Thompson Rivers University Animal Health Building Energy Assessment

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Sign-off Sheet

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Executive Summary

Thompson Rivers University (TRU), commissioned Stantec Consulting Ltd (Stantec) to conduct a detailed energy assessment at its Animal Health building located at the Kamloops Campus, 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 1,180m^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 $39,000 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 83 tonnes.

Total Investment	Total Cost Savings	Payback	Total Natural Gas Savings (GJ)	Total Electricity Savings (kWh)	CO2 Reduction (Tons)
$1,071,000	$39,000	28	1,540	237,450	83

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.

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	168,706	$13,496	2,309	$23,089	810,065	$39,586	120	686
Reference Building (Academic) 280								
Post Retrofit	150,255	$12,020	1,771	$17,713	642,285	$29,733	42	544
Savings	11%	11%	23%	23%	21%	25%	65%	21%

		Measure	Recommended for Implementation
Mechanical & Electrical Measures	ECM 1	Implement Boiler Upgrade (including repiping)	✓
	ECM 2	Replace Rooftop Units	✓
	ECM 3	rezone isolation room HVAC	✓
	ECM 4	Insulate Hot Water/ DHW Distribution Pipework	✓
	ECM 5	Install Solar Water Heater	✓
	ECM 6	Install Solar PV System	✓

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	Boiler Upgrade	132	$ 1,316	-	$ -	-	$ -	$ 198,536	$ 1,481	134.1	6.6
ECM 2	Rooftop Unit Replacment	352	$ 5,433	18,451	$ 1,476	-	$ -	$ 627,300	$ 5,433	115.5	18.1
ECM 3	Revise Zone Control Paramters	901	$ 9,011	-	$ -	-	$ -	$ 78,970	$ 9,011	8.8	45.1
ECM 4	Pipework Insulation	54	$ 970	-	$ -	-	$ -	$ 5,700	$ 970	5.9	2.7
ECM 5	Install Solar Hot water Heater	104	$ 1,040					$ 62,700	$ 1,040	60.3	5.2
ECM 6	Install Solar PV System			219,000	$ 17,520	25	$ 3,489	$ 98,100	$ 21,009	4.7	5.7
TOTAL		**1,543**	**17,769**	**237,451**	**18,996**	**25**	**3,489**	**1,071,306**	**38,943**	**28**	**83**

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 Animal Health 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 is reductions in electricity and natural gas consumption from heating ventilation and air conditioning equipment; opportunities for savings in electricity consumption from lighting are not included.

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 Director, Environment and Sustainability
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.[1]

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.

1.1.5.1 Project Funding

This project was made possible through funding from BC Hydro and Fortis BC. This support is gratefully acknowledged.

[1]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 and 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

Item	Value	Unit
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[2] 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 (BTY) 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.

[2] 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 Animal Health building was originally built in 2002 and is comprised of a single storey structure with a gross floor area of 1,180m2. The building gets its name from the animal health technical program which is delivered from this building.

The building is mostly comprised of classroom and lab facilities and also includes faculty offices.

Figure 2.1 Building Envelope & Glazing Units

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

Item	Value	Units
Site Area	1,180	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 & Animal Health Building

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

	Monday - Friday	Saturday	Sunday/Holiday Occupancy
Labs / Classrooms	07:00AM – 10:00PM	-	-
Faculty Offices	07:00AM – 6:00PM	Intermittent	Intermittent

2.2 BUILDING ENVELOPE

A summary of building envelope components is presented below.

Table 4 Building Envelope Descriptions

Assembly	Description	Image
Building Envelope	The building is constructed over a partial basement of poured concrete construction. Construction appears to be of non-combustible design including steel stud, brick cladding	
Fenestration	Building fenestration comprises double glazed units. Window and door systems are typically constructed in aluminum frame and some windows are operable.	

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. The building envelope is performing well, with no areas of concern identified.

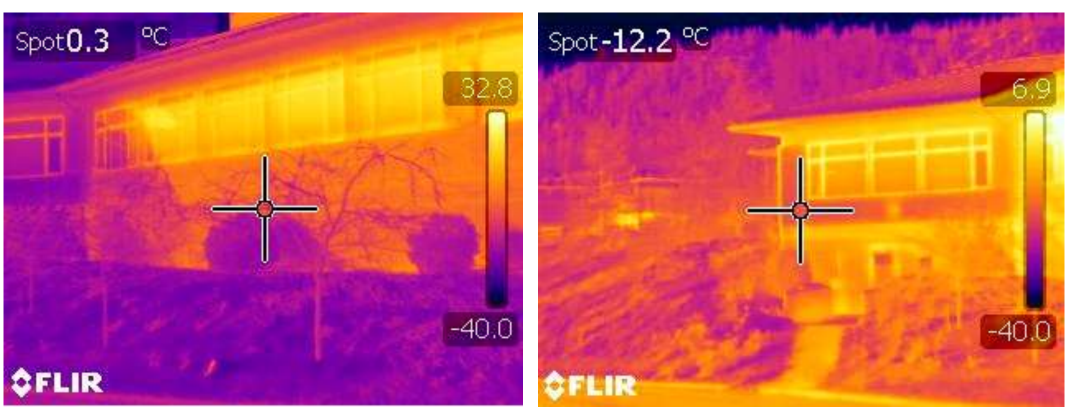


Figure 2.3 Thermographic Inspection of Envelope & Fenestration

2.3 LIGHTING

Building lighting was not in the scope of this study.

2.4 MECHANICAL SYSTEMS

2.4.1 Ventilation

The building ventilation system is comprised of eight (8) rooftop units. Outdoor air is drawn into the mixing boxes where it is blended with return air before being heated or cooled (depending on building thermal requirements). Once the air is conditioned and filtered, it is ducted to ceiling mounted diffusers in the space.

Return air is ducted through ceiling mounted transfer grilles into the ceiling space. The air is then drawn through the return air duct to the mixing box, where it is either exhausted or mixed with outdoor air.

Table 5 Ventilation System Inventory

Unit	Location	Service	Motor Size (kW)	Capacity (L/s)[3]
RTU-1	Roof	East Perimeter Offices	1.49	1,133
RTU-2	Roof	North Interior Zone	1.49	1133
RTU-3	Roof	Room 119	1.59	708
RTU-4	Roof	Multi-use room #1	1.49	566
RTU-5	Roof	Multi-use room #2	1.49	750
RTU-6	Roof	South Interior Zone	1.59	1,067
RTU-7	Roof	South Perimeter Zone	1.12	755
RTU-8	Roof	Kennels	0.75	967

On review of air handling operation schedule, it was noted that the majority of rooftop units are programmed to operate 24/7, with RTU-3 operational 6am – 9pm.

[3] From balancing report

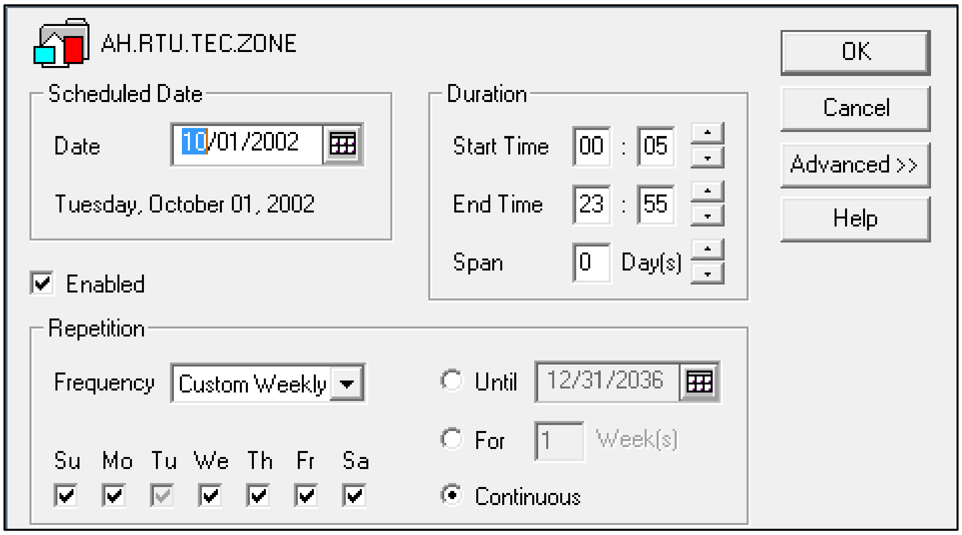


Figure 2.4 RTU Operation Schedule from DDC

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	Isolation Exhaust	0.186kW	95
EF-2	Roof	Surgery Exhaust	0.373kW	660
EF-3	Roof	Developing Exhaust	0.186kW	100
EF-5	Roof	Multi-Use Room #1	0.186kW	283
EF-6	Roof	Washrooms, Janitor & Storage	0.186kW	175
EF-7	Roof	Chemical Storage	0.186kW	140
EF-8	Roof	Animal Areas	0.56kW	1,745
EF-9	Roof	Hood Exhaust	0.186kW	140

2.4.2 Heating

On site heating is generated using a 'Burnham' natural gas boiler. The boiler has a specified gross input of 528MBH and a nameplate efficiency of 80%. It is a naturally vented mid-efficiency unit that appears to be original to the time of construction. During the time of the site visit, the boiler fired periodically and appears to be operating effectively. It was noted that boiler supply and return lines are not insulated.

Figure 2.5 Hot Water Boiler, Domestic Hot Water Heater and Hot Water Distribution

Table 6 Boiler Specification

Manufacturer	Model Number	Input (MBH)	Output (MBH)	Rated eff.	Manufactured
Burnham	P-809	528	422	~80%	2002

The heating system comprises two circuits, primary and secondary. Circulating pumps P-2 & P-3 draw the heated water/glycol solution through the boiler and circulate it through the primary loop to the secondary pumping system. Circulating pumps P-4 & P-5 circulate heated water to the building serving force flow heaters, unit heater, radiant ceiling panels and baseboard radiation. P-7 serves the underfloor heating system. Rooftop units located on the building roof incorporate indirect natural gas fired heating, which supplement the boiler heating capacity by 305kW.

Figure 2.6 Baseboard Heater and Gas Fired RTU

2.4.3 Domestic Hot Water

Domestic Hot Water at the facility is generated by a "A.O Smith" natural gas fired domestic hot water heater. See table below for heater specification. A vent damper has been installed on the domestic hot water tank heater but not on the boiler.

Table 7 DHW Heater Specification

Manufacturer / Model #	Input (MBH)	Storage Capacity (L)	Rated eff.	Photo
A.O Smith / G75 -125	399	380	~80%	

2.4.4 Cooling

Building cooling loads are satisfied using the RTU DX cooling coils. Total RTU cooling capacity is 33 Tons.

2.4.5 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 in slab heating.

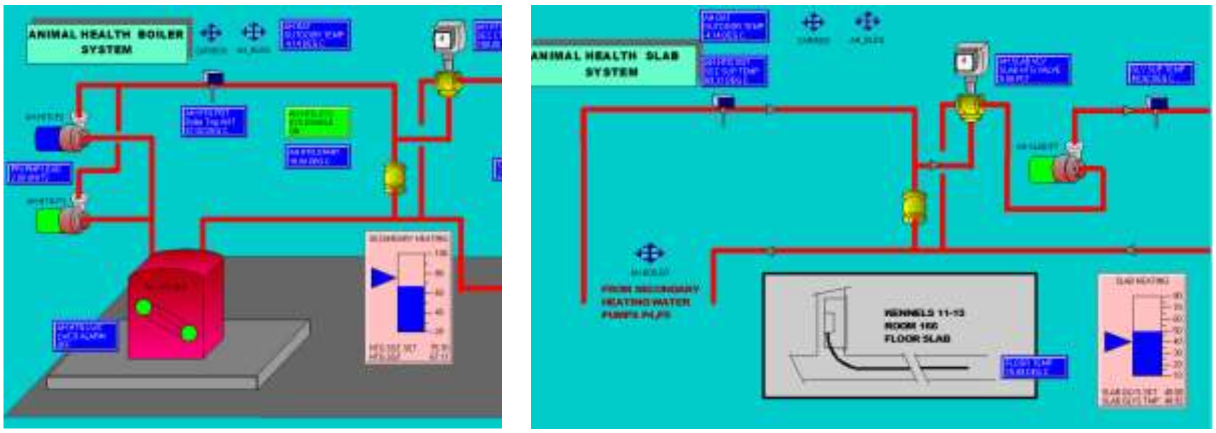


Figure 2.7 Level 2 DDC Graphic

2.5 ELECTRICAL EQUIPMENT

2.5.1 Incoming Power Supply

BC Hydro currently provides TRU with a single, 3-phase primary 25kV service from the Southeast corner of the campus. The original service was established in the 1960s, with multiple high voltage load break switches added over the years.

The existing main substation is located outside the Food Training building and consists of a main circuit breaker, transformers, and load break switches serving high voltage switchgear distributed throughout the campus. Distribution throughout the campus is routed underground via a series of manholes and duct banks. The majority of the underground distribution through the campus is at 25kV, with some instances of 12.5kV and shorter feeds into buildings at 480V and 600V. The Animal Health building incoming feed is 600V.

2.5.1 Emergency Generators

The TRU campus does not have a centralized emergency distribution system. Several buildings are backed up locally with an emergency generator. There are currently four diesel emergency generators on campus:

- Old Main Building – 150kW (Feeds life safety systems and some heating in the Old Main building with small panel feeds to the Gymnasium, Science Building, Clock Tower and Food Training Centre)
- International Building – 60kW (Life Safety systems with a feed to the Arts and Entertainment building)
- Residence – approx. 30kW (Life Safety Systems)
- BC Center for Open Learning – 150kW (Supplies life safety distribution and stand-by power for the Data center)

Each generator supplies emergency loads only and are not intended to maintain normal operation of the building.

3.0 BUILDING ENERGY ANALYSIS

3.1 CURRENT ENERGY USE

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

Electricity	Electrical utility data was extracted from the Pulse Energy system provided for the facility for 2012-2015
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.

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.

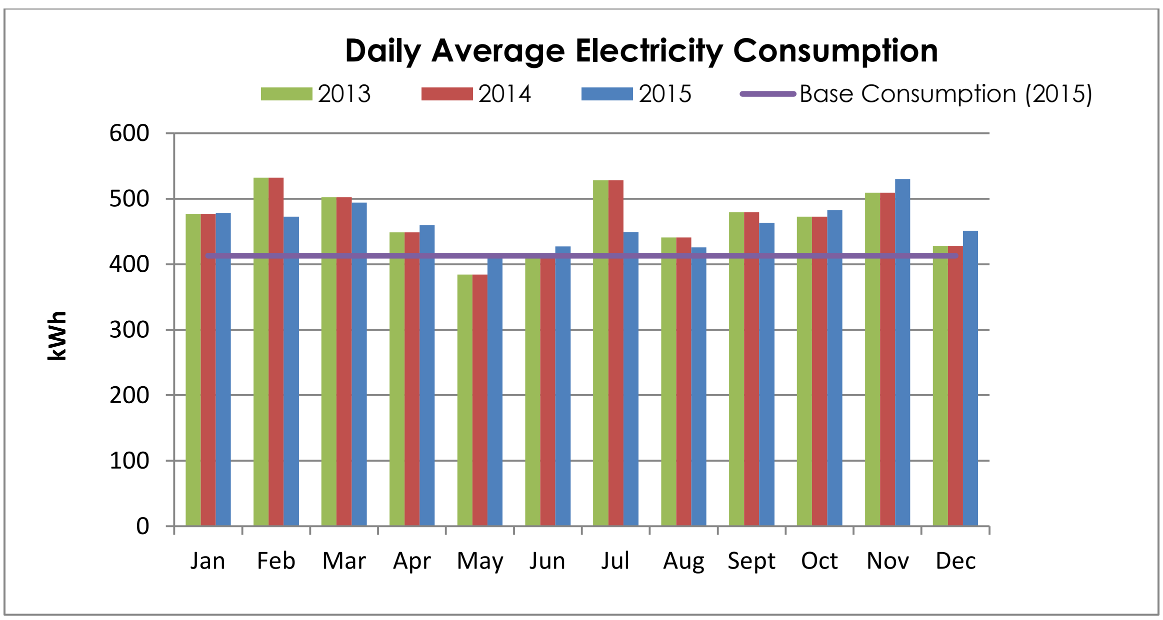


Figure 3.1 Average Daily Non-Heating Electricity Consumption for 2012–2015

The daily lowest electricity consumption in 2015 for the facility is 413kWh 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. Slight increases in electricity consumption during summer periods can be attributed to the operation of the RTU DX cooling systems.

Total electricity consumption has remained relatively consistent in the reporting period 2012-2015 (see table below). The following energy conservation measures have been implemented by TRU to maximize efficiency[4]:

- HVAC override controls installed and ventilation scheduling systems have been installed.
- T12 lamps and ballasts replaced with higher efficiency T8 models.

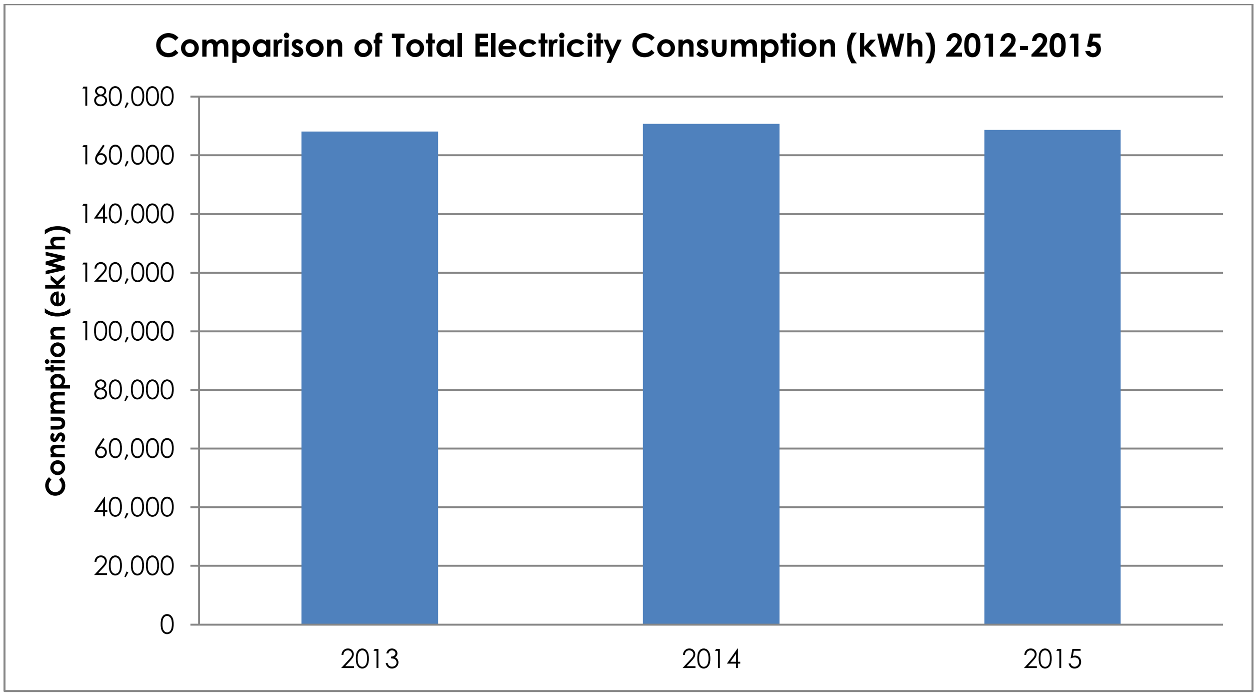


Figure 3.2 Total Electricity Consumption Comparison 2012-2015

3.1.2 Electricity Demand

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

- Greater occupancy numbers during term time
- DX cooling in Summer & extended hours of lighting operation in winter

The lowest monthly electricity demand in 2015 occurs in June, and was 31kW. This also correlates with the electricity consumption profile.

[4] https://www.tru.ca/sustain/initiatives/Energy_Efficiency_at_TRU/aht.html

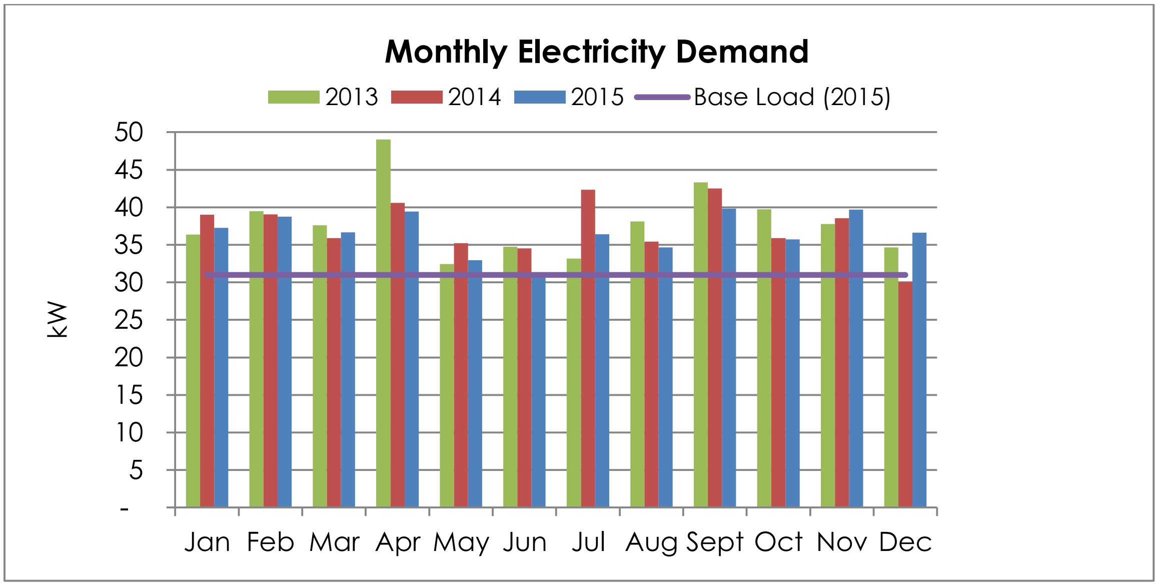


Figure 3.3 Building Demand Profile (2013-2015)

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.

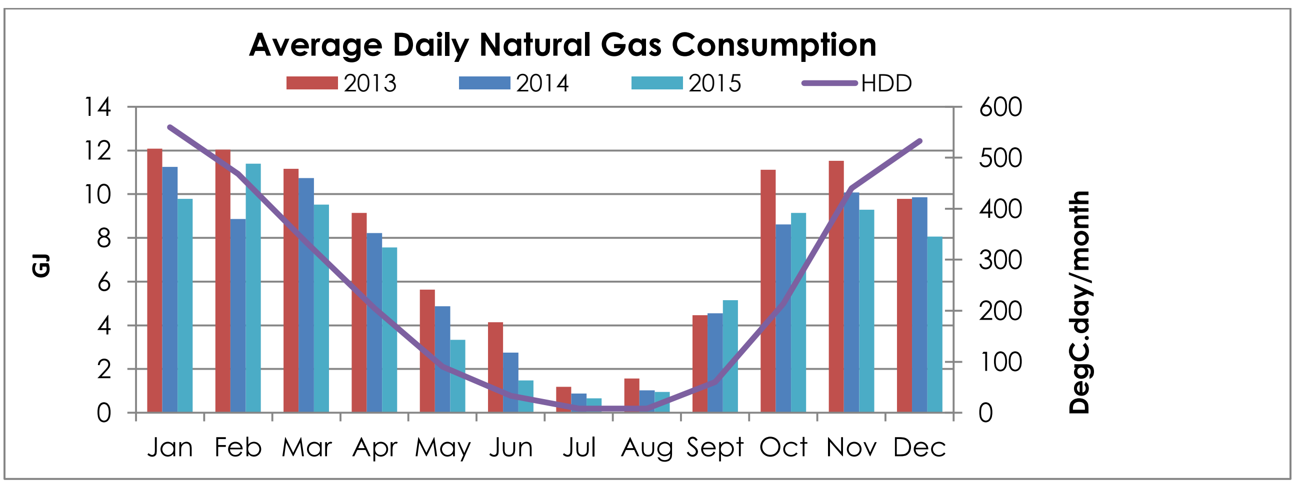


Figure 3.4 Average daily Natural Gas consumption and heating degree-days (2013–2015)

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 February at 11 GJ/day with summer base load of around 1 GJ/Day. Consumption of 1GJ/Day in June-August 2015 can be attributed to the domestic hot water loads in the building.

Total natural gas consumption has decreased almost 19% in the 2013-2015 reporting period. This may in part be attributed to the following energy retrofits implemented by TRU:

- HVAC override controls installed and ventilation scheduling systems have been installed.

Table 8 Comparison of Natural Gas Consumption

Year	Total Annual Natural Gas Consumption (GJ)	Yearly Deviation
2013	2,844	-
2014	2,481	-13%
2015	2,309	-7%
Total Reduction 2013 - 2015		-19%

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 Animal Health building;

Table 9 BEPI for Animal Health Building

	Electricity Cons. (kWh)	Electricity Cost ($)	Natural Gas Cons. (GJ)	Natural Gas Cost ($)	Total ekWh	Total Cost[5]	GHG Emissions (tonnes)	BEPI $kWh/m^2/yr$
Existing	168,706	13,500	2,309	23,100	810,065	39,600	120	686

Analysis of the building energy use intensity reveals that it exceeds the average for a building of this type. In particular, natural gas consumption is very high. This can be attributed to the 24/7 operation of the roof top units.

[5] 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. Natural gas consumption is four times greater than electricity consumption at the facility and it this consumption which drives the large energy use intensity. Typical education buildings have closer to a fifty/fifty split between electricity and natural gas, confirming that natural gas at this building is irregular.

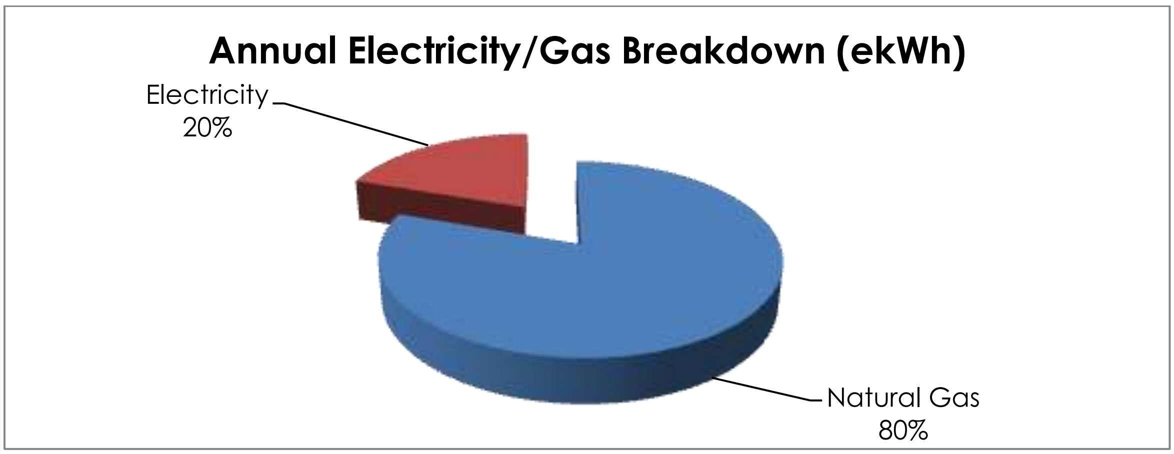


Figure 3.5 Breakdown of Energy Consumption by Fuel type

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/processes are lighting and ventilation/cooling which accounts for almost 75% of total building electricity consumption.

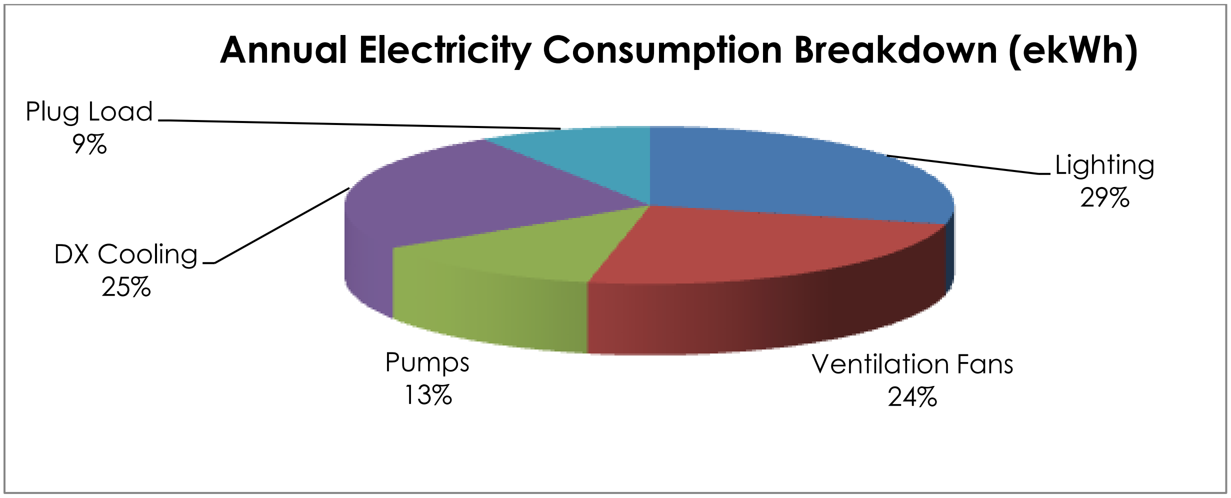


Figure 3.6 Breakdown of Electricity Consumption in kWh (2015)

3.2.3 Natural Gas (Heating)

Building heating constitutes the largest portion of the building natural gas load. This profile is not surprising given the winter climate in Kamloops, however there may also be significant opportunities to reduce the building heating load through implementation of energy conservation measures. Natural gas fired rooftop units satisfy the ventilation related heating demand, with skin loads provided by the natural gas boiler.

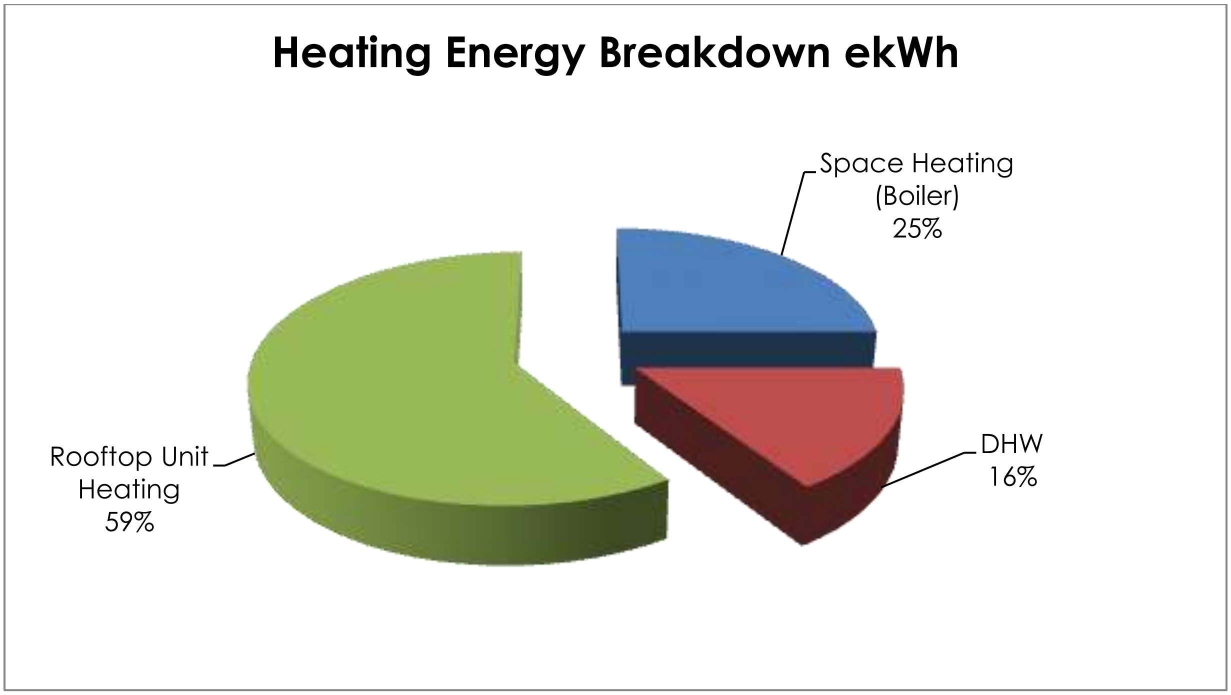


Figure 3.7 Natural Gas End Use Profile (2015)

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 1 – REPLACE EXISTING "BURNHAM" BOILER & A.O. SMITH DOMESTIC WATER HEATER WITH CONDENSING BOILER

The animal health building incorporates a 399MBH domestic hot water heater and 528MBH boiler. The boiler serves the radiant heating system and under-floor heating in the kennels.

It is proposed that the existing "Burnham" boiler be replaced with two condensing boilers and a brazed heat exchanger for DHW. 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 as the in-slab heating will return at optimal condensing temperatures (~40°C).

4.1.1 Scope of Work

It is proposed the existing boiler and DHW heater 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, however it is estimated that two (2) 500MBH boilers will be sufficient. During initial investigation, the option to use space heat return water to pre-heat DHW was reviewed. However, due to the relatively low hot water consumption at Animal health, this opportunity was deemed to be uneconomic.

Outline	Description
Baseline equipment	There is currently a "Burnham" natural gas boiler in operation to provide building heating, and an A.O. Smith natural gas water heater to provide domestic hot water.
Upgrade Description	It is proposed that the existing boiler & water heater be decommissioned and replaced with two condensing boilers and heat exchanger.
Affected area in building	The existing boilers are located in the ground floor boiler room.
Service life	The estimated service life of the condensing boilers will be 25-30 years.
Non energy benefits	Implementation of this measure will reduce greenhouse gas emissions from space heat.
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.

4.1.2 Methodology of Savings Calculations

Savings have been based on an Improvement in building heating and domestic hot water boiler efficiency from 80% to 93% using condensing boilers.

4.1.3 Cost, Saving and Payback

A summary of anticipated costs and savings are as follows:

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 217,900
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 3,189
PAYBACK (years)	68.3

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 – ROOFTOP UNIT REPLACEMENT

The eight existing gas fired rooftop units (RTUs) are indirect gas heating and DX (electric) cooling types. They have been in operation since the building was occupied in 2002. It is estimated that they are operating with a thermal (heating) efficiency of 79% and they have an average nameplate cooling energy efficiency ratio (EER) of 9.2.

It is proposed that the existing units be replaced with high efficiency units that typically operate with a thermal (heating) efficiency of around 81% and EER of at least 12.0. Additionally, it is recommended that solar PV panels be integrated with the rooftop unit installation to generate electricity for cooling during summer conditions. If implemented, this would decrease electricity consumption and demand for the building.

4.2.1 Scope of Work

Outline	Description
Baseline equipment	Six Lennox rooftop units and two engineered air makeup air units. Units are indirect fired natural gas heated and DX cooled.
Upgrade Description	It is proposed that the rooftop units be replaced with equivalent units. Lennox “Energence” units as an example offer improved performance and could be replaced on a one to one basis. These units also have the ability to incorporate solar PV panels, which generate electricity to offset cooling demand and consumption.
Affected area in building	The affected units are located on the building roof.
Service life	25 years
Non energy benefits	Non energy benefits will include improved control.
Risk assessment	This is a low risk retrofit.

4.2.2 Methodology of Savings Calculations

On comparison of heating efficiencies for the existing and proposed new rooftop units, there are natural gas savings potential by replacing the existing units. The existing units have a nameplate efficiency of 79%, while the new units will have an average efficiency of 81%.

There are considerable savings potential from the cooling system. The existing units EER ratings range from 8.8 to 9.6. The new units have an EER rating of 12.0 to 12.6. This equates to an almost 30% savings potential for the RTU DX system.

Additional Opportunities:

It is proposed that the replacement units integrate solar PV technology, such as the Lennox Energence units. If implemented, this measure will offset electricity consumption, and also demand, especially during peak cooling periods.

4.2.3 Cost, Saving and Payback

The anticipated savings are as follows:

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$627,300
TOTAL SAVINGS	$5,433
PAYBACK (years)	**115**

4.2.4 Impact on Operations and Maintenance

There will be a reduced O&M demand with the installation of new rooftop units.

4.2.5 Risk Analysis

When solar modules are covered by snow, they do not receive sunlight and will not generate solar power. If solar modules should be installed, they should be erected at an angle to allow the snow slide down. In the event of accumulation, the snow will need to be brushed off to get solar power.

4.3 ECM 3 – REVISE ZONE CONTROL PARAMETERS

The Animal Health building has isolation room spaces that are maintained continuously at 24°C. A common rooftop unit (RTU-1) serves the isolation rooms and adjacent office spaces and as such, there is no capacity to set back office room temperatures during unoccupied periods.

There is a significant potential to reduce energy consumption in these zones by providing a dedicated rooftop unit to serve the isolation room, thereby permitting setback in adjacent spaces.

4.3.1 Scope of Work

The scope of work will comprise installation of a new roof top unit to supply tempered air to the isolation room. In addition, temperature set back will be implemented in the office spaces.

Outline	Description
Baseline equipment	The space is currently serviced using roof top unit RTU-1.
Upgrade Description	It is proposed that an additional rooftop unit be installed (RTU-9) to service the isolation room. Once installed, office spaces and multi-use spaces can be re-programed to provide setback during non-operating hours.
Affected area in building	The east perimeter offices will be impacted directly. North perimeter offices and multi-use spaces may also be set back.
Service life	Estimated service life will be 25 years.
Non energy benefits	Setting back equipment will reduce run time thereby saving on maintenance costs
Risk assessment	There are no technical risks to implementing this measure.

4.3.2 Methodology of Savings Calculations

Calculated savings have been estimated by implementing set back in the east perimeter area from 24 °C to 18 °C for the period 6 PM to 6 AM during winter / should season conditions.

4.3.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 74,500
TOTAL SAVINGS	$ 9,011
PAYBACK (years)	8.8

4.3.4 Impact on Operations and Maintenance

The installation of a new roof top unit will have minimal impact on operations and maintenance.

4.3.5 Risk Analysis

This is a relatively low risk energy conservation measure.

4.4 ECM 4 – INSULATE HOT WATER/ DHW DISTRIBUTION PIPEWORK

During the site visit the Stantec engineers noted that the much of the hot water distribution pipework in the boiler room was un-insulated or the current insulation was in disrepair. This has resulted in a significant amount of heat loss to the room.

It is recommended that all HW pipework undergo an insulation retrofit.

4.4.1 Scope of Work

Outline	Description
Baseline Equipment	Existing hot water pipework is missing insulation in many areas, and some pipework which is insulated is seeing the insulation fail and tear away.
Upgrade Description	It is proposed the all hot water pipework undergo an insulation retrofit. Insulation should be fibre-glass pipe wrap

	with install thickness based on pipe diameter.
Affected Area in Building	Boiler/Mechanical Room
Service Life	20 years
Non Energy Benefits	Improved temperature conditions in the boiler room for maintenance staff.
Risk Assessment	There is minimal risk associated with the implementation of this measure.

4.4.2 Methodology of Savings Calculations

Energy savings have been calculated given a reduction in heat loss through hot water pipework.

4.4.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$5,700
TOTAL SAVINGS	$970
PAYBACK (years)	5.9

4.4.4 Impact on Operations and Maintenance

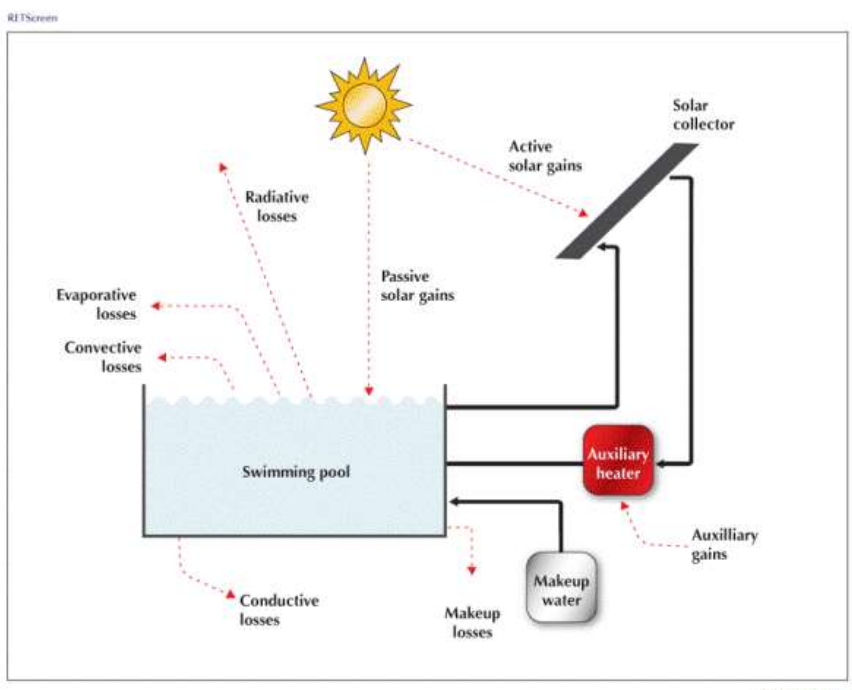
Implementation of this measure will not have an impact on building operations and maintenance.

4.5 ECM 5 – 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.



[6]

The Animal Health 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 March to October, there is a

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

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

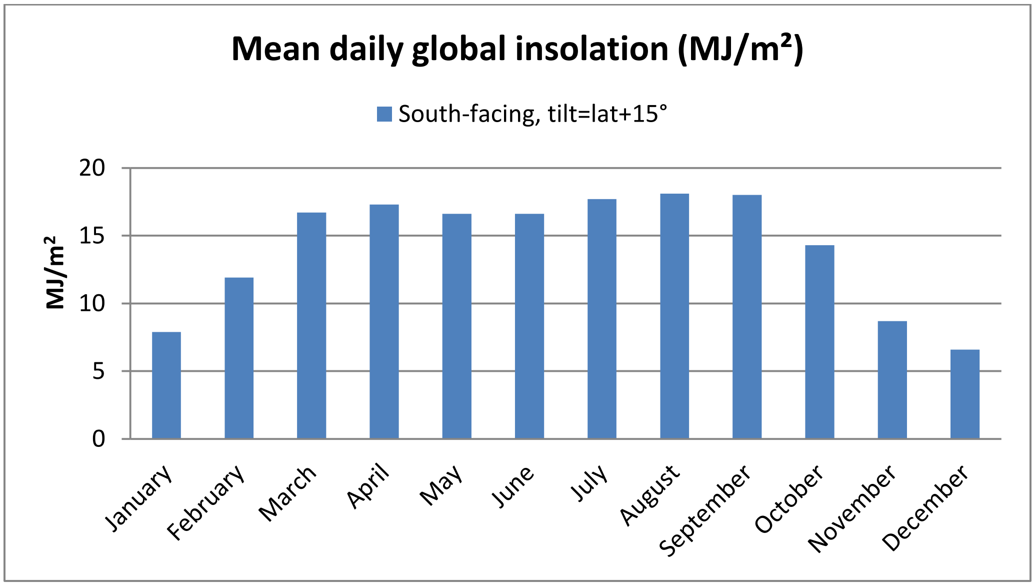


Figure 4.1 Graph of Solar Radiation in Kamloops BC

4.5.1 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. It will involve the installation of a collector on the roof of the facility and a pre-heat storage tank installation in the ground floor boiler room. This could serve as preheat for the condensing boiler retrofit outlined in ECM-1.
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 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.

4.5.2 Methodology of Savings Calculations

Savings have been calculated by performing a RETScreen analysis.

4.5.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$62,700
TOTAL SAVINGS	$1,040
PAYBACK (years)	60

4.5.4 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.

4.5.5 Risk Analysis

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

4.6 ECM 6 – INSTALL SOLAR PHOTOVOLTAIC SYSTEM

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

It 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.

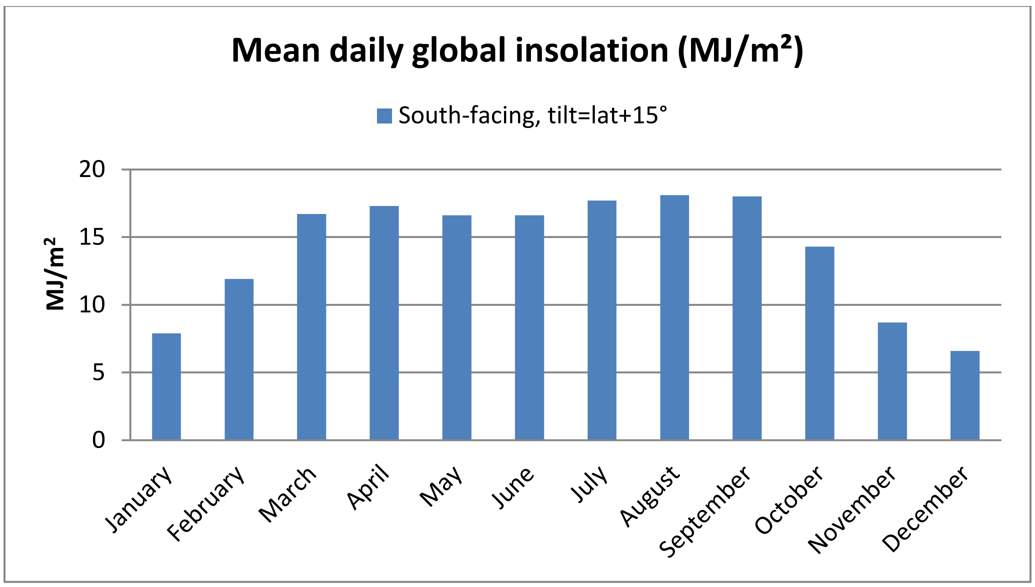


Figure 4.2 Graph of Solar Radiation in Kamloops BC

4.6.1 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.

4.6.2 Methodology of Savings Calculations

Savings have been calculated by performing a RETScreen analysis.

4.6.3 Cost, Saving and Payback

The anticipated savings are as follows;

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

4.6.4 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.

4.6.5 Risk Analysis

This is a relatively low risk energy conservation measure.

5.0 BUILDING MANAGEMENT AND BEHAVIORAL OPPORTUNITIES

5.1 FURTHER UPGRADES

Other than the proposals outlined in this report, there are no upgrades being planned for this facility at this time.

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 the City of Victoria. 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.

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	Boiler Upgrade	132	$ 1,316	-	$ -	-	$ -	$ 198,536	$ 1,481	134.1	6.6
ECM 2	Rooftop Unit Replacment	352	$ 5,433	18,451	$ 1,476	-	$ -	$ 627,300	$ 5,433	115.5	18.1
ECM 3	Revise Zone Control Paramters	901	$ 9,011	-	$ -	-	$ -	$ 78,970	$ 9,011	8.8	45.1
ECM 4	Pipework Insulation	54	$ 970	-	$ -	-	$ -	$ 5,700	$ 970	5.9	2.7
ECM 5	Install Solar Hot water Heater	104	$ 1,040					$ 62,700	$ 1,040	60.3	5.2
ECM 6	Install Solar PV System			219,000	$ 17,520	25	$ 3,489	$ 98,100	$ 21,009	4.7	5.7
TOTAL		**1,543**	**17,769**	**237,451**	**18,996**	**25**	**3,489**	**1,071,306**	**38,943**	**28**	**83**

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	168,706	13,500	2,309	23,100	810,065	39,600	120	686
Reference Building (Educational Services)								280
Post retrofit	150,255	$12,020	1,771	$17,713	642,285	$29,733	42	544
Savings	11%	11%	23%	23%	21%	25%	65%	21%

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 120 tonnes/year[7].

Table 12 Emissions Reductions Associated with the ECMs Recommended

EMISSIONS REDUCTIONS						
	Electricity		Natural Gas		Total	
Total Energy Saved	237,451	kWh/yr	1,543	Gj	665,960	ekWh
Total CO_2e Emissions Saved	6	tonnes/yr	77	tonnes/yr	83	tonnes/yr

The emissions savings projection of 35 tonnes per year equates to approximately 29% of current GHG emissions.

[7] 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 its Animal Health facility 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 involved 1,180m^2 (gross) of building and 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

Mechanical & Electrical Measures		Measure	Recommended for Implementation
	ECM 1	Implement Boiler Upgrade (incld. Repiping)	✓
	ECM 2	Replace Rooftop Units	✓
	ECM 3	rezone isolation room HVAC	✓
	ECM 4	Insulate Hot Water/ DHW Distribution Pipework	✓
	ECM 5	Install Solar Water Heater	✓
	ECM 6	Install Solar PV System	✓

It is anticipated that should all of the selected measures be implemented, there would be annual savings in utilities of approximately $41,000 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 91 tonnes (equivalent to around 71% of current emissions).

Total Investment	Total Cost Savings	Payback	Total Natural Gas Savings (GJ)	Total Electricity Savings (kWh)	CO2 Reduction (Tons)
$1,090,000[8]	$40,651	27	1,694	237,000	91

[8] 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;
- Lighting energy conservation measures were not included in the scope of work
- 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.

Appendix A CONTACT DETAILS

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Appendix B UTILITY CONSUMPTION (2011 – 2013)

	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	374	31	12	349	31	11	303	31	10
Feb	337	28	12	248	28	9	319	28	11
Mar	346	31	11	333	31	11	295	31	10
Apr	274	30	9	247	30	8	227	30	8
May	175	31	6	151	31	5	103	31	3
Jun	124	30	4	83	30	3	44	30	1
Jul	37	31	1	27	31	1	20	31	1
Aug	49	31	2	32	31	1	30	31	1
Sept	134	30	4	137	30	5	155	30	5
Oct	345	31	11	267	31	9	283	31	9
Nov	346	30	12	303	30	10	279	30	9
Dec	303	31	10	306	31	10	250	31	8
Total	**2,844**			**2,481**			**2,309**		

	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	14,391	31	464	14,789	31	477	14,838	31	479
Feb	13,320	28	476	14,900	28	532	13,226	28	472
Mar	14,729	31	475	15,574	31	502	15,323	31	494
Apr	14,737	30	491	13,465	30	449	13,802	30	460
May	13,063	31	421	11,905	31	384	12,813	31	413
Jun	11,995	30	400	12,484	30	416	12,811	30	427
Jul	14,230	31	459	16,374	31	528	13,924	31	449
Aug	13,355	31	431	13,663	31	441	13,202	31	426
Sept	14,593	30	486	14,386	30	480	13,895	30	463
Oct	15,099	31	487	14,650	31	473	14,972	31	483
Nov	15,257	30	509	15,279	30	509	15,910	30	530
Dec	13,401	31	432	13,273	31	428	13,990	31	451
Total	**168,170**			**170,742**			**168,706**		