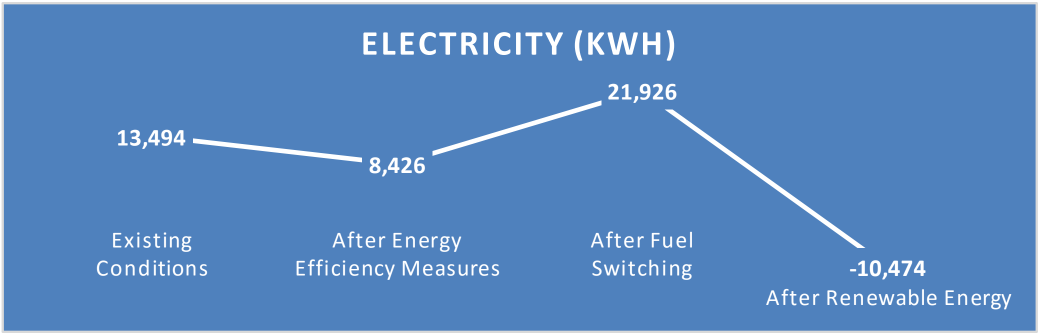


Figure 10: Potential Progression of Electrical Consumption

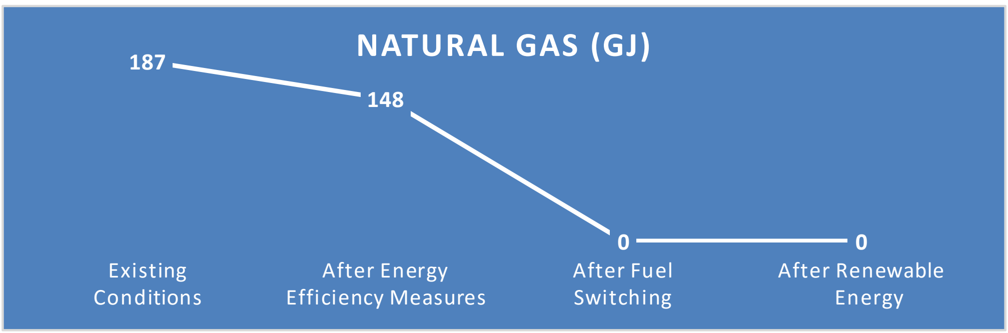


Figure 11: Potential Progression of Gas Consumption

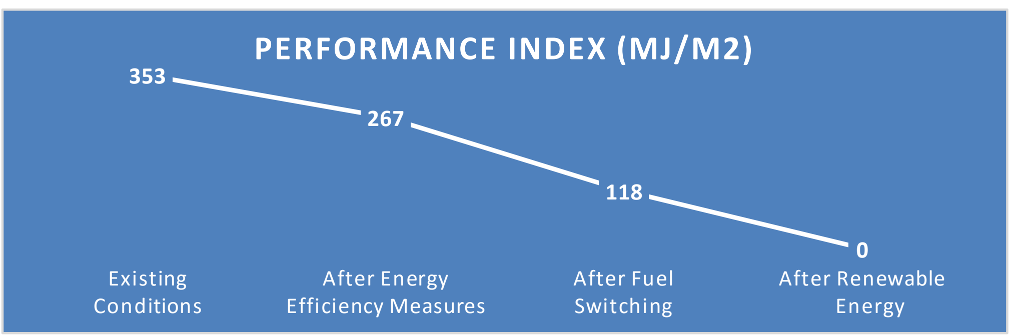


Figure 12: Potential Progression of Performance Index

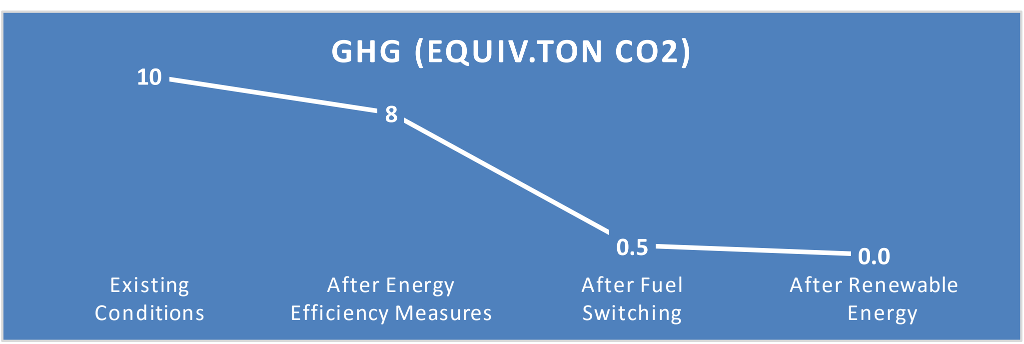
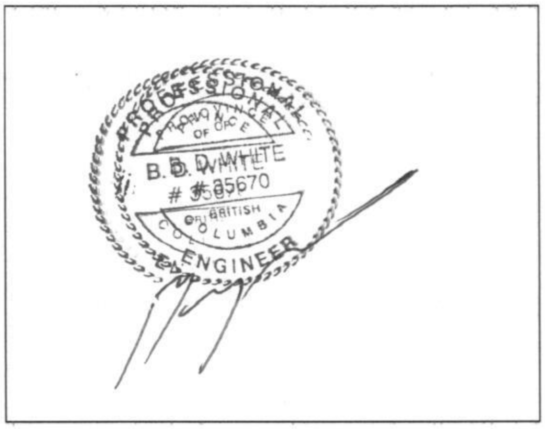


Figure 13: Potential Progression of GHG Emission

PROFESSIONAL ENGINEER'S APPROVAL

The calculations contained in this document have been reviewed for accuracy and completeness by:
Brad White, P.Eng.



Signature: ______________________ Date: Nov 4, 2013