Thompson Rivers University Clock Tower Building Energy Assessment

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Sign-off Sheet

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Kenney McNamee

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Executive Summary

Thompson Rivers University (TRU), commissioned Stantec to conduct a detailed energy assessment at its Clock Tower 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 2,980m^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 $9,000 at a rate of $10.00 GJ for natural gas and $0.08 per kilowatt hour for electricity and a reduction in GHG emissions of around 12 tonnes (equivalent to around 29% of current emissions).

Total Investment	Total Cost Savings	Payback (Years)	Total Natural Gas Savings (GJ)	Total Electricity Savings (kWh)	CO_2 Reduction (Tons)
$602,000[1]	$8,550	70	203	65,000	12

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/m^2/yr)**
Existing	270,506	$21,640	1,019	$10,185	553,431	$33,277	58	186
Reference Building (Academic) 280								
Post Retrofit	205,636	$15,118	815	$8,154	432,125	$23,271	46	145
Savings	24%	30%	20%	20%	22%	30%	20%	22%

[1] Total investment is total material & labour cost

Mechanical & Electrical Measures		Measure	Recommended for Implementation
	ECM 1	Replace Lecture Theatre Rooftop Unit	✓
	ECM 2	Implement Demand Control Ventilation – Fans F1 & F2	✓
	ECM 3	Replace Existing Chiller	×
	ECM 4	Install Premium Efficiency Motors	✓
	ECM 5	Implement DDC Upgrade& Optimimisation	✓
	ECM 6	Implement Solar Hot water 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	Theatre RTU Replacement	16	$ 159	10,974	$ 878	5	$ 716	$ 179,700	$ 1,753	102.5	1.1
ECM 2	DCV for F-1 & F-2	94	$ 941	25,598	$ 2,048	-	$ -	$ 29,400	$ 2,989	9.8	5.4
ECM 3	Replace Chiller	-	$ -			-	$ -				-
ECM 4	Motor Efficiency	-	$ -	10,554	$ 844	4	$ 617	$ 63,500	$ 1,461	43.5	0.3
ECM 5	DDC Upgrade	93	$ 931	17,743	$ 1,419	-	$ -	$ 329,500	$ 2,350	140.2	5.1
ECM 6	Solar DHW			-	$ -	-	$ -				-
TOTAL		**203**	**2,032**	**64,870**	**5,190**	**10**	**1,333**	**602,100**	**8,554**	**70**	**12**

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 Clock Tower 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 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

1.1.2 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]

1.1.3 Acknowledgements

Stantec would like to acknowledge the contribution of Thompson 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

Item	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 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 9.

[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 Clock Tower building was originally built in 1989 and underwent a mechanical system upgrade in 1993. The building is comprised of four storey structure with a gross floor area of 2,975m². The building gets its name from the clock tower, an architectural feature incorporated in the building.

The building is home to Alumni Theatre lecture hall, Journalism labs, TRU senior administration, TRU Research Innovation & Graduate Studies, Institutional Planning & Analysis, and the office of Advancement.

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	2,975	m²
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 & Clock Tower 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

The building is constructed on slab on grade. Construction appears to be of non-combustible design including steel stud, metal and stucco cladding and aluminum double glazed windows. Typical thermal performances in buildings of this vintage include:

- R-20 Walls
- R-38 Roof
- U 0.5 Windows
- R-10 Below Grade

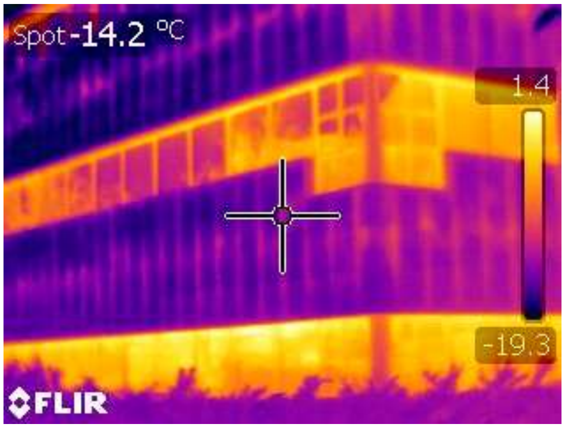
A summary of building envelope components is presented below.

Table 4: Building Envelope Descriptions

Assembly	Description	Image
Building Envelope	Construction appears to be of non-combustible design including steel stud, brick cladding stucco.	
Fenestration	Building fenestration comprises double glazed units. Window and door systems are typically constructed in aluminum frame with the majority of windows inoperable.	

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. Thermal scan of clock tower walls reveals extensive ghosting highlighting thermal bridging at steel stud locations. Upgrades to building enclosures generally are not cost effective. Should replacement of the cladding be considered in future it is recommended to implement a cladding system with improved thermal performance.



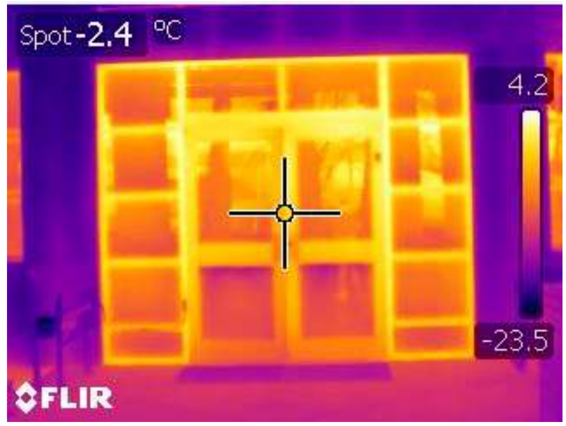


Figure 2.3: Thermographic Inspection of Envelope & Fenestration

2.3 LIGHTING

Building lighting was not in the scope of this study.

2.4 MECHANICAL SYSTEMS

2.4.1 Ventilation

Two primary air handling systems provide ventilation, heating and cooling to the Clock Tower. F-1 is located on the 4th floor and serves the third and fourth floors and F-2 is located on the first floor and serves levels one and two. Outdoor and return air are drawn to the mixing section by the fans, conditioned, filtered and distributed to the building through a series of ductwork which terminate at ceiling mounted diffusers. Variable Air Volume (VAV) terminal boxes located in the supply ductwork vary supply air volume to maintain space temperature setpoints. Airflow to each floor is regulated by a static pressure controller and VAV box to maintain a minimum static pressure in the duct. Return air is drawn through ceiling mounted return grilles and ducted back to the air handler mixing section to maintain effective air balance.

In addition to F1 & F2, an 8,000 CFM rooftop unit (RTU-1) is installed to serve the alumni theatre lecture hall. Programmable thermostats located in the theatre provide control for the RTU.

Table 5: Ventilation System Inventory

Unit	Location	Service	Motor Size (HP)	Capacity (CFM)[4]
F-1	4th Floor Mech. Room	3rd & 4th Floors	10	3,000
F-2	1st Floor Mech.	1st & 2nd Floors	10	3,000

[4] From balancing report

	Room			
RTU-1	Roof	Alumni Theatre	5	8,000

On review of air handling operation schedule with building operations, it was noted that the ventilation system is typically programmed to operate 8am – 6pm daily.

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. Exhaust fan EF-1 provides general exhaust and is interlocked with air handling unit F-1. All other exhaust fans are manually controlled by either a wall switch of a speed controller.

Unit	Location	Service	Motor Size (HP)	Capacity (CFM)
EF-1	Roof	General Exhaust	1.0	6300
EF-2	Roof	Lecture Exhaust	0.5	2100
EF-3	Roof	Stage Exhaust	0.3	1000
EF-23	Roof	Electrical Room	0.1	224
Additional Fans	Throughout the facility	Washrooms, staff rooms, etc.	-	-

2.4.2 Heating

On site heating is generated using two 'Thermal Solutions' condensing natural gas boiler and a gas fired rooftop unit.

The boilers have each a specified gross input of 1,000MBH and a nameplate efficiency of 88%. The boiler plant was upgraded in 2012 to condensing units. Circulating pump P-3 serves the third and 4th floors, P-5 serves the first and second floor while P-4 serves as a stand-by unit. Heating water is supplied to wallfin radiation and radiant ceiling panels in the building to satisfy thermal comfort requirements.

The Lennox RTU incorporates natural has heating and serves the lecture theatre. It has a capacity of 370MBH with an estimated efficiency of 80%.

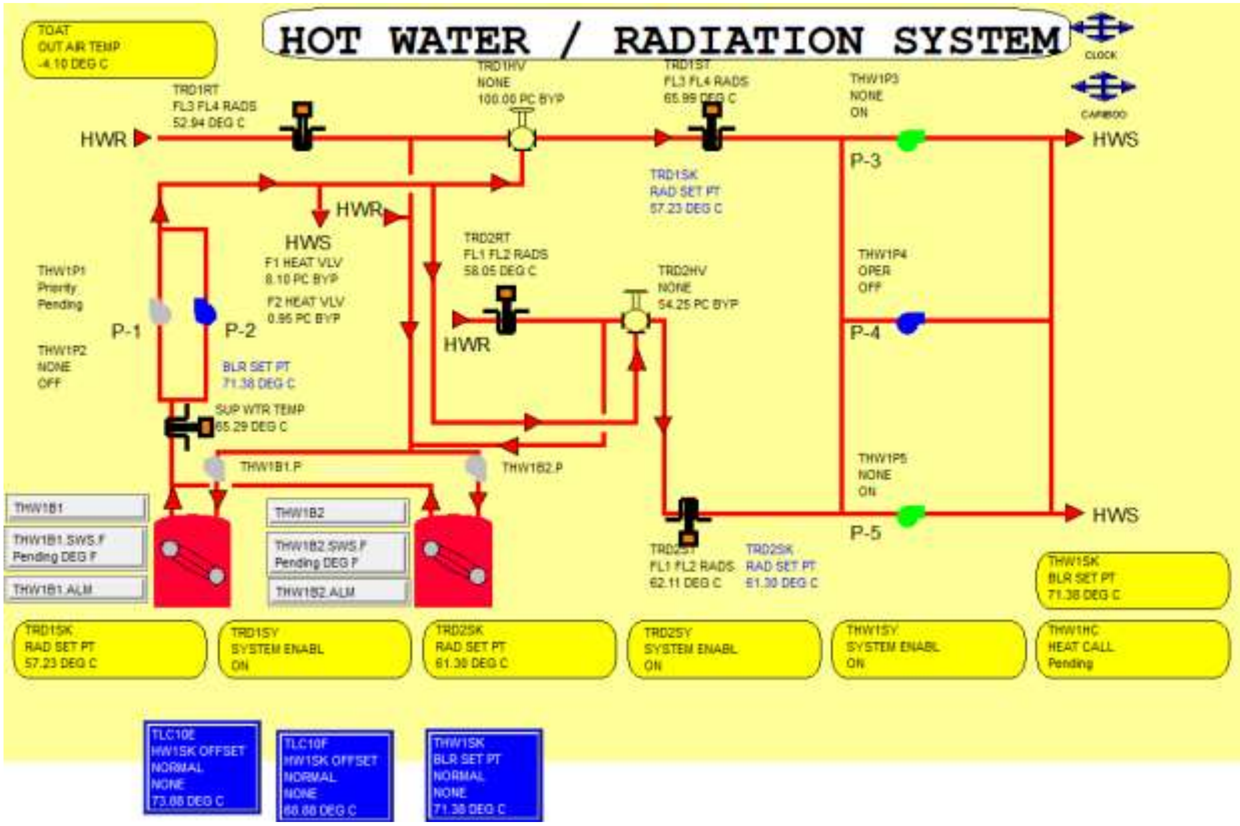


Figure 2.4: Hot water Radiation System – DDC Controls Graphics

Figure 2.5: Hot water boilers and hot water distribution pumps

Table 6: Boiler Specification

Manufacturer	Model Number	Input (MBH)	Output (MBH)	Rated eff.	Manufactured
Thermal Solutions	EVA-1000	1,000	880	~88%	2012

2.4.1 Domestic Hot Water

Domestic Hot Water at the facility is generated by three "A.O Smith" 1.5kW electric domestic hot water heaters. The DHW heaters comprise a 15 Gallon storage capacity, heated using a single element.

2.4.2 Cooling

One packaged "McQuay" chiller (CH-1) and four pumps (P-6, P-7, P-8, P-10) provide chilled water to cooling coils in the air handling units. The packaged chiller is equipped with an integral control panel to satisfy temperature set point.

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 theatre rooftop unit. Compressed air is utilized to operate the controls hardware (dampers etc.).

Figure 2.6: Theatre Rooftop Unit – DDC Graphic & compressed air damper actuator

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 incoming feed is 480V.

There is a single 1500kVA incoming BC Hydro supply service to the building. Electrical transformers located on site convert incoming supply voltage to 208/120V. The majority of the 208V panel boards will be replaced as part of upcoming electrical retrofit works.

2.5.2 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:

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 through the radiant system, RTU and AHU heating coils.
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.

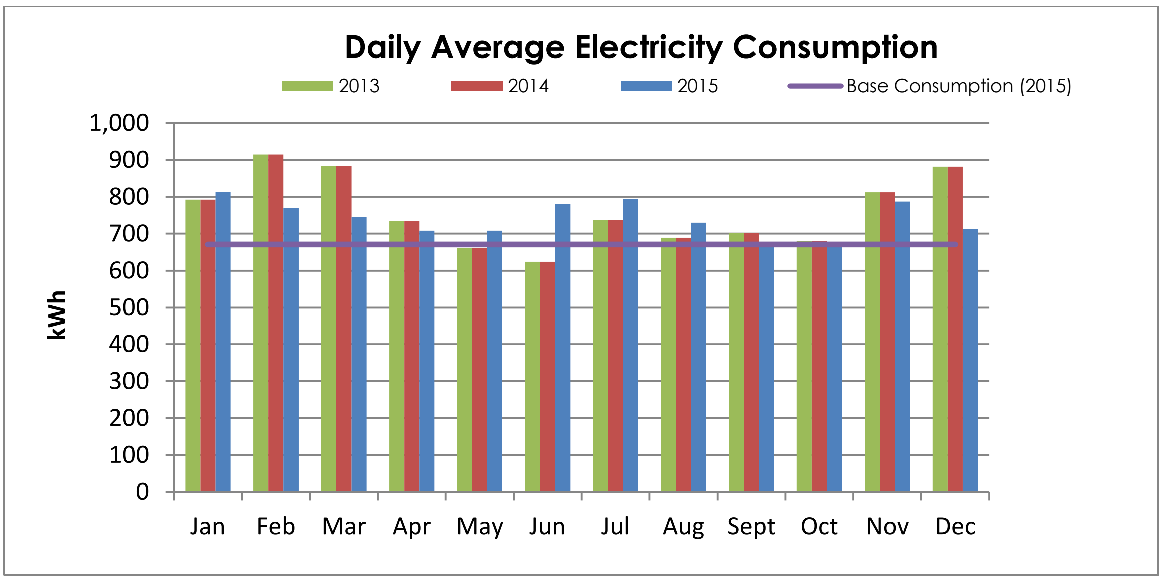


Figure 3.1: Average daily non-heating electricity consumption for 2012–2015

The daily lowest electricity consumption in 2015 for the facility is 671kWh and occurs in October. 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 and central 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[5]:

- Demand controlled ventilation systems installed to provide on-demand ventilation depending on occupancy levels (judged by carbon dioxide content in air) for the Clocktower Theatre
- Ventilation schedules have been better aligned with building occupancy schedules
- T12 lamps and ballasts have been replaced with higher efficiency models

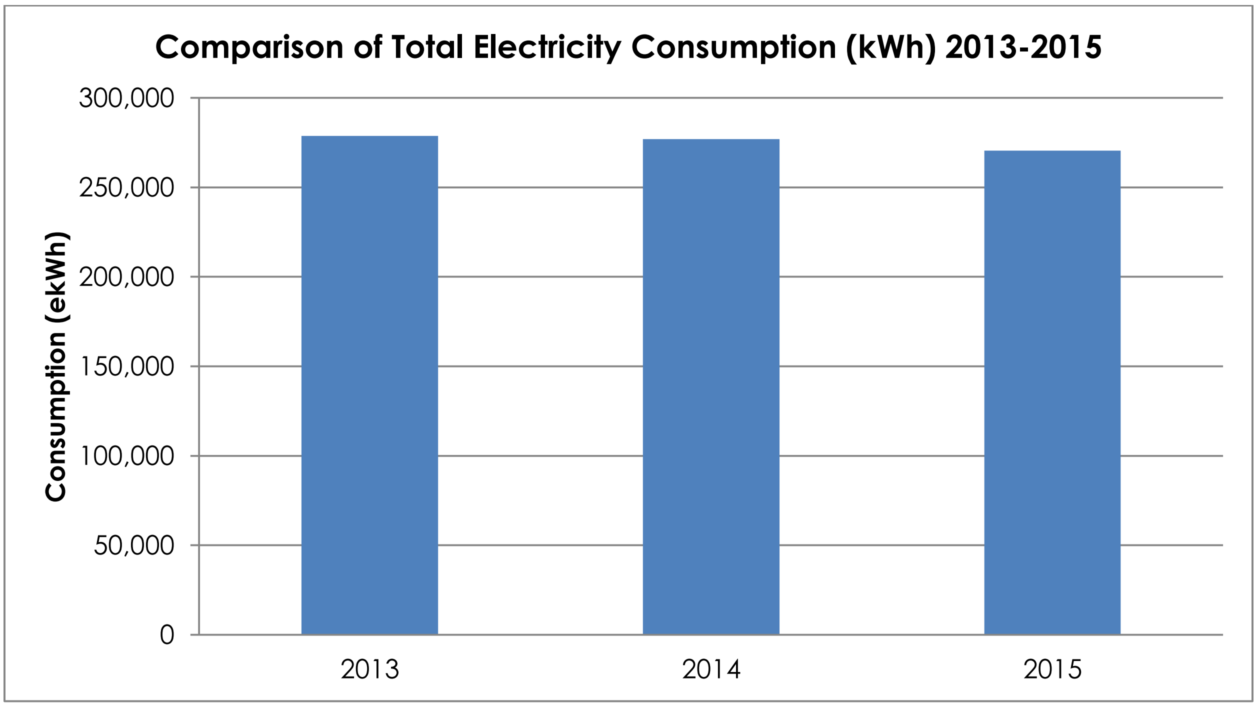


Figure 3.2: Total electricity consumption comparison 2012-2015

3.1.2 Electricity Demand

Demand data was extracted from the 'Pulse Energy' website and the data illustrates increased demand during the summer period. This can be explained by the operation of the cooling systems during summer. The lowest monthly electricity demand in 2015 occurs in March, and was 60kW.

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

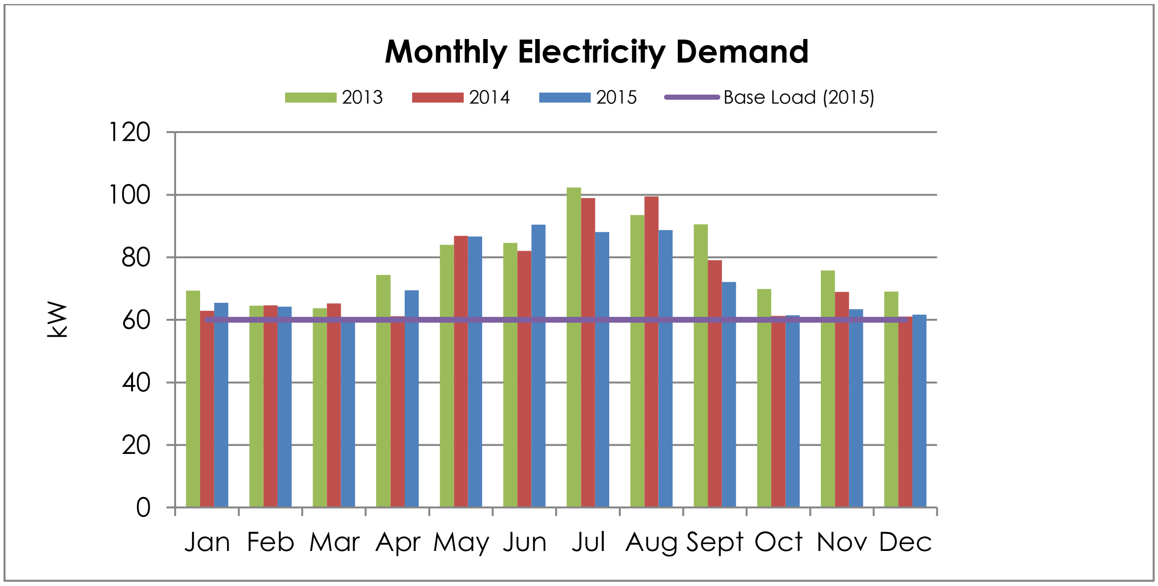


Figure 3.3: Building Demand Profile (2013-2015)

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.

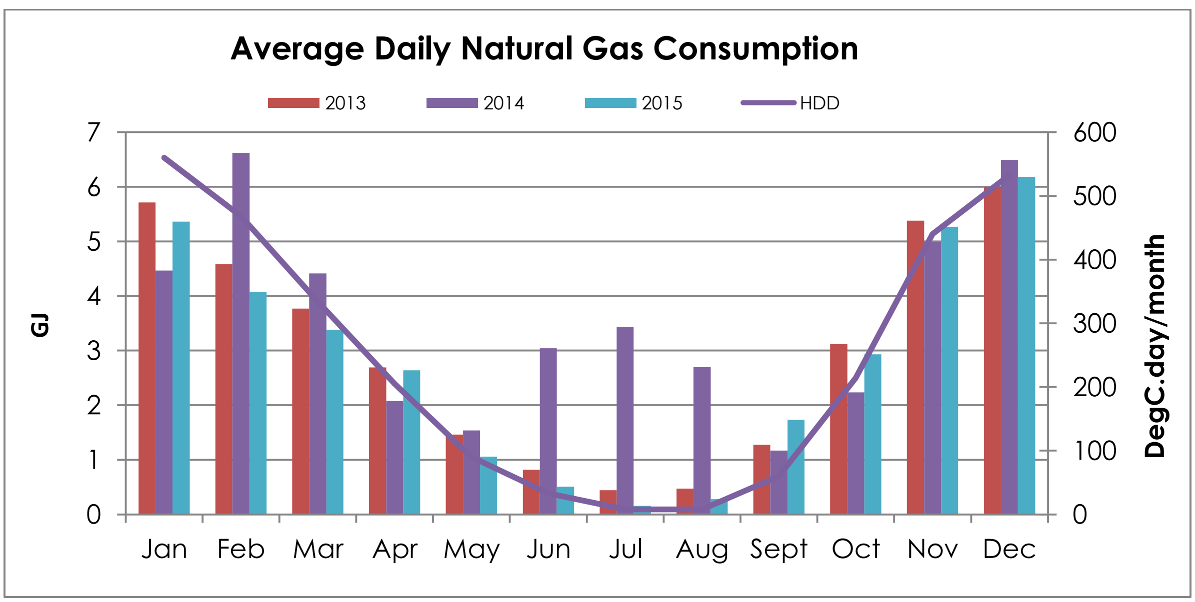


Figure 3.4: Average daily Natural Gas consumption and heating degree-days (2013–2015)

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. As domestic hot water loads are satisfied using electric hot water heaters, there is minimal natural gas consumption during summer periods. An anomalous consumption profile was noted from June – August 2014. It was not obvious as to what caused this increased consumption as the buildings operation staff were not aware of any operational changes during this time.

Peak consumption in 2015 was recorded in February at 6 GJ/day with summer base load of less than 0.5GJ/Day. Total natural gas consumption increased by almost 20% between the 2013 & 2014 reporting period. This can be attributed to greater than expected consumption in February, March & June – August 2014. This performance was then improved in 2015 when natural gas consumption dropped by 22%. On consultation with TRU operations staff, the reason for this deviation could not be determined.

Table 7: Comparison of Natural Gas Consumption

Year	Total Annual Natural Gas Consumption (GJ)	Yearly Deviation
2013	1,083	-
2014	1,307	+20%
2015	1,019	-22%

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 8 below indicates the current measured energy consumption for the Clock Tower building;

Table 8: BEPI for the Clock Tower 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/m²/yr
Existing	270,506	21,640	1,019	10,185	553,431	57,289	58	186

[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 in this building.

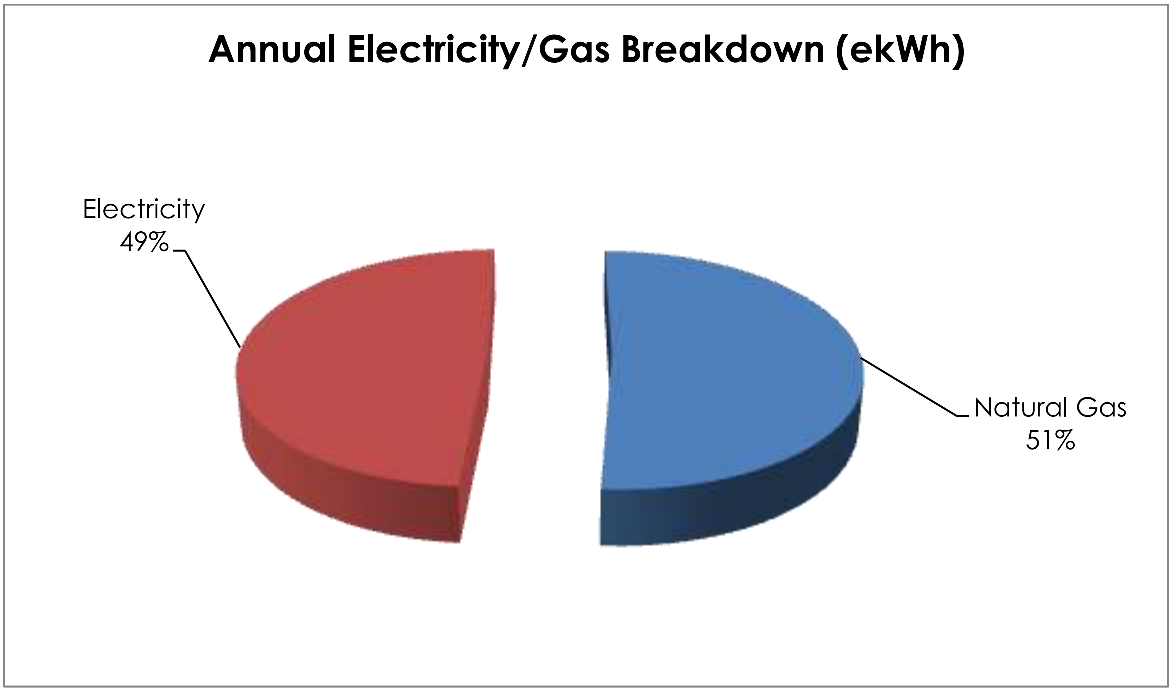


Figure 3.5: Breakdown of Energy Consumption by Fuel type

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 **Error! Reference source not found.**. The largest lectrical consuming equipment/processes are lighting and ventilation which accounts for almost 60% of total building electricity consumption.

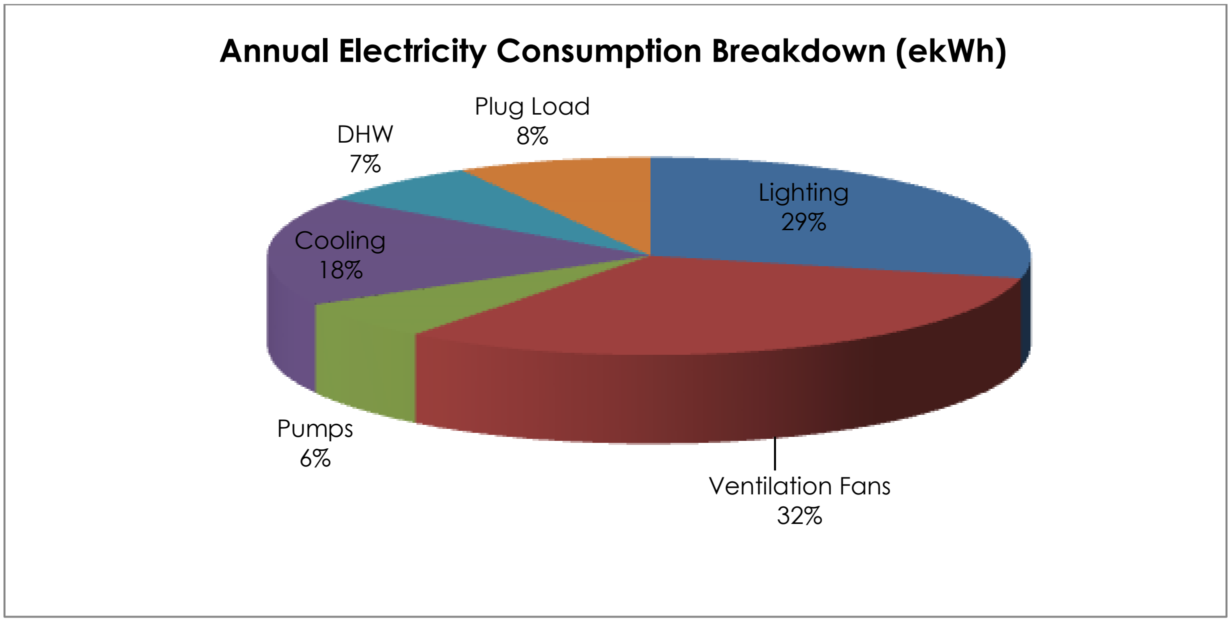


Figure 3.6: Breakdown of Electricity Consumption in kWh (2015)

3.2.3 Natural Gas (Heating)

Building heating is the sole consumer of natural gas at this facility. The rooftop unit consumes approximately 16% of total natural gas load, with the remaining natural gas consumption being driven by the condensing boilers.

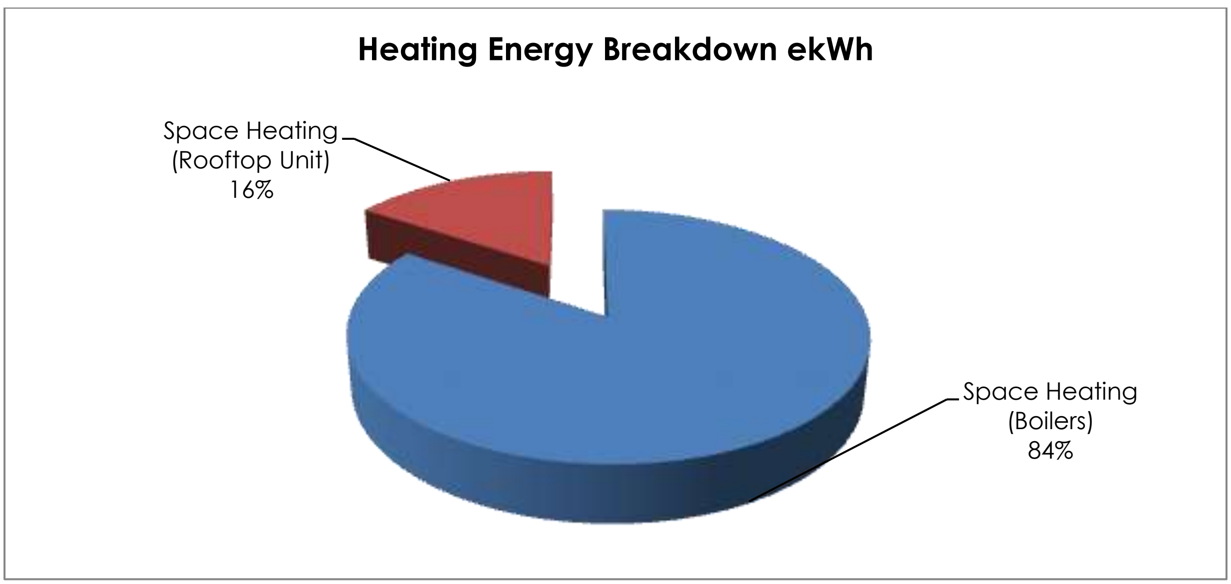


Figure 3.7: Natural Gas End Use Profile (2015)

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 – INSTALL NEW ROOFTOP UNIT

A rooftop unit is installed on the roof of the Clock Tower building and serves the Lecture Theatre. The unit provides outdoor air and DX cooling to the lecture theatre to maintain temperature and ventilation requirements.

The unit is typically operational from 8am to 6 pm from Monday to Friday. It is assumed that the unit operates with a cooling energy efficiency ratio (EER) of 9.0.

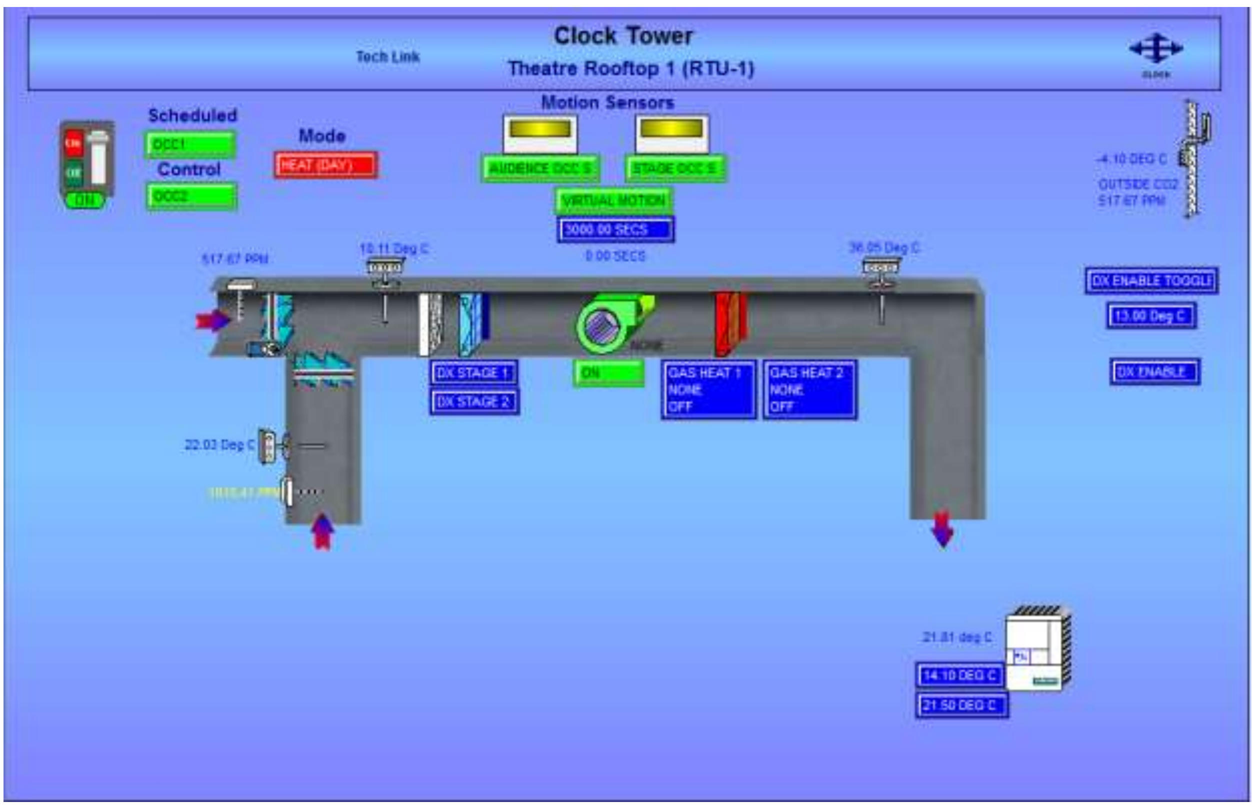


Figure 8: DDC Image of RTU-1

It is proposed that the existing unit be replaced with high efficiency units that typically operate with a cooling EER of at least 12.0.

Additionally, it is proposed that the replacement units integrate solar PV technology. The Lennox Energence units are a technology which if implemented will offset electricity consumption, and also demand, especially during peak cooling periods.

4.1.1 Scope of Work

Outline	Description
Baseline equipment	DX cooling, direct fired natural gas fired rooftop unit.
Upgrade Description	It is proposed that the Lennox unit be replaced with equivalent. Lennox "Energence" units offer improved performance and can be a direct replacement for the existing unit.
Affected area in building	RTU-1 is 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.

4.1.2 Methodology of Savings Calculations

There are considerable savings potential from upgrading the unit. The existing unit EER rating has been estimated at 9.0. 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.

Additionally, with the installation of solar PV panels, the unit will be able to satisfy the majority of its cooling demand using this renewable source. When the PV system provides power, and cooling is not required, the excess power is rejected to the grid or battery storage.

4.1.3 Cost, Saving and Payback

A summary of anticipated costs and savings are as follows:

SIMPLE PAYBACK	
BASELINE COST	$46,000
TOTAL RETROFIT COST	$ 179,700
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 1,750
PAYBACK (years)	103

4.1.4 Impact on Operations and Maintenance

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

4.1.5 Risk Analysis

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

Note: Currently, only the 3-6 ton emergence units are available with the SunSource PV System. The existing rooftop units are 3-6 tons in size, and as such, should be replaced like for like.

4.2 ECM 2 – IMPLEMENT DEMAND CONTROL VENTILATION FOR FANS F1 & F2

Where spaces have variable occupancy patterns, there can be significant potential to save energy through matching zone ventilation requirements with equipment operation.

On review of F1 & F2 supply air units at the clock tower building; there is an opportunity to reduce outdoor air supply to the building by implementing a demand control system.

Figure 4.9: Supply Fans F-1 & F-2

In order to ensure space occupancy patterns and CO_2 concentrations dictate outdoor air supply volumes to the building, it is recommended a CO_2 sensor be installed in the return air ductwork.

Energy savings will be realized as outdoor air will only be supplied to the building as required.

4.2.1 Scope of Work

It is proposed that a CO_2 sensor be installed in F1 & F2 return air ductwork and used to modulate outdoor air quantities based on fresh air demand. This strategy will ensure fresh air is supplied to the building as necessitated by occupancy rates.

Outline	Description
Baseline equipment	F1 and F2 Air Handling Units c/w VFD control
Upgrade Description	Install CO_2 sensors in the return air ductwork to monitor CO_2 concentrations and modulate outdoor air volumes accordingly.
Affected area in building	Floors 1-4
Service life	20 Years.
Non energy benefits	n/a

Risk assessment	There is minimal risk with implementation of this measure.

4.2.2 Methodology of Savings Calculations

Savings have been estimated given the following operational improvements;

- Installation of CO_2 sensor in return air duct which will ensure outdoor air is only supplied to the building as dictated by fresh air requirements. It was assumed that there will be minimal fresh air requirement in the building before 9am and after 6pm. Savings having been calculated on the assumption that the OA damper will be set at a minimum position during these times and will vary during the day as dictated by changing occupancy.
- Testing & balancing process in conjunction with installation of controls system.

4.2.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 29,400
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 2,989
PAYBACK (years)	9.8

4.2.4 Impact on Operations and Maintenance

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

4.3 ECM 3 – REPLACE EXISTING CHILLER

Cooling demand in summer and shoulder seasons is met using a chilled water system, where a packaged air cooled water chiller generates chilled water before distribution to air handling unit cooling coils.

Chilled water is circulated through the piping loop by pumps P-6/P-7. The existing chiller is approaching its end of life. New chiller unit's offer improved cooling efficiencies and it is recommended that the existing chiller be replaced to realize energy savings.

4.3.1 Scope of Work

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

Outline	Description
Baseline equipment	Packaged "McQuay" chiller
Upgrade Description	Replace the existing McQuay chiller with new high efficiency model, with similar cooling capacity to the existing unit.
Affected area in building	Building roof
Service life	25 years
Non energy benefits	There will be reduced O&M requirements with the installation of new equipment.
Risk assessment	This is a low risk ECM. However, upon further discussion with TRU staff, it was revealed the existing chiller is relatively new and therefore replacement would be premature. This measure is not recommended for implementation.

4.3.2 Methodology of Savings Calculations

Savings have been based on improved compressor efficiencies achieved through installing a new chiller. Average EER of the existing units is 8 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	$ 278,600
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 1,122
PAYBACK (years)	248

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 chiller will be replaced on a like for like basis.

4.4 ECM 4 – INSTALL PREMIUM EFFICIENCY MOTORS

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 Clock Tower 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	$ 63,500
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 1,461
PAYBACK (years)	44

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 – IMPLEMENT DDC UPGRADE & OPTIMISATION

The existing DDC / Building controls system in the Clock Tower has exceeded its useful life. The system comprises outdated pneumatic controls technology and DDC interface, such as control cabinets and software.

This ECM is a key priority item for Thompson Rivers University, due to operations and maintenance requirements. Much of the controls components are no longer available, leading to loss of system functionality and reduced opportunities for performance optimization, such as optimal start, outdoor air reset programs and demand control ventilation.

It is recommended that a new building controls system be implemented to optimize system performance and realize energy savings.

4.5.1 Methodology of Savings Calculations

Savings are calculated based on potential system optimization measures including savings from reduction in air handler heating and cooling:

1. Adjustment to setpoint temperature
2. Installation of Occupancy Sensors

4.5.2 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 329,500
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 2,350
PAYBACK (years)	140

4.5.3 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 electronic actuators and new control cabinets will require minimum maintenance.

4.5.4 Risk Analysis

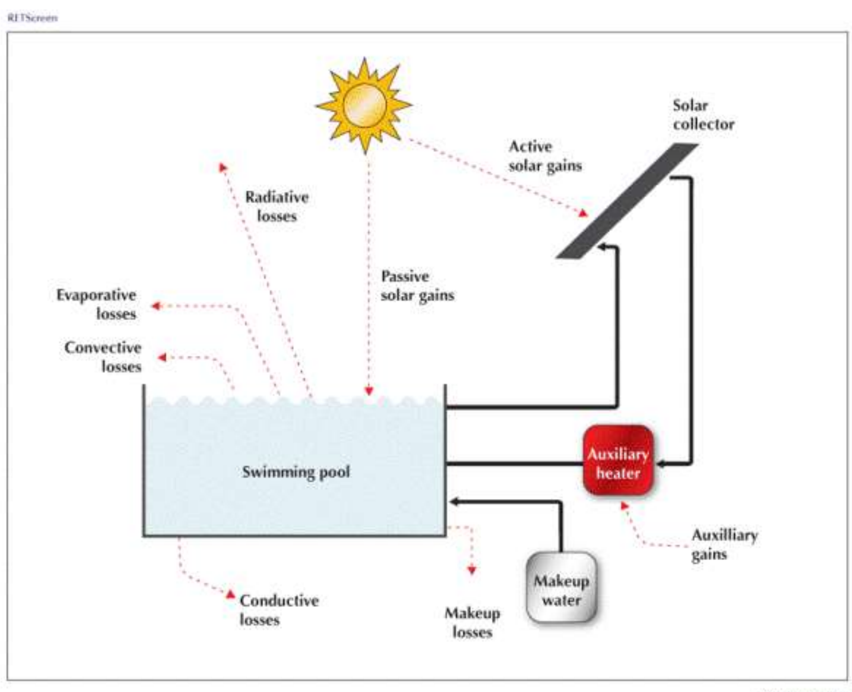
This measure is a low risk measure.

4.6 ECM 6 – 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 Clock Tower 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.

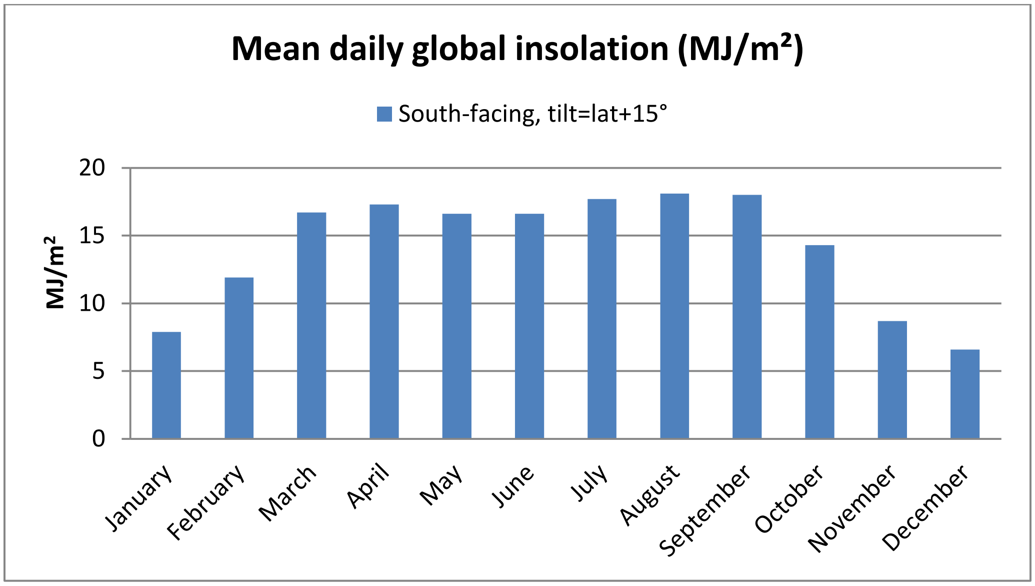


Figure 4.10: Graph of Solar Radiation in Kamloops BC

4.6.1 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 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. Given the limited occupancy of the Clock Tower for extended periods, there is a risk that this ECM will not be cost effective and is therefore not recommended for implementation.

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	$ 98,000
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 1,040
PAYBACK (years)	94

4.6.4 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.

4.6.5 Risk Analysis

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

5.0 BUILDING MANAGEMENT AND BEHAVIORAL OPPORTUNITIES

5.1 PROCUREMENT POLICY

Purchasing efficient products reduces energy costs without compromising quality. It is recommended that a procurement policy be implemented as a key element for the overall energy management strategy at Thompson Rivers University. 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.

5.2 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.

5.3 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 9: 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	Theatre RTU Replacement	16	$ 159	10,974	$ 878	5	$ 716	$ 179,700	$ 1,753	102.5	1.1
ECM 2	DCV for F-1 & F-2	94	$ 941	25,598	$ 2,048	-	$ -	$ 29,400	$ 2,989	9.8	5.4
ECM 3	Replace Chiller	-	$ -			-	$ -				-
ECM 4	Motor Efficiency	-	$ -	10,554	$ 844	4	$ 617	$ 63,500	$ 1,461	43.5	0.3
ECM 5	DDC Upgrade	93	$ 931	17,743	$ 1,419	-	$ -	$ 329,500	$ 2,350	140.2	5.1
ECM 6	Solar DHW			-	$ -	-	$ -				-
TOTAL		203	2,032	64,870	5,190	10	1,333	602,100	8,554	70	12

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 10 below demonstrates the potential improvement from the existing BEPI.

Table 10: Building Energy Performance Indicator with Post Retrofit Measures Included

Building Energy Performance Index (2013)								
	Electricity (kWh)	**Electricity Cost ($)**	**Natural Gas (GJ)**	**Natural Gas Cost ($)**	**Total ekWh**	**Total Cost ($)**	**GHG Emissions (tonnes)**	**BEPI (ekWh/m²/yr)**
Existing	270,506	$21,640	1,019	$10,185	553,431	$33,277	58	186
Reference Building (Academic) 280								
Post Retrofit	205,636	$15,118	815	$8,154	432,125	$23,271	46	145
Savings	24%	30%	20%	20%	22%	30%	20%	22%

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) 186tonnes/year[8].

Table 11: Emissions Reductions Associated with the ECMs Recommended

EMISSIONS REDUCTIONS						
	Electricity		Natural Gas		Total	
Total Energy Saved	64,870	kWh/yr	203	Gj	121,306	ekWh
Total CO_2e Emissions Saved	2	tonnes/yr	10	tonnes/yr	12	tonnes/yr

The emissions savings projection of 12 tonnes per year equates to approximately 20% 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 its Kamloops 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 Clock Tower Building involved 2,975 m^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

		Measure	Recommended for Implementation
Mechanical & Electrical Measures	ECM 1	Replace Lecture Theatre Rooftop Unit	✓
	ECM 2	Implement Demand Control Ventilation – Fans F1 & F2	✓
	ECM 3	Replace Existing Chiller	✓
	ECM 4	Install Premium Efficiency Motors	✓
	ECM 5	Implement DDC Upgrade	✓
	ECM 6	Implement Solar Hot water Installation	✓

It is anticipated that should all of the selected measures be implemented, there would be annual savings in utilities of approximately $9,000 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 12 tonnes (equivalent to around 29% of current emissions).

Total Investment	Total Cost Savings	Payback	Total Natural Gas Savings (GJ)	Total Electricity Savings (kWh)	CO_2 Reduction (Tons)
$602,000[9]	$8,550	70	203	64,900	12

[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.

Appendix A CONTACT DETAILS

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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	177	31	6	138	31	4	166	31	5
Feb	128	28	5	185	28	7	114	28	4
Mar	117	31	4	137	31	4	105	31	3
Apr	81	30	3	62	30	2	79	30	3
May	45	31	1	48	31	2	33	31	1
Jun	24	30	1	91	30	3	15	30	1
Jul	14	31	0	107	31	3	5	31	0.2
Aug	15	31	0	84	31	3	9	31	0.3
Sept	38	30	1	35	30	1	52	30	2
Oct	97	31	3	69	31	2	91	31	3
Nov	161	30	5	150	30	5	158	30	5
Dec	186	31	6	201	31	6	192	31	6
Total	1,083			1,307			1,019		

	Annual Electricity Consumption Utility Records (kWh)								
	2013			2014			2015		
	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.
Jan	26,901	31	868	24,574	31	793	25,216	31	813
Feb	22,214	28	793	25,599	28	914	21,562	28	770
Mar	22,413	31	723	27,374	31	883	23,085	31	745
Apr	20,592	30	686	22,059	30	735	21,234	30	708
May	22,277	31	719	20,508	31	662	21,946	31	708
Jun	19,992	30	666	18,720	30	624	23,401	30	780
Jul	24,113	31	778	22,878	31	738	24,604	31	794
Aug	21,071	31	680	21,354	31	689	22,632	31	730
Sept	22,415	30	747	21,074	30	702	20,341	30	678
Oct	23,227	31	749	21,096	31	681	20,788	31	671
Nov	26,860	30	895	24,372	30	812	23,602	30	787

Dec	26,678	31	861	27,332	31	882	22,095	31	713
Total	**278,800**			**276,900**			**270,500**		