Thompson Rivers University Arts & Education Building Energy Assessment

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Sign-off Sheet

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Executive Summary

Thompson Rivers University (TRU), commissioned Stantec to conduct a detailed energy assessment at its Arts & Education building located at the TRU Kamloops Campus, British Columbia, to identify energy conservation opportunities. A site visit was conducted on November 24th & 25th 2015.

The aim of this study is to analyze the current energy performance of the asset, conduct an onsite energy assessment and produce a list of energy conservation measures (ECM's) complete with relevant implementation costs.

The building assessment involved 5,660m^2 (gross) of internal floor space and revealed potential for the implementation of mechanical and natural gas utility saving measures, which will improve the overall efficiency of the facility.

It is anticipated that should all of the selected measures be implemented, there would be annual savings in utilities of approximately $47,000 at a rate of $10.00 GJ for natural gas and 0.08 cents per kilowatt hour for electricity and a reduction in GHG emissions of around 111 tonnes (equivalent to around 36% of current emissions).

Total Investment	Total Cost Savings	Payback	Total Natural Gas Savings (GJ)	Total Electricity Savings (kWh)	CO_2 Reduction (Tons)
$770,000[1]	$46,700	16	2,057	323,000	111

The annual average utility consumption for this facility in 2015 is summarized in the table below. The approximate anticipated utility consumption should all the measures suggested within this report be implemented (post retrofit) is estimated and a percentage saving is shown.

[1] Total investment is total material & labour cost

BUILDING ENERGY PERFORMANCE INDEX (2015)								
	Electricity (kWh)	Electricity Cost	Natural Gas (Gj)	Natural Gas (Cost)	Total ekWh	Total Cost	GHG Emissions (tonnes)	BEPI ekWh/m2/yr
Existing	768,310	$61,465	2,928	$29,278	1,581,600	$94,908	167	279
Reference building (Educational Services - 2008)								280
Post retrofit	445,272	$36,171	870	$8,705	687,074	$44,876	55	121
% Saving	42%	41%	70%	70%	57%	53%	67%	57%

		Measure	Recommended for Implementation
Mechanical & Electrical Measures	ECM 1	Replace two existing “Bryan” boiler with two condensing boilers	✓
	ECM 2	Optimize Demand Control Ventilation & install new outdoor air dampers	✓
	ECM 3	Chiller/Heat Pump Replacement	✓
	ECM 4	Install Premium Efficiency Pumps (P-1 & P-101)	✓
	ECM 5	Replace Makeup Air Unit (SF-1) & implement heat recovery	✓
	ECM 6	Repair Vestibule Controls & Weather Proof External Doors	✓
	ECM 7	Install solar hot water heater	✓
	ECM 8	Solar PV Installation	✓

The identification of energy saving measures is made with consideration of the potential benefits incurred through:

- Improved environmental comfort and reduced life cycle impacts;
- Integration of planned capital maintenance expenditures with reduction in operating costs;
- Enduring utility consumption and cost savings; and
- Reduction of greenhouse gas emissions

The energy conservation measures identified and the utility savings are summarized in the table overleaf.

Implementation of the measures identified in this assessment will assist Thompson Rivers University to reduce risks associated with utility market volatility and unplanned capital maintenance expenditures. Stantec will work with the University to implement any or all of the measures identified in this report should you wish to pursue these opportunities. Any questions regarding this report should be directed to Diego Mandelbaum at (250) 470-6106.

ENERGY SAVINGS AND COSTS SUMMARY											
MEASURE		Natural Gas		ELECTRICITY SAVING				FINANCE			EMISSIONS
Reference	Description	Natural Gas (Gj/year)	Natural Gas Saving ($/year)	Electricity Consumption Saving (kWh/year)	Electricity Consumption Saving ($/year)	Electricity Demand Saving (kW/month)	Electricity Demand Saving ($/year)	Cost ($)	Total Savings ($/year)	Payback (years)	CO2 Reduction (tonnes/year)
ECM 1	Install Two New Condensing Boilers	772	$ 7,716	-	$ -	-	$ 966	$ 339,756	$ 8,682	39.1	38.6
ECM 2	OPTIMIZE DEMAND CONTROL VENTILATION & INSTALL NEW OUTDOOR AIR DAMPERS	772	$ 7,716	26,143	$ 1,542	1	$ 121	$ 34,300	$ 5,444	6.3	39.3
ECM 3	Replace Existing Heat Pumps	-	$ -	60,645	$ 4,852	-	$ -	$ 270,000	$ 4,852	55.7	1.6
ECM 4	Install High Efficiency Motors	-	$ -	4,276	$ 342	1	$ 119	$ 53,000	$ 461	114.9	0.1
ECM 5	Replace SF-1 with New Unit	469	$ 4,688	12,974	$ 1,038	-	$ -	$ (46,000)	$ 5,726	-8.0	23.8
ECM 6	Repair Vestibule Controls	45	$ 453	-	$ -	-	$ -	$ 19,100	$ 510	37.5	2.3
ECM 8	Install Solar PV	-	$ -	219,000	$ 17,520	25	$ 3,489	$ 98,100	$ 21,009	4.7	5.7
TOTAL		**2,057**	**20,574**	**323,038**	**25,294**	**27**	**4,695**	**768,256**	**46,684**	**16**	**111**

Glossary

BEPI	Building energy performance index
BMS	Building Management System
CDD	Cooling degree days
CFL	Compact fluorescent lamp
DDC	Direct digital control
ECM	Energy conservation measure
GHG	Greenhouse gas
HDD	Heating degree days
HVAC	Heating, ventilation and air conditioning
kWh	Kilowatt hour
LED	Light-emitting diode
NRCan	Natural Resources Canada
VFD	Variable frequency drive

1.0 CONTEXT AND METHODOLOGY

1.1 BACKGROUND

The intent of this report is to provide a detailed energy assessment of the Arts & Education Building and provide recommendations for improvements in the buildings' operation from an energy performance perspective.

The energy assessment identifies the potential savings in energy consumption and reduction of greenhouse gas (GHG) emissions resulting from the implementation of energy conservation measures. An opinion of probable costs to implement the measures is also provided backed up using quotations from a third party cost consultant. These capital upgrades will provide ongoing operational savings and a reduction in the environmental impact of the site's operation.

The focus of this study will be on reductions in natural gas consumption; however opportunities for savings in electricity consumption are profiled, particularly where there may be synergies between reductions in electricity consumption with that of natural gas consumption.

This report has taken into consideration past retrofit work, future capital maintenance requirements and the proposed energy conservation measures to ensure an effective and viable energy assessment report.

1.1.1 Project Scope

This project includes an assessment of electricity and natural gas saving opportunities from building HVAC equipment.

1.1.2 Complementary Reports

This energy audit was completed as part of a multi-building investigation that includes:

1. Animal Health,
2. Arts and Education,
3. Culinary Arts,
4. Clock Tower,
5. Science Building, and
6. Campus Activity Centre and Gym (Hot Water Systems Only).

1.1.3 Client Information

Customer Name	Thompson Rivers University
Site Address	Thompson Rivers University 900 McGill Road Kamloops, BC, Canada V2C 0C8
Contact Person	Jim Gudjonson
Contact Information	250-852-7253 / jgudjonson@tru.ca
Site Electricity Provider	BC Hydro / 2741787
Natural Gas Account(s) #	Fortis BC / 1178101

1.1.4 Project Drivers

Thompson Rivers University is committed to reducing energy consumption and greenhouse gas emissions in its operations and conduct business in a sustainable and socially responsible manner. This commitment is driven by the Office of Environment & Sustainability which implements the sustainability components of the Campus Strategic Plan.

A key component of this plan is focused on implementing building efficiency upgrades.[2]

1.1.5 Acknowledgements

Stantec would like to acknowledge the contribution of Thompsons River University staff whose help was invaluable in completing this report. We would like in particular like to thank Jim Gudjonson and Natalie Yao from the Sustainability office for their invaluable help in facilitating this exercise. We would also like to thank Tom O'Byrne whose knowledge of the facility providing an excellent basis for the identification of energy conservation opportunities.

[2] http://www.tru.ca/sustain/initiatives/Energy_Efficiency_at_TRU.html

1.2 PROCESS

1.2.1 Site Visits

A site visit was conducted on November 24th & 25th 2015 by Kenneth McNamee & Innes Hood from Stantec. The visit included a detailed interview with staff regarding the building's function, as well as discussing any issues that were persistent and opportunities for operational optimization.

A comprehensive tour of the site was also conducted to evaluate the condition of the HVAC and controls systems.

1.2.2 Utility Analysis

An analysis of building energy consumption provides a good starting point from which to;

1. Identify potential energy conservation measures (ECMs), and
2. Develop a baseline against which ECM performance can be quantified.

The consumption (and demand) registered on historical data for each utility meter can also be examined to identify issues that are affecting the energy performance of the site. Utility data for electricity and natural gas was provided by Thompson Rivers University through its Pulse Energy© subscription.

1.2.3 Utility Rates

In terms of savings related to ECMs, a marginal rate is used which effectively assumes that reduction in consumption and/or demand will only reduce the cost by the rate that applies to the last unit of energy used. These rates are listed in Table 1.

Table 1 Marginal Energy Rates 2015

	Value	Units
Marginal Electricity Cons. Rate	0.08	$/kWh
Marginal Electricity Demand Rate	11.63	$/kW/Month
Natural Gas	10	$/GJ
GHG Emission Costs	25	$/Tonne

1.2.4 Lighting System Assessment

An assessment of the site's lighting installation was excluded from the Scope of Work.

1.2.5 Mechanical System Assessment

The mechanical portion of the assessment involves taking an inventory of mechanical components, an appraisal of operational times and efficiencies for each mechanical component. This is inclusive of all HVAC and process related equipment.

1.2.6 Energy Conservation Measures (ECMs)

ECMs are selected based primarily on the most cost effective opportunity from a simple payback perspective based on the data available and assumptions made. Further criteria include; potential added or reduced maintenance, facility personnel opinion, occupant comfort, integration with existing systems and capital maintenance initiatives.

The energy savings calculations are based on a best estimate of the anticipated reductions taking into consideration direct savings from natural gas & electricity consumption and electrical demand where appropriate. Savings associated with non-process load related measures are calculated relating to heating and cooling degree-days for the site and are taken from the most appropriate local weather data source, which assumes an average balance point[3] temperature of 16°C.

Costs associated with implementing the respective measures are estimated based on the capital cost for the materials and labor (including demolition and installation). Where applicable a retrofit cost (a safety factor to allow for complications arising from installations in existing buildings) and project management cost (including design) are applied to the estimated capital cost at 10% and 15% respectively.

Stantec has engaged a third party cost consultant to derive accurate cost estimates.

For any systems or equipment that are on site and not functioning (not consuming energy) no energy conservation measures have been considered. The scope of this exercise is to find opportunities to reduce energy consumption and where there is no possibility to do so, no measures have been discussed.

1.2.7 Recommendations

From the options considered, recommendations are put forward based on financial and practical feasibility using indicators such as simple payback and capital cost. A full analysis is set out in Table 10.

[3] The balance point temperature is the external temperature at which the building's heating equipment is initiated.

2.0 BUILDING DESCRIPTION AND CONDITION

2.1 GENERAL DESCRIPTION

2.1.1 History

The Arts & Education building was originally built in 1991 and is comprised of a 3-storey structure with a gross floor area of 5,660m2. The building gets its name from the fact that many Faculty of Arts classes and labs are held in the building as well as it being home to teaching options like Early Childhood Education and Bachelor of Education (Elementary).

A language lab (AE 200) is located on the second floor as well as two computer labs (AE 305, AE 361). Faculty and administration offices for Faculty of Arts and the Faculty of Human, Social, and Educational Development are also located in this building.


Figure 2.1: Building Exterior & 1st floor Recreation Space

2.1.2 Site Details

Table 2 lists the site specific details including total area and weather data used for modeling weather sensitive savings opportunities.

Table 2 Site Characteristics

	Value	Units
Site Area	5,660	m^2
Weather data source	www.degreedays.net	[Base 16°C]
HDD	2,953	°C day/year
CDD	644	°C day/year

Figure 2.2 TRU Kamloops Campus Layout

2.1.3 Occupancy

Building occupancy is detailed in Table 3. The facilities will typically be occupied with greater frequency during term time, however the hours outlined below are typical.

Table 3 Typical Occupancy Schedule

Labs (AE305, AE361)	07:00AM – 10:00PM	-	-
Offices	07:00AM – 6:00PM	Intermittent	Intermittent
Classrooms / Common Areas	24/7	-	-

2.2 BUILDING ENVELOPE

A summary of building envelope components is presented below.

Table 4: Building Envelope Descriptions

Assembly	Description	Image
Vestibule	A vestibule at the main entrance has been de-activated, with interior doors permanently open.	
Walls	Exterior walls are supported on concrete foundation and are comprised of brick leaf over steel and timber support. The external walls are in good condition overall, no water ingress.	
Fenestration	Building fenestration typically comprises a mixture of older single and newer double glazed units. Window and door systems are typically constructed in aluminum frame and some windows are operable.	
Roof	The Arts and Education Building is a flat roof. Typical construction is a two ply membrane over R-30 rigid board insulation.	No Image

2.2.1 Envelope Thermal Analysis

A thermographic inspection of the building façade was conducted to identify any potential failures in building insulation or sources of heat loss from the building.

In general, the building envelope is performing adequately, with no areas of concern identified. Building entrances represent a key source of heat loss from the building, with energy savings possible through effective draft proofing or installation of an air curtain to replace the disabled vestibule.

Figure 2.3: Side Entrance & Main Building Entrance Thermographic Inspection

2.3 LIGHTING

Building lighting was not in the scope of this study; however Stantec engineers made the following observations on site.

2.3.1 Existing Luminaires

Based on the site assessment, the existing lighting system combines a mixture of:

- 32W 2&3-lamp T8 Fixtures
- Compact Fluorescent Potlights

A summary of observations by space is presented below:

Room	Description	Image
Distribution Hallways	Compact Fluorescent Potlights	
Classrooms and Hallways	32W 2&3-lamp T8 Fixtures	
Controls	Building lighting is typically controlled using motion sensors located throughout the facility.	

2.4 MECHANICAL SYSTEMS

2.4.1 Ventilation

The building ventilation system is comprised of a primary air supply system (SF-1) which draws air into the system through a motorized inlet damper, a series of filters and heating coil. The supply fan (with VFD) then discharges the conditioned outdoor air through a series of ductwork to several heat pumps located on all 3 building levels. The heat pumps, located in closets on each level, condition the air to meet zone specific temperature requirements. The conditioned air is then supplied through ceiling mounted supply air diffusers. Return air is drawn through ceiling mounted grilles and ducted back to the heat pumps.

Table 5: Ventilation System Inventory

Unit	Location	Service	Motor Size	Capacity (CFM)[4]
SF-1	Mechanical Room	Outdoor air supply to heat pump terminal units	7.5HP	8,000 (3,775L/s)

On review of air handling operation schedule, it was noted that typical SF-1 hours of operation are daily from 07:45 am until 12:30 am. A review of schedules is recommended.

[4] From balancing report

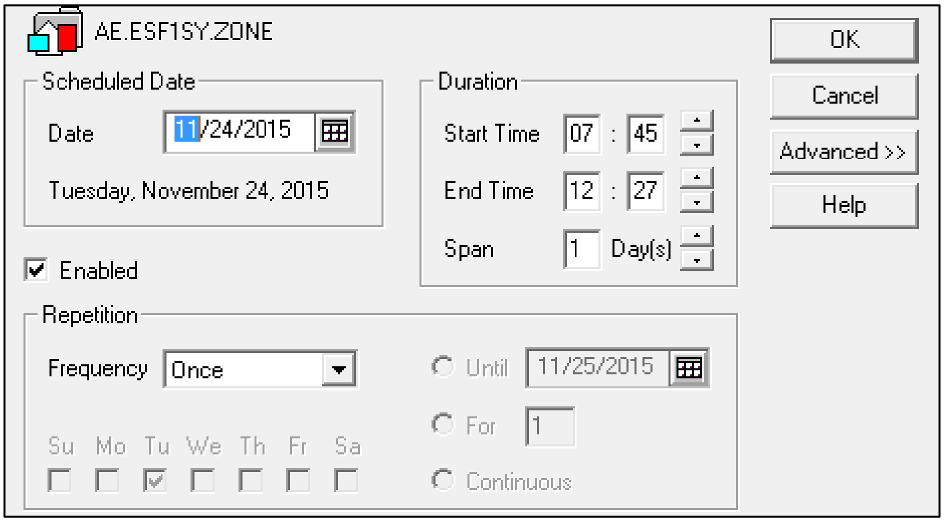


Figure 2.4: SF-1 Operation Schedule from DDC

A number of exhaust air systems / fans operate to ensure an effective air balance in the building. These have been profiled below. Exhaust air is drawn through ceiling mounted grilles by the exhaust fan to be discharged to the outdoors.

Unit	Location	Service	Motor Size	Capacity (L/S)
EF-1	Roof	Main Washrooms	1.49kW	2831
EF-2	Elevator Machine Room	Elevator Machine Room	0.44kW	236
EF-3	Ceiling Mounted	Student Lounge	0.093kW	425
EF-4	Ceiling Mounted	Staff Lounge	0.093kW	425
EF-5	Roof	ECED	0.093kW	378
EF-6	Ceiling Mounted	Anthropology	0.44kW	274

2.4.2 Heating

On site heating is generated using two 'Bryan' natural gas boilers. Each boiler has a specified gross input of 1,200MBH and output of 960MBH, with each boiler serving a separate wing of the building. A heat pump system has been installed in the building to provide heating through terminal units distributed throughout the facility. The boiler injects heat into the heat pump glycol loop as required.

Heating water/glycol is circulated through terminal heating units, a heat exchanger and heating coil loops by circulating pump (P2). Another Pump (P3) circulates the heated glycol solution through a 3-way control either to the coil in the outdoor air supply system (SF-1) or though bypass piping. Pump (P1) circulates water through the heat pump loop to either the heat exchanger during the heating season or fluid cooler during the cooling season. The boiler is staged on/off using a temperature sensor (Aquastat) on the HW return loop.

Table 6: Boiler Specification

Manufacturer	Model Number	Input (MBH)	Output (MBH)	Rated eff.	Manufactured
Bryan	CL120-W	1,200	960	~80%	1991

Figure 2.5: Existing BRYAN Natural Gas Boiler & Circulation Pumps P1 & P2

Hot water generated by the boiler serves three main end uses:

- Hot water supply to the heat exchanger / glycol loop
- Hot water supply to the SF-1 heating coil
- Hot water supply to the wallfin convectors

Figure 2.6: Wallfin Convectors in Stairwells

2.4.1 Domestic Hot Water

Domestic Hot Water at the facility is generated by a "Universal" natural gas fired domestic hot water heater. See table below for heater specification.

Table 7: DHW Heater Specification

Manufacturer / Model #	Input (MBH)	Storage Capacity (L)	Rated eff.	Photo
Universal / G75 -125	125	284	80%	

2.4.2 Cooling

A "Climate Master" heat pump system has been installed in the building to provide cooling through terminal units distributed throughout the facility. Heat is rejected from the system using a "Baltimore Aircoil" fluid cooler.

Figure 2.7: Heat Pump and Fluid Cooler

The fluid cooler has a certified capacity of 365 USGPM and incorporates a 10HP fan motor and 1HP pump.

2.4.1 Building Controls System

The facility incorporates a 'Siemens Insight' central DDC system. Key building components included on the DDC include, the heating water system, ventilation systems and heat pumps.

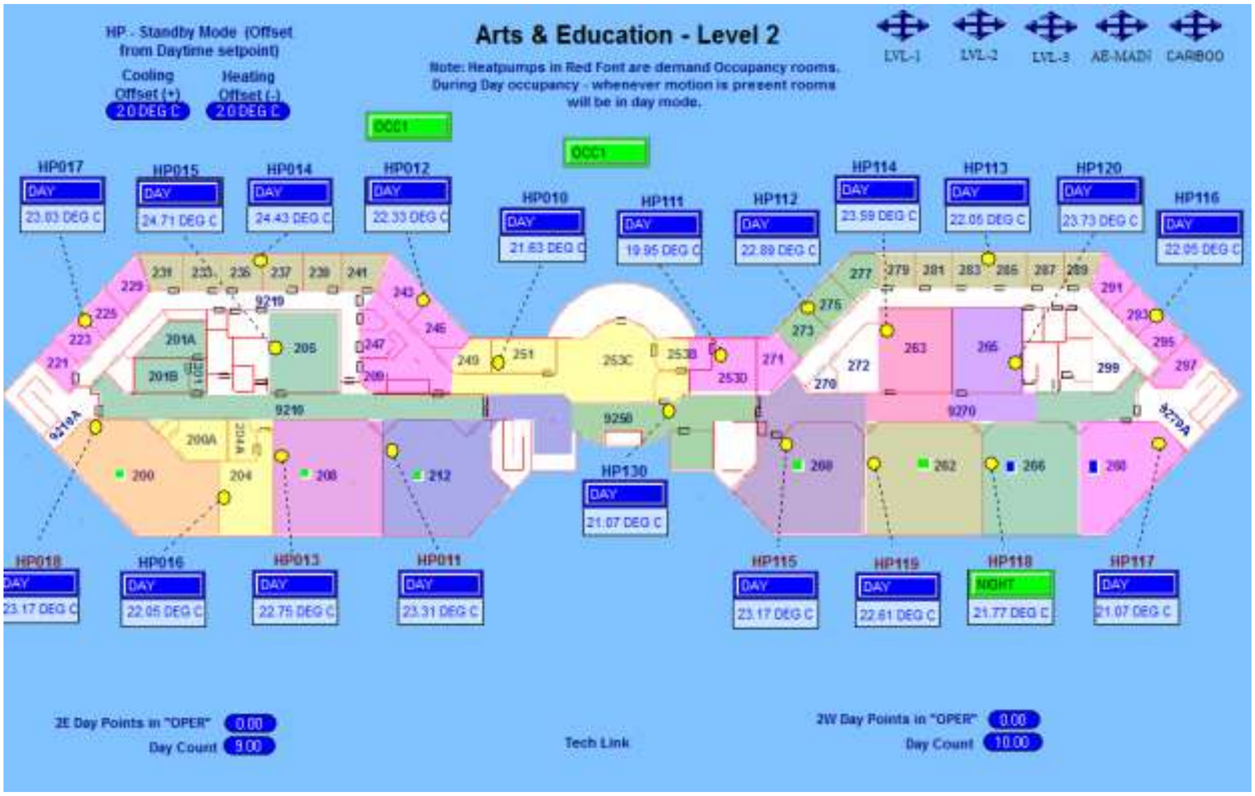


Figure 2.8: Level 2 DDC Graphic

The Arts & Education building has been included in the BC Hydro Continuous Optimization program. The program is designed to improve system performance through implementation of low to no cost energy conservation measures (typically revisions to controls logic).

2.5 ELECTRICAL EQUIPMENT

2.5.1 Incoming Power Supply

There is an outdoor 600 KVA transformer operating at 25KV and 600A service.

3.0 BUILDING ENERGY ANALYSIS

3.1 CURRENT ENERGY USE

Energy usage at the facility is derived from two primary sources:

Natural Gas	Natural gas utility data was extracted from the Pulse Energy system for the facility for 2013-2015. Natural gas consumption is attributable to building heating, and domestic hot water generation.
Electricity	Electrical utility data was extracted from the Pulse Energy system provided for the facility for 2012-2015

3.1.1 Electricity Consumption

Electricity consumption from 2012 to 2015 has been profiled below using utility data provided by TRU. Figure 3.1 shows the consumption profile on a daily average basis.

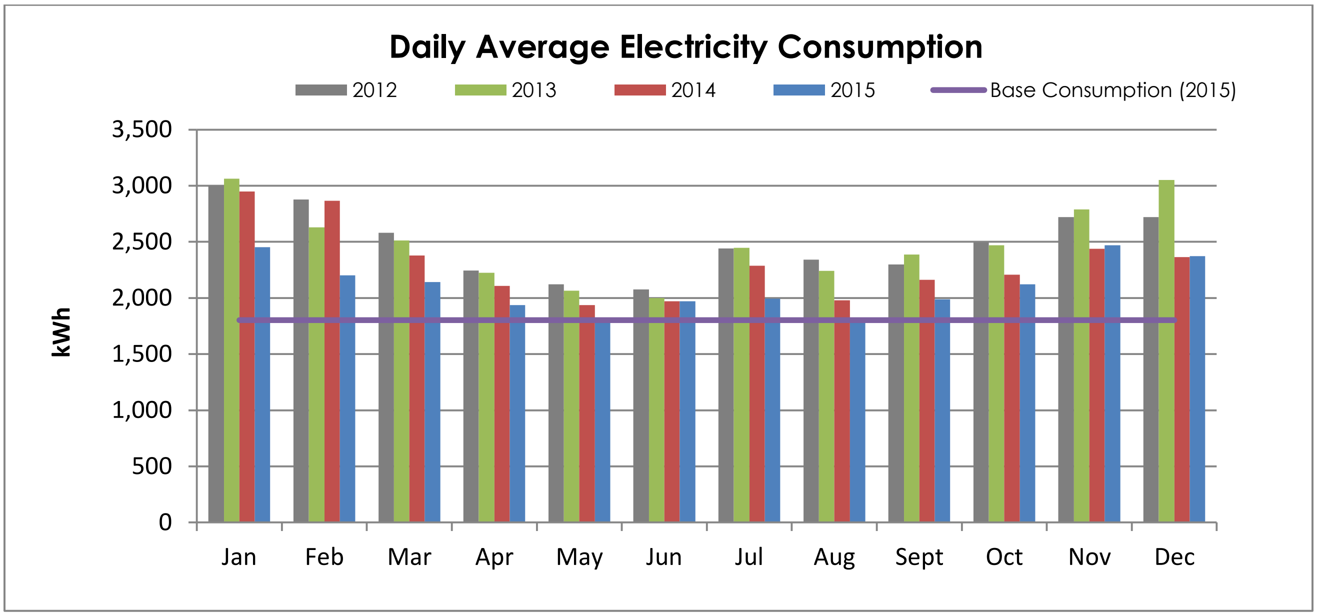


Figure 3.1: Average daily non-heating electricity consumption for 2012–2015

The daily lowest electricity consumption in 2015 for the facility is 1,802kWh and occurs in May. The building has a relatively consistent consumption profile throughout the year with an increase in electricity consumption during winter months (November - April) attributable to increased operation of building lighting systems and increased student occupancy. Increased electricity consumption during summer periods can be attributed to the operation of the fluid cooler.

Total electricity consumption has decreased in the reporting period 2012-2015 (see table below). This can be in part attributed to the following energy retrofits[5]:

- T12 lamps and ballasts were completely replaced with newer high efficiency models, providing a savings of 36,600 kWh and saving an estimated $2400 yearly.

[5] https://www.tru.ca/sustain/initiatives/Energy_Efficiency_at_TRU/ae.html

- HVAC override controls installed, reducing unnecessary heating and cooling.
- Demand controls installed which use a CO_2 sensor to gauge occupancy levels and alter air flow accordingly.
- Motion sensored lighting controls were installed in most classrooms.

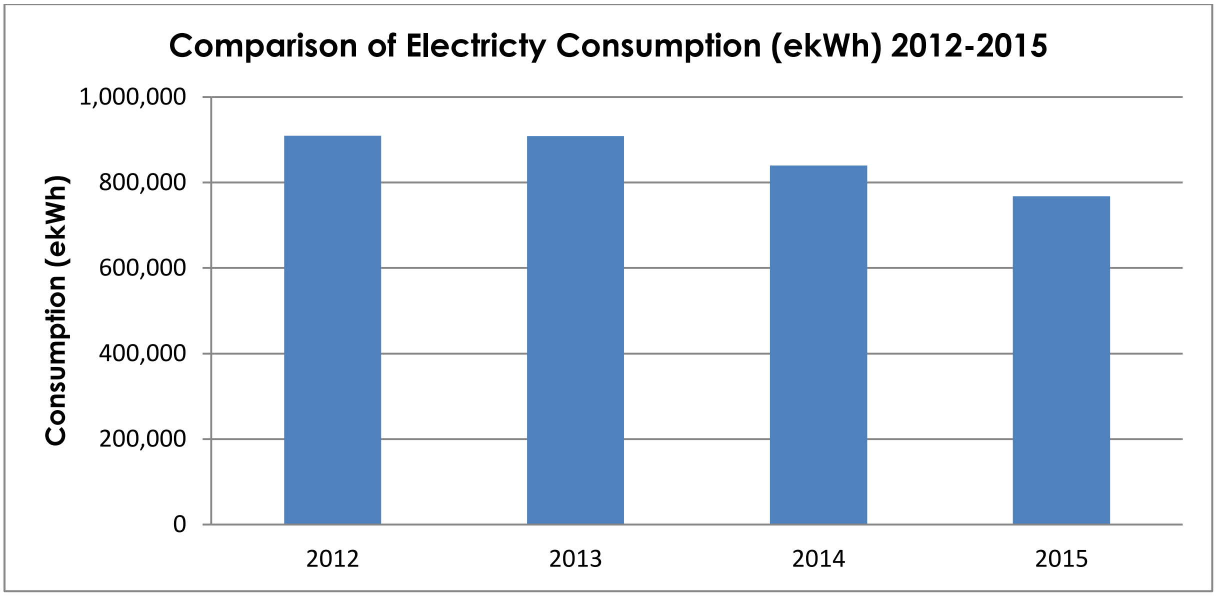


Figure 3.2: Total electricity consumption comparison 2012-2015

3.1.2 Electricity Demand

Demand data was extracted from the 'Pulse Energy' website and the data illustrates a consistent profile over the reporting period. Slight variances in demand can be attributed to minor changes in building operations, including;

- Greater occupancy numbers during term time
- Operation of fluid cooler during summer months

The lowest monthly electricity demand in 2015 occurs in May, and was 167kW. This also correlates with the electricity consumption profile.

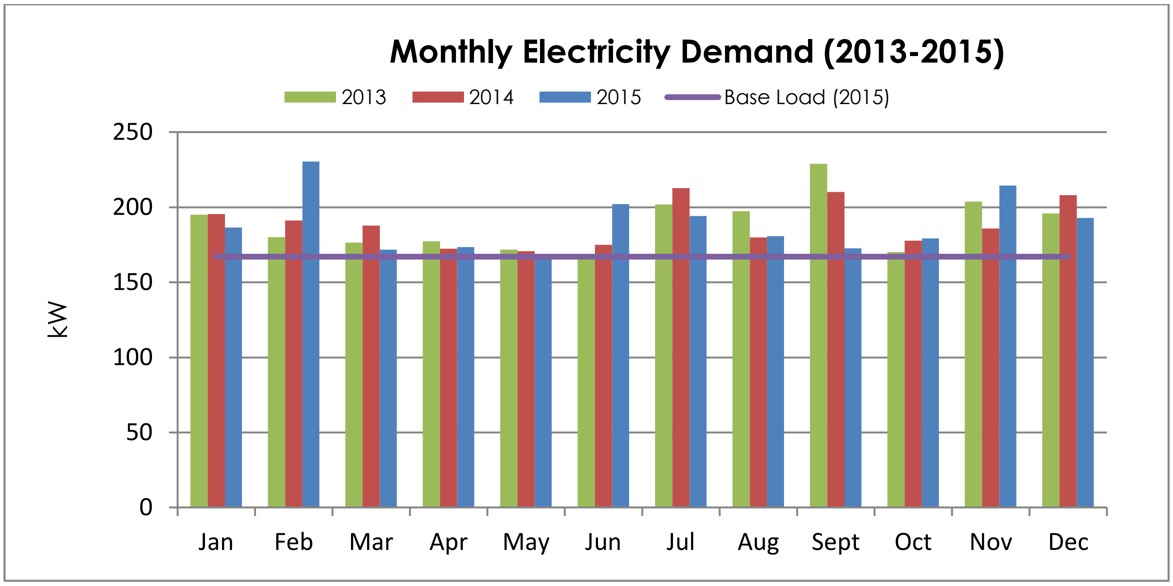


Figure 3.3: Building Demand Profile (2012-2015)

3.1.3 Natural Gas Consumption

Natural Gas consumption from 2013 to 2015 has been profiled below using data extracted from the "Pulse Energy" system. The heating degree day profile for the TRU Kamloops campus has been transposed to provide an indication of natural gas consumption in relation to outdoor air temperature.

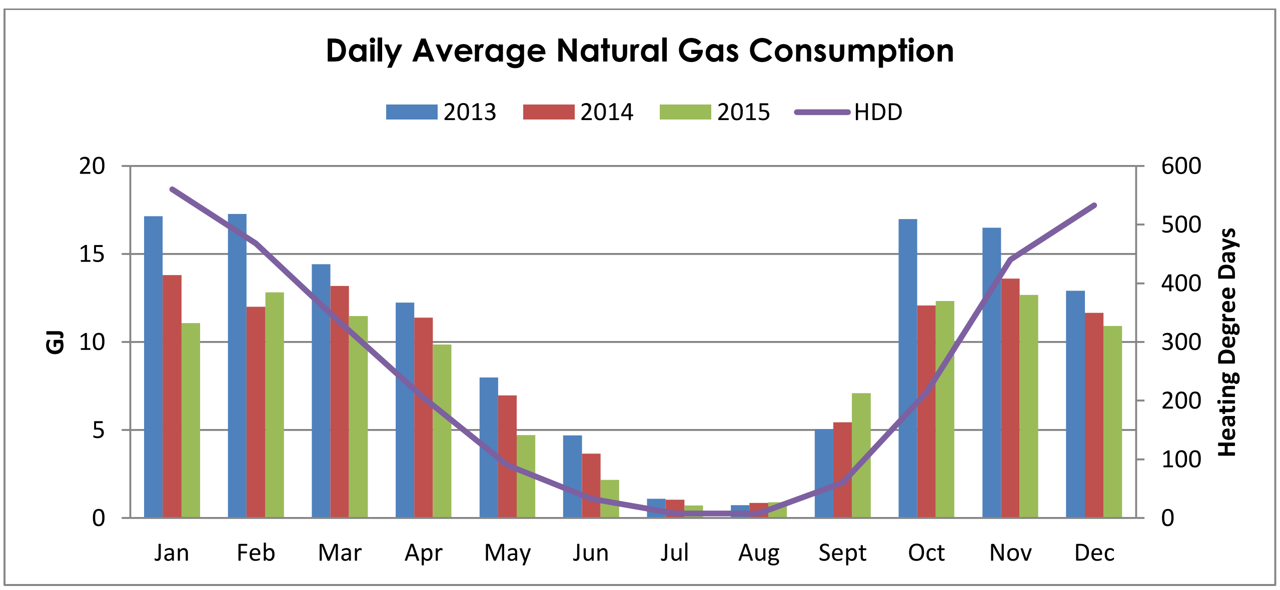


Figure 3.4: Average daily Natural Gas consumption and heating degree-days (2013–2015)

The natural gas intensity profile is reflective of a facility with a significant weather dependent load. Natural gas consumption peaks during colder winter conditions and is reduced during the summer. Peak consumption in 2015 was recorded in November at 13 GJ/day with summer base load of around 1 GJ/Day. Consumption of 1GJ/Day in July and August 2015 can be attributed to the domestic hot water loads in the building.

Total natural gas consumption has decreased almost 25% in the 2013-2015 reporting period. This may in part be attributed to the following energy retrofits:

- HVAC override controls installed, reducing unnecessary heating and cooling.
- Demand controls installed which use a CO_2 sensor to gauge occupancy levels and alter air flow accordingly.

Table 8: Comparison of Natural Gas Consumption

Year	Total Annual Natural Gas Consumption (GJ)	Yearly Deviation
2013	3,847	0
2014	3,205	-17%
2015	2,928	-9%
Total Reduction		**-24%**

3.1.4 Building Energy Performance Index

The Building Energy Performance Index (BEPI) is a method of ranking the energy performance of buildings against facilities of similar type. It can also help create a strategy to justify long-term capital expenditures. All energy types are combined using common units (kWh) and divided by the building's conditioned floor area. Table 9 below indicates the current measured energy consumption for the Arts & Education Building;

Table 9: BEPI for Arts & Education Building

BUILDING ENERGY PERFORMANCE INDEX (2015)								
	Electricity Cons. (kWh)	Electricity Cost ($)	Natural Gas Cons. (GJ)	Natural Gas Cost ($)	Total ekWh	Total Cost[6]	GHG Emissions (tonnes)	BEPI kWh/m^2/yr
Existing	768,310	61,465	2,928	29,278	1,581,600	94,900	167	279

[6] Total cost includes carbon tax at $25/Tonne

3.2 ENERGY END-USE ANALYSIS

3.2.1 Total Energy Breakdown

A breakdown of utility consumption for electricity and natural gas has been profiled for 2015 and is presented in Figure 3.5. There is an even split between natural gas and electricity consumption at the facility.

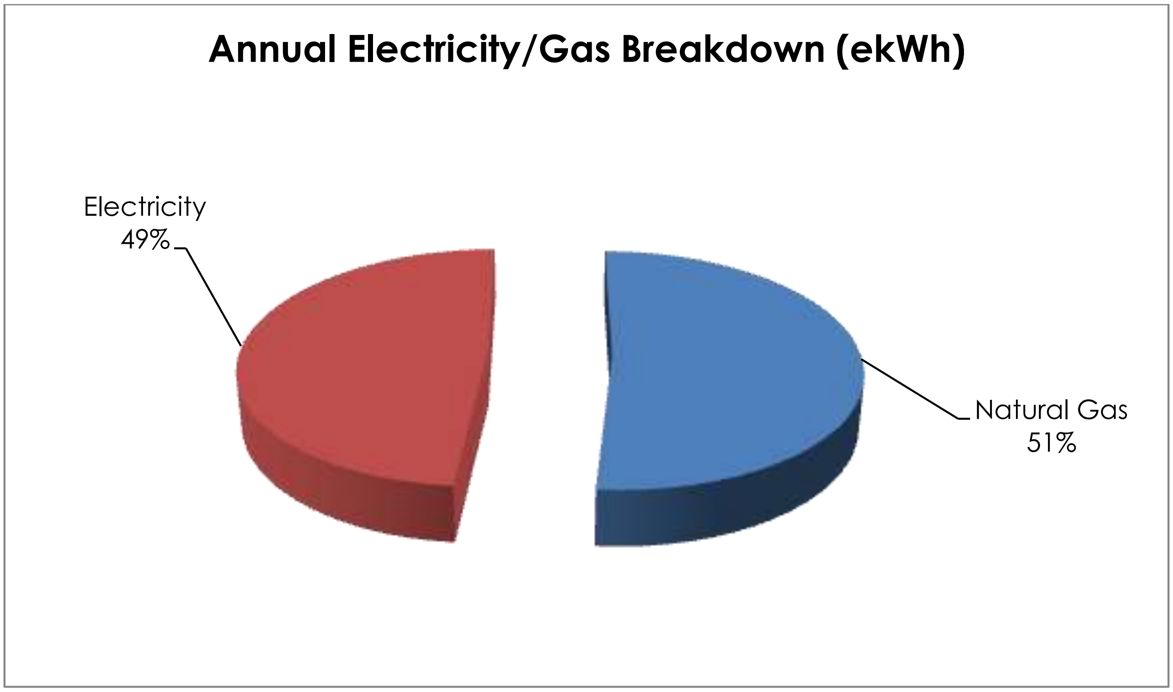


Figure 3.5: Breakdown of Energy Consumption by Fuel type

3.2.2 Electricity

An estimation of the electricity consumption by end use has been made based on the listing of identified equipment on site, the assumed run hours per equipment and any diversity in that use that can be foreseen. The breakdown is shown in Figure 3.6.

The largest electrical consuming equipment/process is the heat pumps and lighting. Heat Pump operation accounts for almost 36% of total building electricity consumption, with lighting accounting for almost 30%. The distributed heat pumps have such a significant load as they are the primary sources of heating and cooling the building.

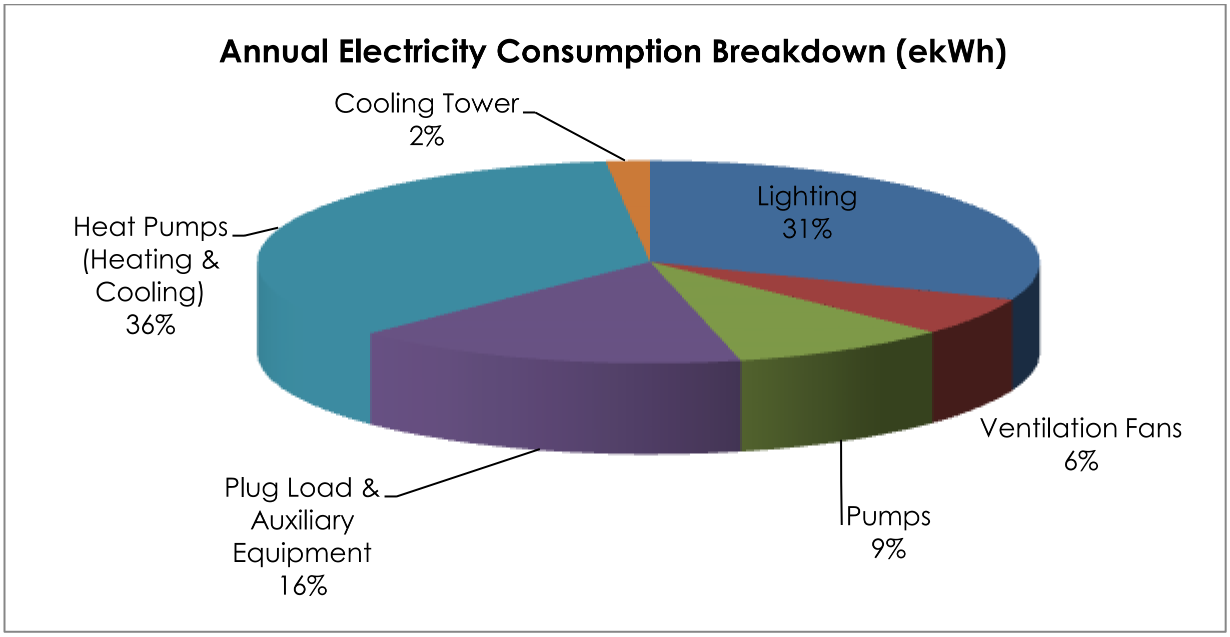


Figure 3.6: Breakdown of Electricity Consumption in kWh (2015)

3.2.3 Natural Gas (Heating)

Building heating constitutes the largest portion of the building natural gas load. The hot water boiler injects thermal energy into the heat pump loop to maintain setpoint temperatures.

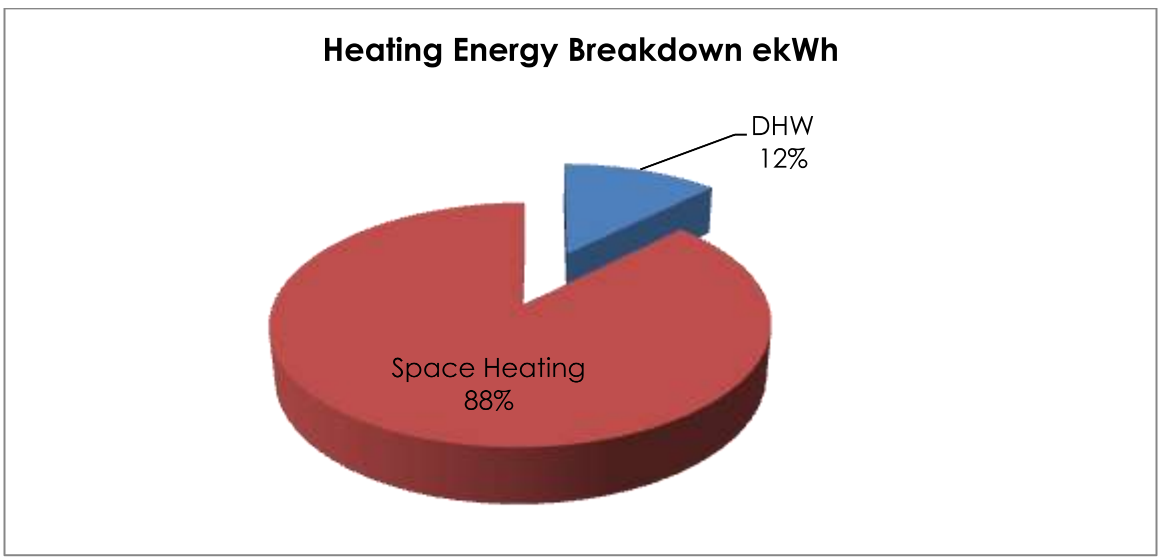


Figure 3.7: Natural Gas End Use Profile (2015)

4.0 ENERGY CONSERVATION MEASURES

Energy conservation measures have been investigated and profiled given the most cost effective and practical solutions to improving building performance.

4.1 ECM 1A – REPLACE EXISTING "BRYAN" BOILER WITH CONDENSING BOILERS

Two Bryan water tube boilers original to the time of construction are installed in the arts & education building. Each boiler serves one wing of the building and has a nominal capacity of 1,200MBH and efficiency of 80%.

It was noted that the boilers are not inter-connected, and one of the boilers failed in 2014 resulting in the need to reduce the level of service to one of the building's wings. It is proposed that the existing standard efficiency boilers be replaced by Condensing boilers. Condensing boilers incorporate an additional heat exchanger to extract heat by condensing water vapor from the products of combustion. They operate at a minimum efficiency of around 85% even when not condensing and can achieve efficiencies in the range of 85-95%.

Lower return water temperatures lead to more condensation and higher efficiencies. It is recommended that the dual return feature be utilized on the condensing boilers where heat pump and radiant loop can be returned to the boiler at a lower temperature than the air handling unit heating coil loop. This will result in higher overall operational efficiencies.

Two potential options have been identified for this work:

Option	Boiler Capacity (MBH)	Description	Recommendation
Option 1	2,250	Install three (3.) 750MBH boilers to provide maximum turndown potential; Total heating capacity is under the	Not recommended due to increased price and space constraints
Option 2	2,500	Install one (1) 1500MBH & one (1) 1000MBH boiler to satisfy total heating capacity.	recommended

During the detailed engineering design of this energy conservation measure, building heating demand will be verified to ensure that boiler capacity is in line with the demand profile.

Option 2 will be the most cost effective from a capital cost perspective and it is recommended that option 2 is implemented as a priority. If space constraints on site do not allow the installation of the larger 1500MBH unit, then option 1 can be implemented.

4.1.1 Scope of Work

It is proposed the existing boilers be decommissioned and replaced with equivalent capacity condensing boilers. The replacement boiler capacity will be confirmed during the detailed mechanical design of the boiler upgrades.

Outline	Description
Baseline equipment	There are currently two "Bryan" natural gas boilers in operation. They provide heating for the building and having been installed in 1991. A baseline replacement cost of $153,000 is assumed.
Upgrade Description	It is proposed that the existing boilers be decommissioned and replaced with condensing boilers. Option 2 as described previously is the preferred retrofit option.
Affected area in building	The existing boilers are located in the mechanical penthouse boiler room.
Service life	The estimated service life of the condensing boilers will be 20 years.
Non energy benefits	The new boilers will be modulating which will provide for improved performance at part load conditions.
Risk assessment	Condensing boilers are a mature technology and are a low risk investment. Before implementation, an assessment must be made as to a route for new flue/stack. The current boilers are not inter-connected meaning that if one of the boilers goes down, there is risk of service disruptions for an entire wing. Replacement with new boilers and adjustment of the piping configuration will increase the overall system reliability

4.1.2 Methodology of Savings Calculations

Savings have been based on an Improvement in building heating boiler efficiency from 80% (existing fire tubes) to 93% using condensing boilers.

4.1.3 Cost, Saving and Payback

A summary of anticipated costs and savings are as follows:

SIMPLE PAYBACK	
BASELINE COST	$987,600)

TOTAL RETROFIT COST	339,700
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 8,680
PAYBACK (years)	39.1

4.1.4 Impact on Operations and Maintenance

Installation of condensing boilers will have a positive impact on maintenance expenditure as the older boilers are reaching end of life.

4.2 ECM 2 – OPTIMIZE DEMAND CONTROL VENTILATION & INSTALL NEW OUTDOOR AIR DAMPERS

SF-1 is the primary method of building ventilation for the arts and education building. The unit incorporates a variable frequency drive on the supply fan to module air flow depending on duct pressure feedback. Heat pumps located throughout the facility modulate air flow based on CO2 sensor feedback within designated zones.

On analysis of measured CO_2 concentrations within the building, it was noted that certain areas were over-ventilated, with measured CO_2 concentrations at atmospheric levels (400-450 ppm). Acceptable concentrations for Carbon Dioxide in occupied spaces are defined by ASHRAE 62.1. In general, concentrations in the range of 800 to 1000 ppm are acceptable and as such, there is an opportunity to reduce ventilation rates in the building by optimizing the demand control ventilation system. Reducing ventilation rates will have a positive performance on energy consumption, as reduced outdoor air supply in winter will reduce heating load, and in summer, cooling load will be reduced.

Figure 8: Heat Pump Operational Parameters from DDC & Measured CO2 Concentration

4.2.1 Scope of Work

Where spaces have a variable occupancy pattern, there can be significant potential to save energy through matching supply air volumes to ventilation demand. This is typically achieved by sensing carbon dioxide levels in return air and adjusting outside air supply volumes accordingly.

CO_2 sensors have been installed at the arts and education building to control individual zone ventilation rates to match occupancy demand. There are opportunities to improve the performance of the demand control ventilation system.

It is proposed that the CO_2 sensor set-points be increased to better reflect occupant comfort requirements/ventilation demand in each zone. It is proposed that set points be increased to 750 PPM, then monitored for effectiveness. In addition to increasing the CO_2 set points, outdoor air damper should be controlled to modulate outdoor air flow with demand.

The scope of work is as follows:

Outline	Description
Baseline equipment	SF-1 is primary method of ventilating the building. The supply fan VFD modulates based on CO_2 concentrations measured within specific building zones.
Upgrade Description	It is proposed that the CO_2 sensor set points be adjusted to

	750 PPM. It is also proposed that the CO_2 sensors be calibrated to ensure accuracy. It is also recommended that SF-1 outdoor air damper operation be verified and replaced if appropriate. It was not possible for the Stantec engineers to verify damper operation on site as access was restricted.
Affected area in building	This will affect all building areas.
Service life	As required to maintain comfortable conditions.
Non energy benefits	n/a
Risk assessment	If implemented, it is recommended that the effectiveness of this measure be investigated using hand-held CO_2 meters. When the Stantec engineers referenced the handheld device readings with the CO_2 levels recorded by the DDC there was a large discrepancy. In order to ensure the effectiveness and accuracy of this ECM it is recommended that manual verification supplement DDC controls revisions.

4.2.2 Methodology of Savings Calculations

Savings have been based on a reduction in outdoor air supply volume by 10%. This value has been derived as a reasonable savings expectation and to illustrate the potential for savings. It is difficult estimate the exact reduction in outdoor air volume as it is heavily dependent on occupancy.

4.2.3 Cost, Saving and Payback

Costs have been based on hiring a controls contractor to reprogram the existing setpoints in summer.

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 34,300
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 5,444
PAYBACK (years)	6.3

4.2.4 Impact on Operations and Maintenance

There will be minimal impact on operations and maintenance.

4.2.5 Risk Analysis

Risk involved with implementing this measure will be reduced through verification of CO_2 levels in the building using hand held measurement devices post retrofit.

4.3 ECM 3 – CHILLER/HEAT PUMP REPLACEMENT

Cooling demand in summer and shoulder seasons is met using a number of water source distributed heat pump units which serve individual zones. Heat rejection from the heat pump loop is achieved using a fluid cooler located in the upper mechanical room.

The heat pumps and fluid cooler are original to the building and as such are beyond their useful life. There is potential for reduced electricity consumption by retrofitting the existing heat pumps and fluid cooler with more efficient units.

4.3.1 Scope of Work

The scope of work will involve the decommissioning and replacement of the existing cooling system. A complete overview is provided below.

Outline	Description
Baseline equipment	Fluid cooler and distributed water source heat pump system.
Upgrade Description	Half of the heat pumps were replaced in 2015. The other 30 heat pumps will be upgraded as part of this measure. Upgrade the existing heat pumps and fluid cooler with a high efficiency unit.
Affected area in building	Distribute heat pumps located throughout the facility and fluid cooler in the mechanical room.
Service life	25 years
Non energy benefits	Not Applicable
Risk assessment	The risk associated with this ECM is focused on the ability to remove the fluid cooler from the mechanical room, and whether there are sufficient clearances to do so. Additionally, the heat pumps should be replaced during a period when the building has minimal occupancy, as there will be reduced ventilation and heating/cooling in the building during this time.

4.3.2 Methodology of Savings Calculations

Savings have been based on improved compressor efficiencies achieved through retrofitting the older units with new high efficiency units. Average EER of the existing units is 10.9 and new EER average is 14.1.

4.3.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$270,000
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$4,852
PAYBACK (years)	55.7

4.3.4 Impact on Operations and Maintenance

It is anticipated that there will be a reduction in operations and maintenance costs through implementation of this measure, especially in the coming years as the existing system has reached its end of life.

4.3.5 Risk Analysis

This is a low risk measure as existing heat pumps will be replaced on a like for like basis. Risks are increased if the fluid cooler requires removal, due to its size and confined space.

4.4 ECM 4 – INSTALL PREMIUM EFFICIENCY PUMPS (P-1 & P-101)

4.4.1 Scope of Work

Existing standard and low efficiency motors can be replaced with premium efficiency alternatives to reduce energy consumption. Electric motors become less efficient over time, especially if rewound. The recreation centre incorporates a number of motors, many of which are original to the building.

It is recommended that existing motors are replaced with premium efficiency alternatives to achieve an 8- 10% improvement in motor energy consumption.

4.4.2 Methodology of Savings Calculations

Savings are calculated on published BC Hydro motor efficiency data. Savings are based on replacement of existing old motor with premium efficiency alternative.

4.4.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$53,000
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$461
PAYBACK (years)	115

4.4.4 Impact on Operations and Maintenance

It assumed that there will be a positive impact on operations and maintenance through implementation of this measure as new motors will require minimum maintenance.

4.4.5 Risk Analysis

This measure is a low risk measure.

4.5 ECM 5 – REPLACE MAKEUP AIR UNIT (SF-1) & IMPLEMENT HEAT RECOVERY

The building ventilation system is comprised of a primary air supply system (SF-1) which draws air into the system through a motorized inlet damper, a series of filters and heating coil. The supply fan (with VFD) then discharges the conditioned outdoor air through a series of ductwork to several heat pumps located on all 3 building levels.

The unit was installed in 1991 and has passed its useful and as such should be replaced with a more efficient model which will result in energy savings.

4.5.1 Scope of Work

The scope of work will involve hiring a mechanical contractor to decommission the existing ventilation unit and install a new unit.

Outline	Description
Baseline equipment	The existing Engineered Air (LM-15-C) unit was installed in 1991. It incorporates a 7.5HP supply fan motor which is fitted with VFD.
Upgrade Description	It is proposed that the existing unit be replaced with a new air supply system comprising energy efficient motors, enhanced controls and a heat recovery unit.
Affected area in building	This upgrade will impact all conditioned space in the building
Service life	A service life of 25 years is expected
Non energy benefits	Not applicable
Risk assessment	This is a low risk measure.

4.5.2 Methodology of Savings Calculations

Savings have been based on reductions in natural gas consumption from heat recovery as well as reduced electricity from energy efficient motors and reduced fan power.

4.5.3 Cost, Saving and Payback

Costs have been estimated from a cost consultant review. Savings were estimated from engineering calculations.

The anticipated savings are as follows;

SIMPLE PAYBACK	
BASE CASE	$(46,000)
TOTAL RETROFIT COST	$92,800
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$4,788
PAYBACK (years)	16.2

4.5.4 Impact on Operations and Maintenance

It assumed that there will be no impact on operations and maintenance through implementation of this measure.

4.5.5 Risk Analysis

There is minimal risk associated with implementation of this measure.

4.6 ECM 6 – REPAIR VESTIBULE CONTROLS & WEATHER PROOF EXTERNAL DOORS

During the site visit, Stantec engineers noted that the vestibule doors at the main entrance to the building had been locked to the open position. This meant that as students & faculty were entering the building entrance doors, significant thermal energy was being lost.

On speaking with the facility operator, it was noted that the vestibule doors had been locked open due to operability / controls issues. It is encouraged that the controls issues be resolved and the automated vestibule doors reinstated.

Figure 4.9: Vestibule Doors in "Open" Positon

In addition to the main entrance door, it was noted that weather stripping at the side entrance door had failed and should be repaired to limit outdoor air infiltration.

4.6.1 Scope of Work

This scope of work will involve refurbishing or replacing the existing vestibule controls panel. If problems persist, it is encouraged that an air curtain device be installed to replace the vestibule.

Outline	Description
Baseline Equipment	The automated vestibule doors are locked in the "open" position. This is due to operability issues with the door controls.
Upgrade Description	It is proposed the controls system be reinstated and refurbished as required.
Affected Area in Building	This measure will impact the building entrance lobby.

Service Life	20 years
Non Energy Benefits	Improved space comfort conditions, by limiting large temperature variations.
Risk Assessment	There is minimal risk associated with the implementation of this measure.

4.6.2 Methodology of Savings Calculations

Energy savings have been calculated given:

- Reduction in heat loss through the main entrance door
- It is assumed that there is a single air change in the vestibule and adjacent lobby area each time the entrance door is opened
- By reinstating the door controls system, heating (natural gas) energy savings have been calculated during winter conditions.

4.6.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$19,000
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$510
PAYBACK (years)	37.5

4.6.4 Impact on Operations and Maintenance

Implementation of this measure will not have an impact on building operations and maintenance.

4.6.5 Risk Analysis

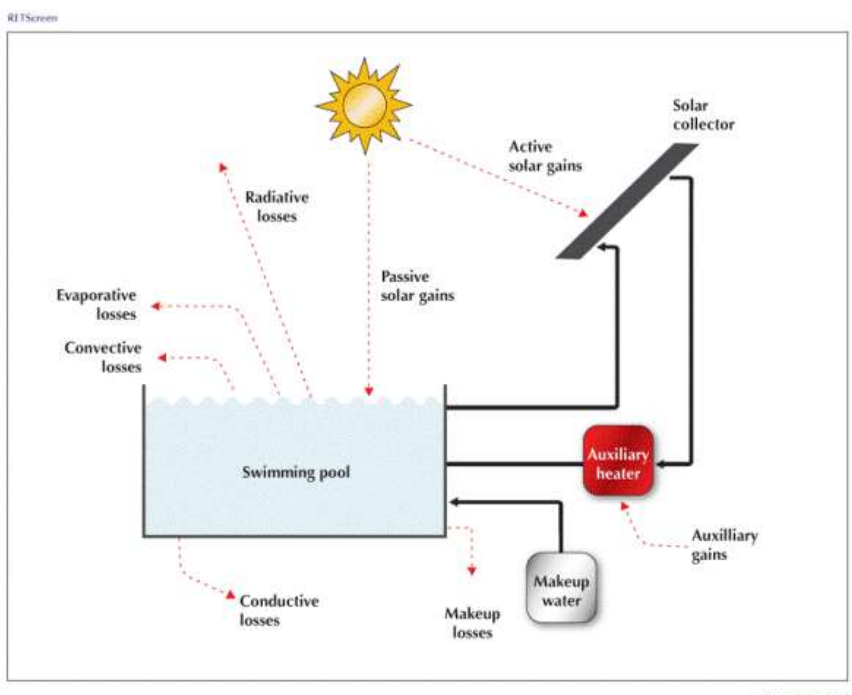
There is no risk associated with implementation of this measure.

4.7 ECM 7 – INSTALL SOLAR HOT WATER HEATER

Solar water heating systems convert solar radiation to heat water. They are normally made up of the following components:

- **Solar collector:** Usually located on the roof of the building being served. Heat transfer is conducted via a liquid (glycol solution) between the collector and storage cylinder
- **Water storage cylinder:** Heat absorbed via the glycol solution is transferred in the water storage cylinder via a metal coil.
- **Pumps and Valves:** Ensure the constant flow of glycol solution with higher pressures reducing the possibility of the liquid freezing in winter, whilst also availing of higher operating efficiencies

It is proposed that a solar water heater be installed to offset a portion of the building heating and domestic hot water demand from natural gas.



[7]

The Arts and Education building operation profile is particularly suited to solar hot water heating technology. There is a constant domestic hot water demand year round and as such, the solar energy available especially during the shoulder season months, can offset a significant portion of the heating demand.

As can be seen from the graph below, solar radiation values for Kamloops BC are greater in the shoulder season and summer months. Between the months of March to October, there is a

[7] http://www.retscreen.net/ang/g_solarw.php

significant potential to reduce building natural gas consumption through installation of a solar hot water heater.

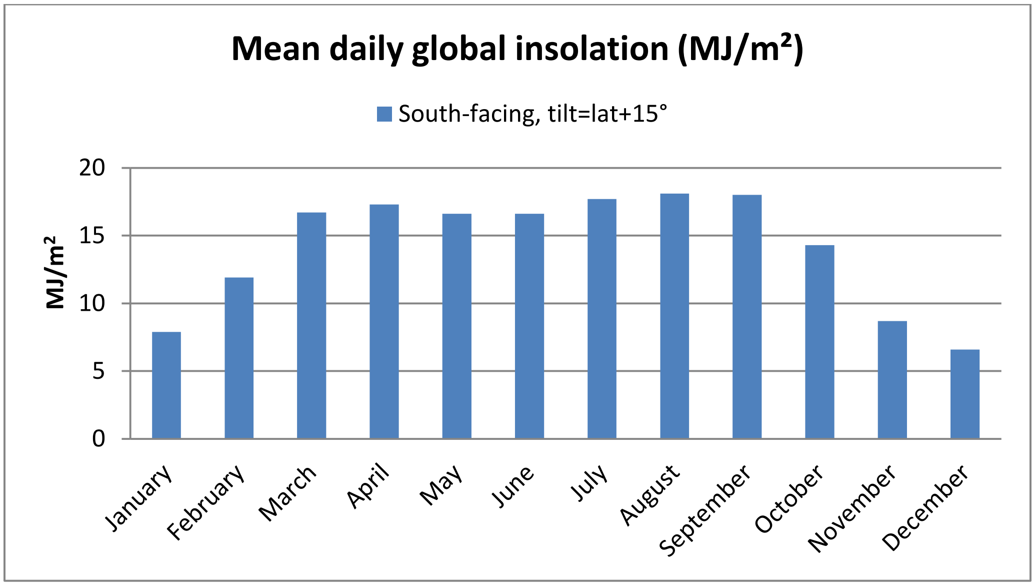


Figure 4.10: Graph of Solar Radiation in Kamloops BC

4.7.1 Scope of Work

The scope of work will comprise installation of an evacuated tube solar water heater, on or close to the south facing roof of the roof area. As well as the solar water heater, a storage cylinder and circulation pump will be installed. It is recommended that the solar water heaters be installed at 50° elevation to maximize solar exposure.

Outline	Description
Baseline equipment	The installation of a solar water heater would supplement the existing natural gas fired heating and domestic hot water system.
Upgrade Description	It is proposed that solar water heater be installed to generate hot water preheating on the roof. It will involve the installation of a collector on the roof of the facility and a pre-heat storage tank installation in the mechanical room.
Affected area in building	The solar hot water panels will be installed on the roof. It is recommended an assessment as to the structural support requirements of the installation be conducted at an early stage.
Service life	Estimated service life will be 25 years.
Non energy benefits	Installation will reduce greenhouse gas emissions and offers

	the potential for the university to act as an advocate for green technologies.
Risk assessment	Solar hot water heaters are a maturing technology, however have been in operation internationally for decades.

4.7.2 Methodology of Savings Calculations

Savings have been calculated by performing a RETScreen analysis.

4.7.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$97,980
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$1,040
PAYBACK (years)	94

4.7.4 Impact on Operations and Maintenance

The installation of the solar water tubes will result in increased maintenance to ensure the collectors are free of dirt and are operating optimally. The evacuated tube system may also need to be recharged with glycol.

4.7.5 Risk Analysis

This is a relatively low risk energy conservation measure. Thompson Rivers University is experienced with Solar Hot Water projects.

4.8 ECM 10 – SOLAR PV INSTALLATION

Solar photovoltaic systems convert solar radiation directly to electricity. They are normally made up of the following components:

- **Solar collector:** Crystalline cells are mounted on panels located on the roof of the building being served. Units may come with on board inverter to convert from DC to AC

t is proposed that a solar PVs be installed to offset a portion of the building electricity demand. When generation exceeds demand, electricity may be sold back onto the grid.

As can be seen from the graph below, solar radiation values for Kamloops BC are greater in the shoulder season and summer months. Between the months of March to October, there is a significant potential to reduce building electricity demand though installation of PV panels.

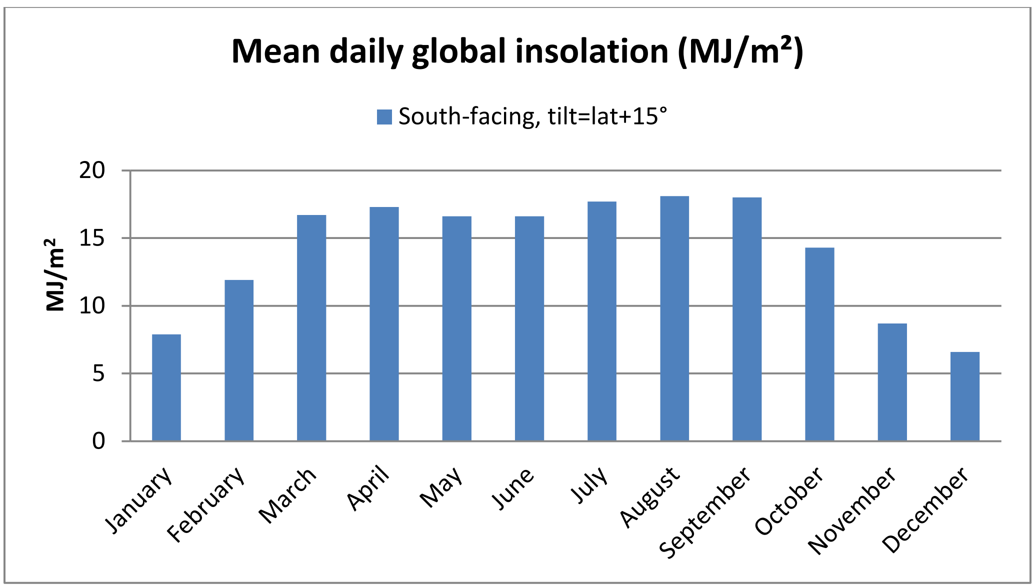


Figure 4.11: Graph of Solar Radiation in Kamloops BC

4.8.1 Scope of Work

The scope of work will comprise installation of PV panels mounted on south facing roof of the roof area. It is recommended that the solar water heaters be installed at 50° elevation to maximize solar exposure.

Outline	Description
Baseline equipment	The installation of a solar PV would offset electricity purchased from BC hydro.
Upgrade Description	It is proposed that solar PV be installed on the roof and inter-connected to the building's electricity lines via switchgear.

Affected area in building	The solar PV panels will be installed on the roof. It is recommended an assessment as to the structural support requirements of the installation be conducted at an early stage. Additional space in the electrical room will be required for switchgear.
Service life	Estimated service life will be 25 years.
Non energy benefits	Installation offers the potential for the university to act as an advocate for green technologies.
Risk assessment	Solar PV are a maturing technology, however have been in operation internationally for decades.

4.8.2 Methodology of Savings Calculations

Savings have been calculated by performing a RETScreen analysis.

4.8.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$98,100
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$21,009
PAYBACK (years)	4.7

4.8.4 Impact on Operations and Maintenance

The installation of the solar PV will result in increased maintenance to ensure the collectors are free of dirt and are operating optimally.

4.8.5 Risk Analysis

This is a relatively low risk energy conservation measure.

5.0 BUILDING MANAGEMENT AND BEHAVIORAL OPPORTUNITIES

5.1 FURTHER UPGRADES

There are various further upgrades currently being proposed for this facility as identified in VFA Top Priority Requirements report (5-Nov-2015). These include:

- Inverted Roof Membrane Assembly Renewal
- Exhaust System - Restroom Renewal
- Exhaust System - Service Rooms Renewal
- Glazing Upgrades
- HVAC Electrical Controls Renewal

5.2 PROCUREMENT POLICY

Purchasing efficient products reduces energy costs without compromising quality. It is strongly recommended that a procurement policy be implemented as a key element for the overall energy management strategy at TRU. An effective policy would direct procurement decisions to select EnergyStar® qualified equipment, in contracts or purchase orders. For products not covered under EnergyStar®, the EnerGuide labeling should be reviewed to select products with upper level performance in their category. Improved energy performance will involve the investment in energy efficient equipment coupled with user education and awareness program.

5.3 STAFF TRAINING AND OCCUPANT AWARENESS

Equipment operation practices and policies can also have a significant impact upon energy consumption. There is generally ample opportunity for energy savings from office equipment and lighting as they may be left on when not in use. An energy efficiency awareness program should be put in place to encourage patrons and staff to turn off equipment when not in use during the day, at the end of the day, and for the weekend.

5.4 RECOMISSIONING & SYSTEM BALANCING

If energy conservation measures are to be implemented (as suggested in this report) then it is recommended a full building re-commissioning take place. Re-commissioning the systems in a building of this vintage can offer real benefits with regard to energy savings and enhanced performance.

5.5 BUILDING ENERGY MANAGEMENT SYSTEM

The existing building controls system at the facility is electronic over pneumatic. It is recommended that the controls hardware be updated to a fully electronic system, which will negate the need for compressed air, resulting in reductions in energy demand. Another added benefit of this work will

Estimated costs for this work have been estimated at $300,000-$400,000.

6.0 SUMMARY OF ENERGY SAVINGS

6.1 SUMMARY OF ECMS

The following table provides a summary of the ECMs recommended along with approximate costs, savings, paybacks and emission reductions.

Table 10: Energy Savings and Costs Summary

ENERGY SAVINGS AND COSTS SUMMARY												
MEASURE		Natural Gas		ELECTRICITY SAVING				FINANCE			EMISSIONS
Reference	Description	Natural Gas (Gj/year)	Natural Gas Saving ($/year)	Electricity Consumption Saving (kWh/year)	Electricity Consumption Saving ($/year)	Electricity Demand Saving (kW/month)	Electricity Demand Saving ($/year)	Cost ($)	Total Savings ($/year)	Payback (years)	CO2 Reduction (tonnes/year)
ECM 1	Install Two New Condensing Boilers	772	$ 7,716	-	$ -	-	$ 966	$ 339,756	$ 8,682	39.1	38.6
ECM 2	OPTIMIZE DEMAND CONTROL VENTILATION & INSTALL NEW OUTDOOR AIR DAMPERS	772	$ 7,716	26,143	$ 1,542	1	$ 121	$ 34,300	$ 5,444	6.3	39.3
ECM 3	Replace Existing Heat Pumps	-	$ -	60,645	$ 4,852	-	$ -	$ 270,000	$ 4,852	55.7	1.6
ECM 4	Install High Efficiency Motors	-	$ -	4,276	$ 342	1	$ 119	$ 53,000	$ 461	114.9	0.1
ECM 5	Replace SF-1 with New Unit	469	$ 4,688	12,974	$ 1,038	-	$ -	$ (46,000)	$ 5,726	-8.0	23.8
ECM 6	Repair Vestibule Controls	45	$ 453	-	$ -	-	$ -	$ 19,100	$ 510	37.5	2.3
ECM 8	Install Solar PV	-	$ -	219,000	$ 17,520	25	$ 3,489	$ 98,100	$ 21,009	4.7	5.7
TOTAL		2,057	20,574	323,038	25,294	27	4,695	768,256	46,684	16	111

6.2 REVIEW OF BUILDING ENERGY PERFORMANCE INDICATOR

By implementing the measures suggested previous, we can anticipate the buildings projected performance in reference to the existing BEPI. Table 11 below demonstrates the potential improvement from the existing BEPI.

Table 11: Building Energy Performance Indicator with Post Retrofit Measures Included

BUILDING ENERGY PERFORMANCE INDEX (2015)								
	Electricity (kWh)	Electricity Cost	Natural Gas (Gj)	Natural Gas (Cost)	Total ekWh	Total Cost	GHG Emissions (tonnes)	BEPI ekWh/m2/yr
Existing	768,310	$61,465	2,928	$29,278	1,581,600	$94,908	167	279
Reference building (Educational Services - 2008)								280
Post retrofit	445,272	$36,171	870	$8,705	687,074	$44,876	55	121
% Saving	42%	41%	70%	70%	57%	53%	67%	57%

6.3 EMISSIONS REDUCTION

The Canadian government is creating emission reduction targets that will determine the path of all business in Canada for the foreseeable future. An emissions reduction plan for Green House Gas (GHG) emissions is the first step in achieving a reduced impact on the environment.

The Energy Savings measures proposed for will have an immediate and positive effect on our local and global environment. The immediate impact on our local environment will follow as a reduction in demand offsets power generation from grid sources and from natural gas combustion at the site.

The site's total current annual equivalent carbon dioxide emissions (CO_2e) are 167 tonnes/year[8].

Table 12: Emissions Reductions Associated with the ECMs Recommended

EMISSIONS REDUCTIONS						
	Electricity		Natural Gas		Total	
Total Energy Saved	323,038	kWh/yr	2,057	Gj	894,525	ekWh
Total CO_2e Emissions Saved	8	tonnes/yr	103	tonnes/yr	111	tonnes/yr

The emissions savings projection of 187 tonnes per year equates to approximately 24% of current GHG emissions.

[8] The CO_2 emissions are calculated using conversion factors of 9.4t CO_2e/GWh for electricity

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Thompson Rivers University commissioned Stantec to conduct an energy assessment at Kamloops site to identify energy conservation opportunities. The energy assessment identifies the potential savings in energy consumption resulting from the implementation of energy conservation measures, and an initial opinion of probable costs to implement the measures. These capital upgrades will provide ongoing operational savings and are done so in an environmentally conscientious manner.

The assessment of the site Arts and Education Building revealed potential for the implementation of electricity and natural gas energy saving measures, which would improve the overall efficiency of the assessed facility.

7.2 RECOMMENDED MEASURES

		Measure	**Recommended for Implementation**
Mechanical & Electrical Measures	ECM 1	Replace two existing "Bryan" boiler with two condensing boilers	✓
	ECM 2	Optimize Demand Control Ventilation & install new outdoor air dampers	✓
	ECM 3	Chiller/Heat Pump Replacement	✓
	ECM 4	Install Premium Efficiency Pumps (P-1 & P-101)	✓
	ECM 5	Replace Makeup Air Unit (SF-1) & implement heat recovery	✓
	ECM 6	Repair Vestibule Controls & Weather Proof External Doors	✓
	ECM 7	Install solar hot water heater	✓
	ECM 8	Solar PV Installation	✓

It is anticipated that should all of the selected measures be implemented, there would be annual savings in utilities of approximately $42,000 at a rate of $10.00 GJ for natural gas and 0.08 cents per kilowatt hour for electricity and a reduction in GHG emissions of around 107 tonnes (equivalent to around 36% of current emissions).

Total Investment	Total Cost Savings	Payback	Total Natural Gas Savings (GJ)	Total Electricity Savings (kWh)	CO_2 Reduction (Tonnes)
$770,000[9]	$46,700	16	2,057	323,000	111

[9] Total investment is total material & labour cost

8.0 STUDY LIMITATIONS

This report was prepared by Stantec for Thompson Rivers University. The material in it reflects our professional judgment in light of the following:

- Our interpretation of the objective and scope of works during the study period;
- Information available to us at the time of preparation;
- Third party use of this report, without written permission from Stantec, are the responsibility of such third party;
- Measures identified in this report are subject to the professional engineering design process before being implemented.

The savings calculations are our estimate of saving potentials and are not guaranteed. The impact of building changes in space functionality, usage; equipment retrofit and weather need to be considered when evaluating the savings.

Any use which a third party makes of this report, or any reliance on decisions to be made are subject to interpretation. Stantec accepts no responsibility or damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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Appendix B UTILITY CONSUMPTION (2013 – 2015)

	Annual Natural Gas Utility Records (GJ)								
	2013			2014			2015		
	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.
Jan	532	31	17	428	31	14	343	31	11
Feb	483	28	17	336	28	12	359	28	13
Mar	447	31	14	409	31	13	356	31	11
Apr	367	30	12	342	30	11	295	30	10
May	247	31	8	216	31	7	146	31	5
Jun	141	30	5	110	30	4	65	30	2
Jul	34	31	1	32	31	1	22	31	1
Aug	23	31	1	26	31	1	28	31	1
Sept	152	30	5	163	30	5	213	30	7
Oct	527	31	17	374	31	12	382	31	12
Nov	494	30	16	408	30	14	380	30	13
Dec	400	31	13	362	31	12	338	31	11
Total	3,847			3,205			2,928		

	Annual Electricity Consumption Utility Records (kWh)								
	2011			2012			2013		
	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.
Jan	94,932	31	3,062	91,394	31	2,948	76,013	31	2,452
Feb	73,580	28	2,628	80,256	28	2,866	61,640	28	2,201
Mar	77,917	31	2,513	73,774	31	2,380	66,389	31	2,142
Apr	66,697	30	2,223	63,200	30	2,107	58,087	30	1,936
May	64,030	31	2,065	60,038	31	1,937	56,249	31	1,814
Jun	59,981	30	1,999	59,147	30	1,972	59,137	30	1,971
Jul	75,877	31	2,448	70,876	31	2,286	61,835	31	1,995
Aug	69,510	31	2,242	61,352	31	1,979	55,854	31	1,802
Sept	71,646	30	2,388	64,877	30	2,163	59,639	30	1,988
Oct	76,535	31	2,469	68,447	31	2,208	65,786	31	2,122
Nov	83,627	30	2,788	73,154	30	2,438	74,121	30	2,471
Dec	94,549	31	3,050	73,327	31	2,365	73,560	31	2,373
Total	908,881			839,842			768,310		