Thompson Rivers University Culinary Arts Building Energy Assessment

Prepared for:

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Sign-off Sheet

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Reviewed by

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Executive Summary

Thompson Rivers University (TRU), commissioned Stantec to conduct a detailed energy assessment at its Culinary Arts 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 1,859m^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 $35,000 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 47 tonnes (equivalent to around 26% of current emissions).

Total Investment	Total Cost Savings	Payback	Total Natural Gas Savings (GJ)	Total Electricity Savings 9kWh)	CO_2 Reduction (Tons)
$941,000[1]	$34,600	27	800	252,000	47

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	415,684	33,250	3,366	33,660	1,350,687	71,400	179	727
Reference Building (Academic) 280								
Post Retrofit	163,624	$6,112	2,566	$25,661	876,440	$31,773	133	471
Savings	61%	82%	24%	24%	35%	55%	26%	35%

[1] Total investment is total material & labour cost

	Measure		Recommended for Implementation
Mechanical & Electrical Measures	ECM 1	Replace air Handling and Makeup Air Units	✓
	ECM 2	Replace Kitchen Exhaust and Makeup Air Unit	✓
	ECM 3	Install New Rooftop Unit	✓
	ECM 4	Implement Chiller Upgrade	✓
	ECM 5	Insulate Hot Water/ DHW Distribution Pipework	✓
	ECM 6	Solar PV	✓

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	Replace Air Handler & MUA units	712	$ 7,116	6,264	$ 501	-	$ -	$ 382,300	$ 7,618	50.2	35.8
ECM 2	Kitchen Exhaust and MUA	-	$ -	11,151	$ 892	-	$ -	$ 172,400	$ 892	193.3	0.3
ECM 3	RTU replacement	34	$ 339	11,055	$ 884	-	$ -	$ 143,080	$ 1,223	117.0	2.0
ECM 4	Chiller Upgrade	-	$ -	4,591	$ 367	-	$ -	$ 146,100	$ 367	397.8	0.1
ECM 5	Insulate DHW & SH pipes	54	$ 543	-	$ -	-	$ -	$ -	$ -	#DIV/0!	2.7
ECM 6	Solar PV	-	$ -	219,000	$ 17,520	50	$ 6,978	$ 98,100	$ 24,498	4.0	5.7
TOTAL		**800**	**7,999**	**252,060**	**20,165**	**50**	**6,978**	**941,980**	**34,598**	**27**	**47**

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

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

1.2.7 Recommendations

From the options considered, recommendations are put forward based on financial and practical feasibility using indicators such as simple payback and capital cost. A full analysis is set out in Table 11.

[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 Culinary Arts building was originally built in 1970 with additions to the building in 1983. The building is comprised of two storey structure with a gross floor area of 1,859m². The building gets its name from the fact it is home to the culinary arts training program at TRU.

The building is home to office and administration areas, Scratch Café & Market, kitchens and dining areas.

Figure 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	1,859	m²
Weather data source	www.degreedays.net	[Base 16°C]
HDD	2,953	°C day/year
CDD	644	°C day/year

Figure 2 TRU Kamloops Campus Layout & Culinary Arts 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	Tuesday - Friday	Saturday	Sunday/Holiday Occupancy
Scratch Café	Closed	10:00AM – 2:30PM	Closed	Closed
Kitchen / Teaching	8:00AM – 6:00PM	8:00AM – 6:00PM	Closed	Closed
Offices	07:00AM – 6:00PM	07:00AM – 6:00PM	Closed	Closed

2.2 BUILDING ENVELOPE

The building is two storeys above grade and a partial basement, containing the boiler room. Construction appears to be of non-combustible design including including poured concrete walls and aluminum double glazed windows. Typical thermal performances in buildings of this vintage include:

- R-10 Walls
- R-16 Roof
- U 0.75 Windows
- Uninsulated 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 poured concrete walls with steel structural support.	
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. The thermal scan revealed areas of heat loss are limited to glazing/doorway aluminum frame exposure to outdoor.

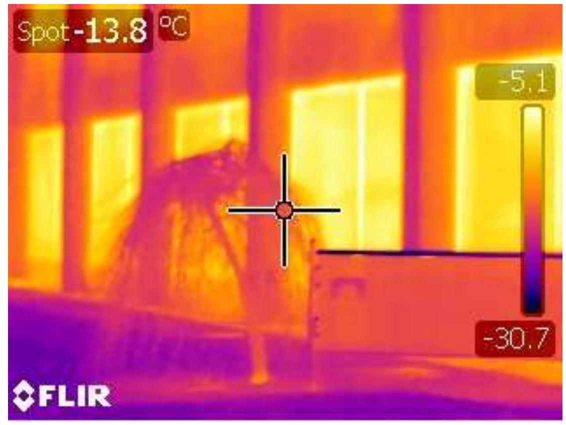

Figure 3: Thermographic Inspection of Envelope & Fenestration

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 Culinary Arts building. F-6 & F-13 are located in the basement mechanical room.

F-6 serves is a dual duct system and serves three primary zones; the floor bakery, lounge & classrooms and general distribution areas. F-13 is also a dual duct system serving 3 zones including the main dining room, student staff dining room and kitchen. The cafeteria incorporates a VAV reheat coil system which provides additional control in this space.

In addition to F6 & F13, rooftop unit (RTU-1) and make-up air unit are installed to serve the alumni dining room and kitchen exhaust respectively. Programmable thermostats located in the dining area provide control for the RTU.

Table 5: Ventilation System Inventory

Unit	Location	Service	Motor Size (HP)	Capacity (CFM)[4]
F-6	Basement Mechanical Room	Bakery, Lounge & classrooms	10	1,500
F-13	Basement Mechanical Room	Dining Room & Kitchen	10	1,500
MAU-1	Roof	Kitchen Makeup Air Unit	7.5	1,500
RTU-1	Roof	Dining Room	5	1,000

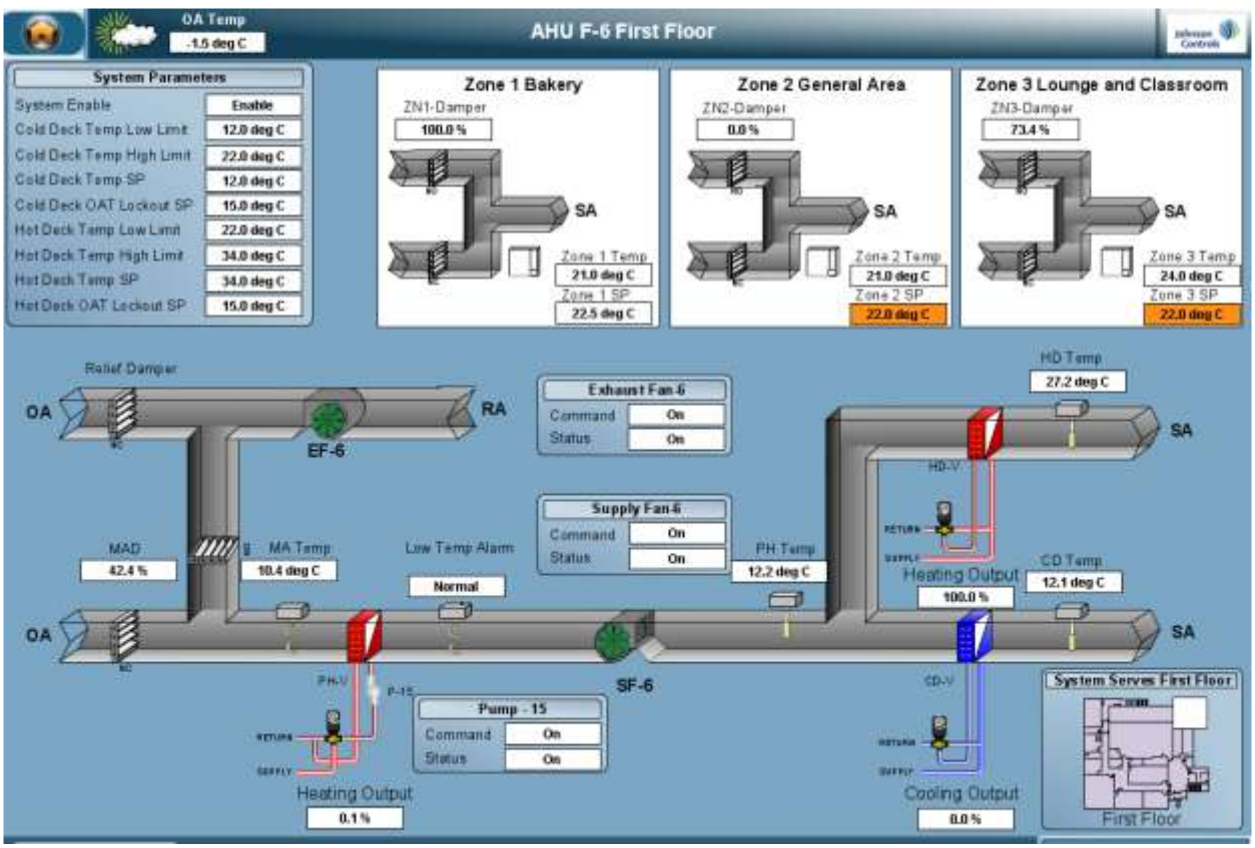

Figure 4: AHU-6 DDC Output

[4] Estimate

On review of air handling operation schedule with building operations, it was noted that the ventilation system is typically programmed to operate 8.30am – 4.00pm daily. See table below for full occupancy schedule.

Table 6: Operation schedule

Unit	Mon-Friday	Saturday	Sunday
F-6	7.00am – 5.00pm	8.30am – 4.00pm	Closed
F-13	7.00am – 5.00pm	8.30am – 4.00pm	Closed
MAU-1	7.00am – 5.00pm	8.30am – 4.00pm	Closed
RTU-1	7.00am – 9.00pm	9.00am – 6.00pm	Closed

Table 7: Exhaust Fan Schedule

Unit	Location	Service	Motor Size (HP)	Capacity (L/S)
EF-1	Roof	Washroom	0.25	472
EF-2	Roof	Classroom	0.2	280
EF-3	Roof	Kitchen Exhaust	0.5	1,000

2.4.2 Heating

On site heating is generated using two 'Thermal Solutions - Evolution' condensing natural gas boiler and a gas fired rooftop unit. The boilers have each a specified gross input of 1,500MBH and a nameplate efficiency of 88%. The boiler plant was upgraded in 2009 to condensing units. Circulating pump P-13 serves the radiant zone loops while P-12 serves the heating coils in the air handling units. The Lennox RTU incorporates natural has heating and serves the dining area. It has a capacity of 370MBH with an estimated efficiency of 75%.

Figure 5: Thermal Solutions Boiler

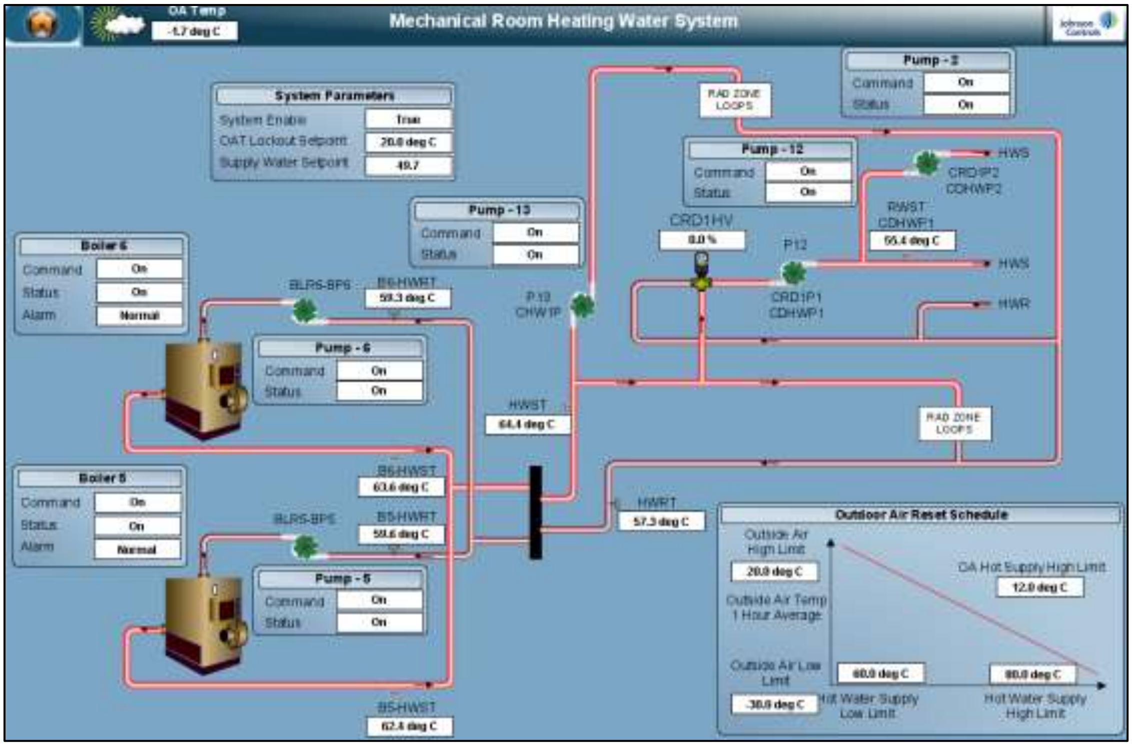

Figure 6: Hot water Heating System – DDC Controls Graphics

Table 8: Boiler Specification

Manufacturer	Model Number	Input (MBH)	Output (MBH)	Rated eff.	Manufactured
Thermal Solutions (B1 & B2)	EVH-1500	1,500	1,320	~88%	2009

2.4.1 Domestic Hot Water

Domestic Hot Water at the facility is generated by two "Raypak" natural gas hot water heaters. Each boiler has an input capacity of 300MBH and rated efficiency of 82%. Two "Rheem Ruud" 75 Gallon storage tanks provide DHW storage capacity. A solar hot water system is also installed to provide domestic hot water preheat. Two (2) 200USG hot water storage tanks are located in the boiler room to provide solar preheat storage capacity.

A solar domestic water pre heat is installed on the roof to temper water. No information on the operation of the system was provided.

Figure 7: Culinary Arts Domestic Hot Water Boiler and Solar Hot Water Panels

2.4.2 Cooling

One packaged 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 8: 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 Culinary Arts building incoming feed is 208V.

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 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 9 shows the consumption profile on a daily average basis.

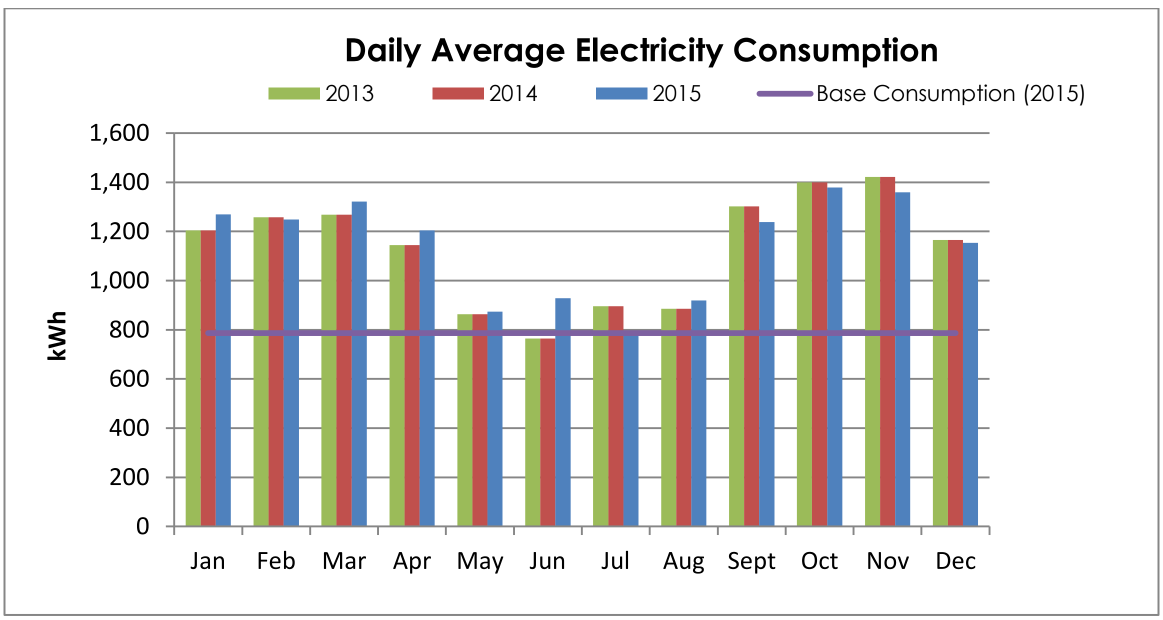

Figure 9: Average daily non-heating electricity consumption for 2012–2015

The daily lowest electricity consumption in 2015 for the facility is 786kWh and occurs in July. The building has a relatively consistent consumption profile during term time; however consumption decreases significantly during summer “vacation” periods. This is indicative of this building type, where a large proportion of energy consumption is from the cooking processes and operation of auxiliary systems, such as refrigeration and kitchen exhaust.

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 energy efficiency[5]:

- A major lighting retrofit implemented in 2012 is on track to save $6,000 annually in electricity costs. All lighting has been replaced with high efficiency units.
- A Wireless Energy Management System was installed in the fall of 2012. WEMS uses wireless sensors to control the HVAC and lighting systems. This innovative wireless technology allows remote sensors to communicate with building automation systems.
- Solar domestic hot water heating panels on the building roof heat the hot water used in kitchens and bathrooms.

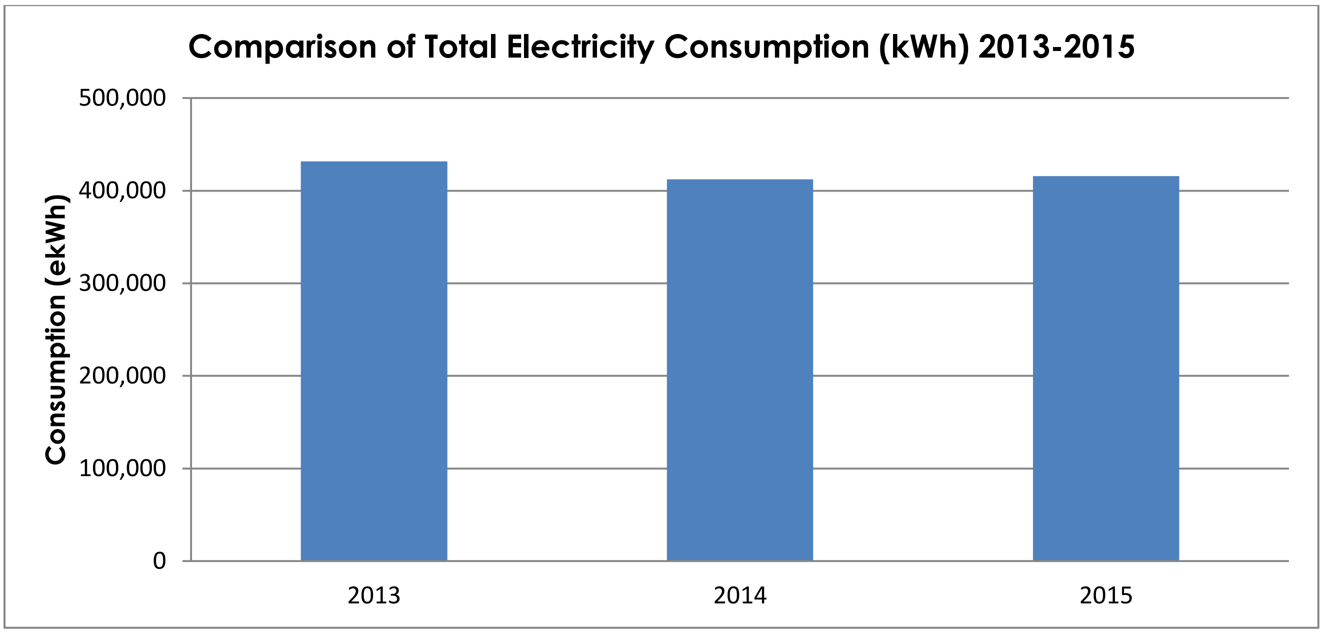

Figure 10: Total electricity consumption comparison 2012-2015

3.1.2 Electricity Demand

Demand data was extracted from the 'Pulse Energy' website and the data illustrates decreased electrical demand during the summer period, which is aligned with the electricity consumption profile. This can be explained by students not occupying the facility during summer operating hours as they are on vacation. The lowest monthly electricity demand in 2015 occurs in July, and was 33kW.

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

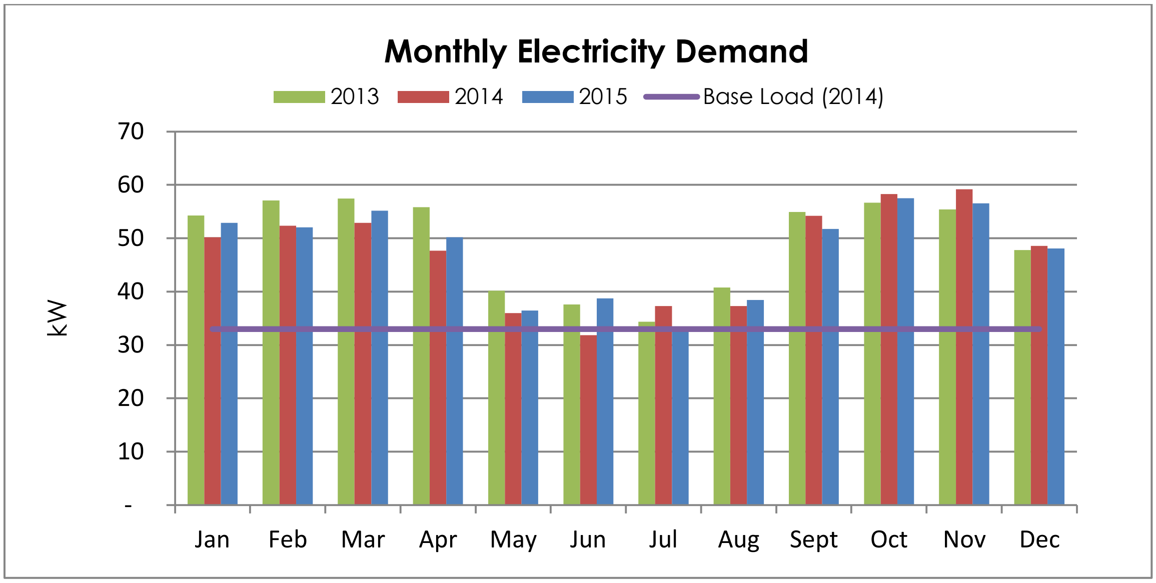

Figure 11: Building Demand Profile (2013-2015)

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.

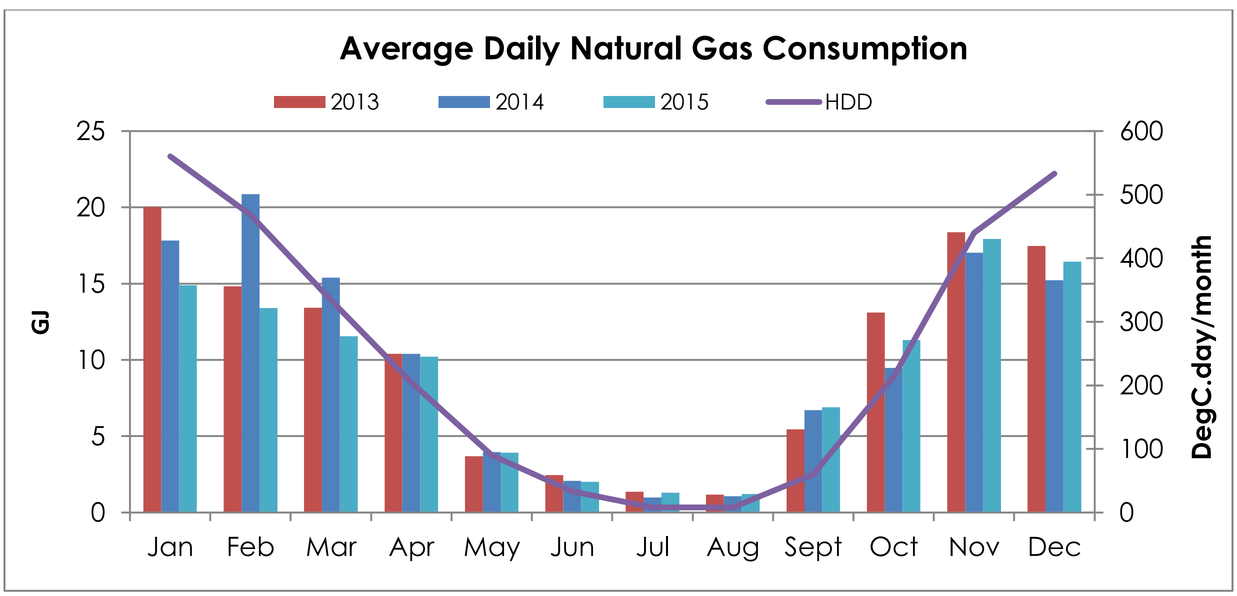

Figure 12: Average daily Natural Gas consumption and heating degree-days (2013–2015)

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 the building is typically unoccupied during summer months and domestic hot water loads are supplemented using solar domestic hot water heaters, there is minimal natural gas consumption during this period.

Peak consumption in 2015 was recorded in November at 18 GJ/day with summer base load of less than 2 GJ/Day. Total natural gas consumption increased by almost 10% between the 2013 to 2015 reporting period.

Table 9: Comparison of Natural Gas Consumption

Year	Total Annual Natural Gas Consumption (GJ)	Yearly Deviation
2013	3,692	-
2014	3,652	-1%
2015	3,366	-8%

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 10 below indicates the current measured energy consumption for the Culinary Arts building.

The total energy intensity of 727 $ekWh/m^2$ represents one of the highest energy consuming facilities at TRU.

Table 10: BEPI for the Culinary Arts Building

BUILDING ENERGY PERFORMANCE INDEX (2015)

	Electricity Cons. (kWh)	Electricity Cost ($)	Natural Gas Cons. (GJ)	Natural Gas Cost ($)	Total ekWh	Total Cost[6]	GHG Emissions (tonnes)	BEPI $kWh/m^2/yr$
Existing	415,680	33,250	3,366	33,650	1,350,687	71,400	179	727

[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 13. Natural gas represents the most significant portion of the building energy load, and can be attributed to water heating, gas cooking equipment and makeup air heating.

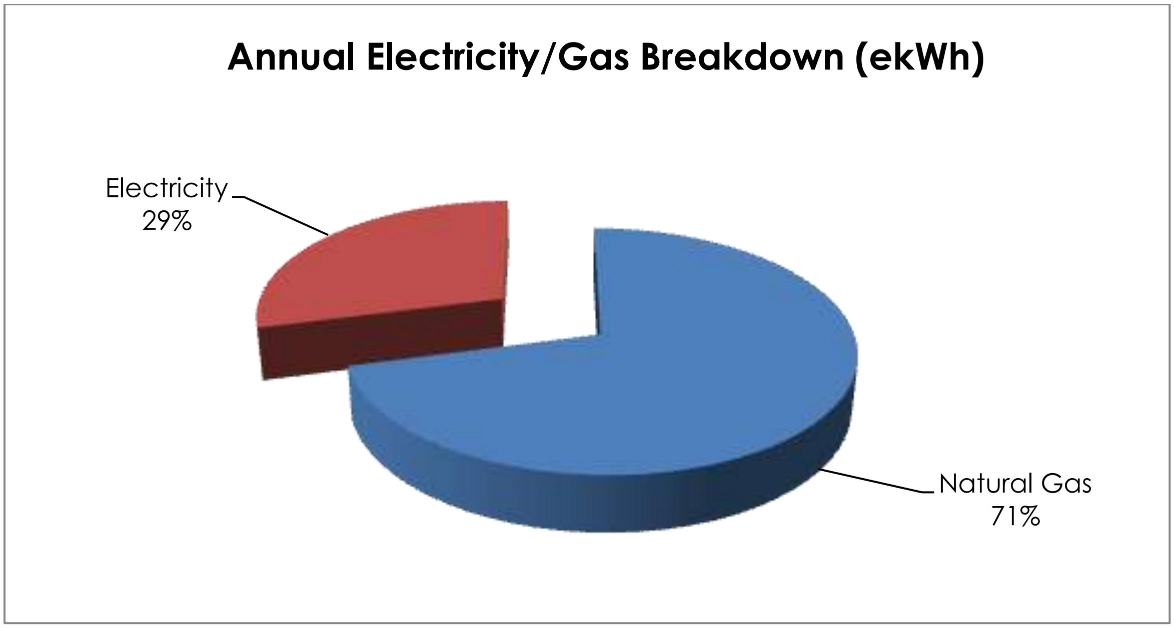

Figure 13: Breakdown of Energy Consumption by Fuel type

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 14. The largest electrical consuming equipment/processes are lighting and ventilation which accounts for almost 60% of total building electricity consumption.

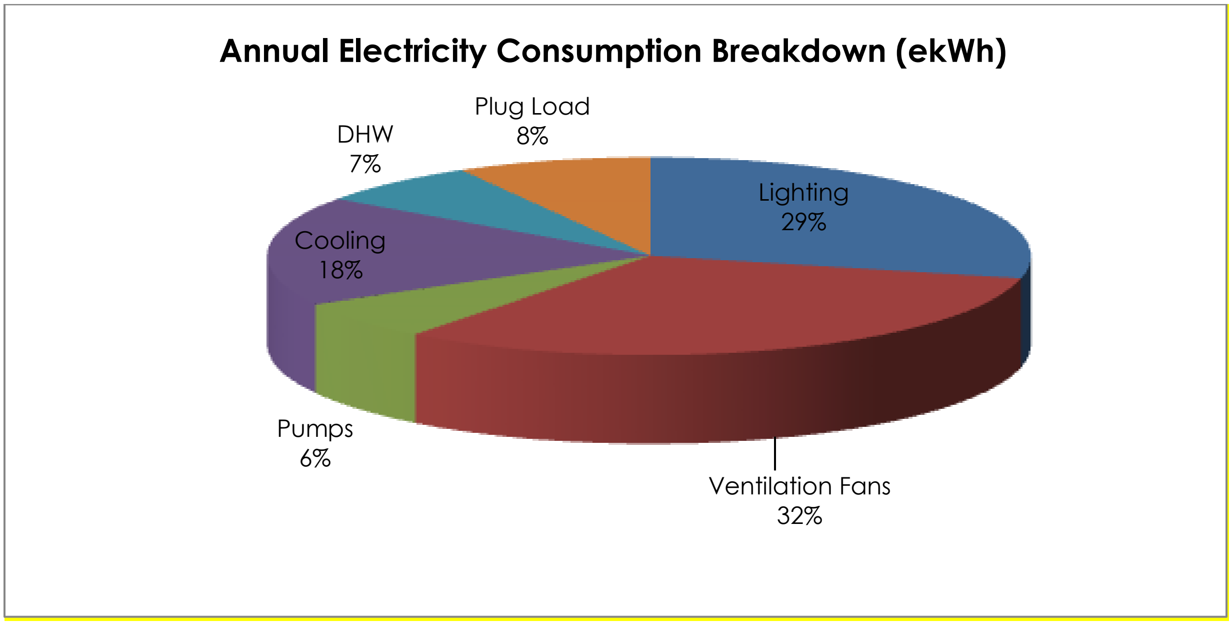

Figure 14: Breakdown of Electricity Consumption in kWh (2015)

3.2.3 Natural Gas (Heating)

Natural gas serves the domestic hot water, cooking and space heat. Space heat is the largest component of natural gas use, estimated at 58% (Figure 15).

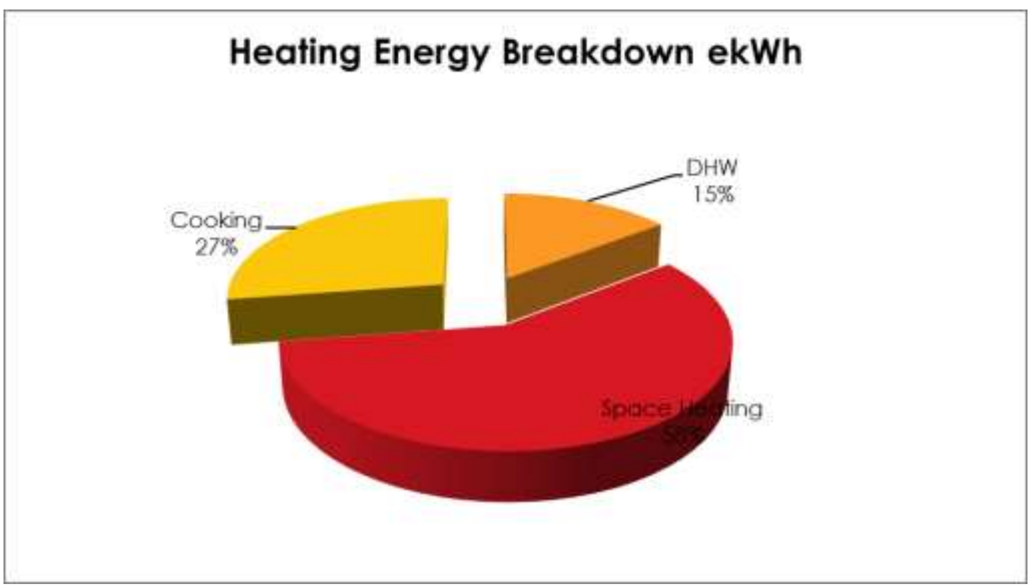

Figure 15: Natural Gas End Use Profile (2015)

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. The preliminary investigation identified condensing boilers as an opportunity for Culinary Arts, however, the detailed investigation revealed that the current boilers are relatively new and efficient. Therefore, installation of condensing boilers was not analysed further.

4.1 ECM 1 – REPLACE AIR HANDLING AND MAKEUP AIR UNITS

Two "Trane" dual duct air handling units (F-6 & F-13) located in the ground floor mechanical room are the primary source of building ventilation. The units are constant volume and use heating and cooling coils to condition outdoor air before supplying to building zones.

Figure 16: AHU-F6 and AHU-F13

The dual duct units supply air to following areas:

Zone Served	AHU-F6	AHU-F13
Bakery		
General Areas		
Lounge & Classrooms		
Dining Room		
Student Staff Dining Room		
Kitchen		

Dual duct air handling units are difficult to control effectively, as two air streams (one "hot" and one "cold") are mixed to provide supply air to individual zones. There are few details on the units, and it is anticipated that they were installed in the 1980s and as such are past useful life.

It is proposed that both units be decommissioned (including building ductwork) and replaced with high efficiency air handling units, complete with variable air volume supply.

4.1.1 Scope of Work

It is proposed that the mechanical ventilation system be decommissioned and replaced with a high efficiency alternative as per below:

Outline	Description
Baseline equipment	Two "Trane" dual duct air handling units are the primary method of ventilating, heating and cooling the building.
Upgrade Description	It is proposed that the existing units and supply ductwork be decommissioned and replaced with high efficiency alternatives. The new units at a minimum should incorporate: • High efficiency heating and cooling coils • Variable air flow based on demand control • Heat recovery (thermal wheel)
Affected area in building	Units are located in the ground floor mechanical room, however as the distribution ductwork will also need to be replaced, this ECM will impact the whole building.
Service life	This measure will persist until the units exceed useful life (approximately 25 years).
Non energy benefits	The existing units are approaching or have exceeded their useful life. By installing new units, ongoing operations and maintenance requirements will be reduced.
Risk assessment	This measure is high risk, as any works on the building interior must be completed outside of term to ensure classes are not disrupted.

4.1.2 Methodology of Savings Calculations

Savings have been based on the following efficiency gains:

- High efficiency motors in the new units, complete with variable frequency drives
- Reduced outdoor air supply volume, correlated to occupant demand

- Heat recovery from installation of thermal wheel

4.1.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 382,300
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 7,618
PAYBACK (years)	50.2

4.1.4 Impact on Operations and Maintenance

Implementation of this measure will have a positive impact on operations and maintenance.

4.2 ECM 2 – REPLACE KITCHEN EXHAUST SYSTEM & MAKEUP AIR UNIT

Food services facilities typically have high energy consumption, with commercial kitchen exhaust being one of the key drivers for energy consumption, especially in colder climates. The kitchen exhaust at the culinary arts building is typically operational Monday – Friday, from 7am to 5pm. The exhaust fan is constant velocity and operates at 100% capacity regardless of ventilation requirements. A constant volume MAU provides makeup air to the kitchen.

It is proposed that the kitchen exhaust fan and makeup air unit be replaced with a variable air system to reduce motor energy consumption and makeup air heating. The energy savings strategy will incorporate the following scope of work:

- Reduce exhaust air demand by installing a high efficiency exhaust hood with low capture and containment (C&C) airflow rates. The current NFPA-96 Standard and require that a hood operate at full design airflows whenever full-load cooking activity occurs underneath an exhaust hood.
- Install an optical sensor in the exhaust air hood to detect cooking activity
- Install new exhaust fan with VFD to reduce fan power and airflow rates whenever cooking activity is detected
- Install new makeup air unit (MAU), complete with variable speed supply fan. The MAU fan speed can modulate based on a static pressure sensor (to detect and maintain negative pressurization) or be linked to exhaust fan speeds through the DDC.

Energy savings will be realized from a reduction in fan power consumption (Exhaust & MAU) and decreased heating demand in line with reduced outdoor air volumes.

4.2.1 Scope of Work

The scope of work is as follows:

Outline	Description
Baseline equipment	An exhaust fan and makeup air unit is located on the building roof to provide kitchen exhaust and ventilation.
Upgrade Description	Decommission existing exhaust fan and makeup air unit, and replace with new kitchen exhaust system. New system will comprise new exhaust hood, exhaust fan with VFD and makeup air unit.
Affected area in building	The affected building areas will be the kitchen and roof where the fan and MAU are located.
Service life	25 Years

Non energy benefits	The exhaust fan and MAU are approaching end of life, and replacing them will have a positive impact on operations and maintenance.
Risk assessment	This is a low risk opportunity.

4.2.2 Methodology of Savings Calculations

Savings are based on the following:

- Reduction in electricity consumption through reduced exhaust and MAU fan operation and new variable speed operation
- Reduced heating energy consumption as makeup air volumes will be reduced in line with reduced exhaust fan volumes

4.2.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 172,400
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 892
PAYBACK (years)	193

4.2.4 Impact on Operations and Maintenance

There will be a reduced O&M demand with a reduction in pool fill frequency.

4.3 ECM 3 – INSTALL NEW ROOFTOP UNIT

A rooftop unit is installed on the roof of the Culinary Arts building which serves the second floor dining room area. The unit provides outdoor air and DX cooling to the dining area, with heating in the dining area provided by radiant panel. The unit is typically operational from 7am to 9pm from Monday to Friday. It is assumed that the unit operates with a cooling energy efficiency ratio (EER) of 9.0.

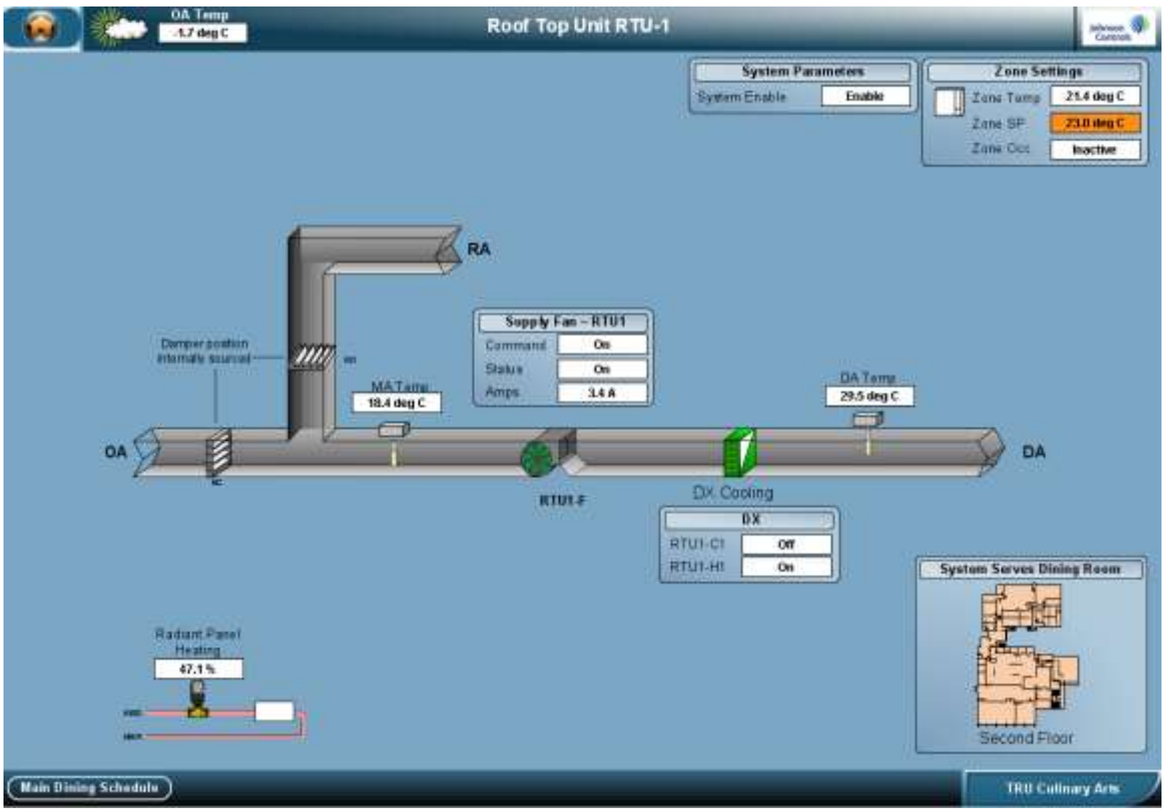

Figure 17: DDC Image of RTU-1

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.

4.3.1 Scope of Work

Outline	Description

Baseline equipment	Existing cooling only 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-1is 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.

4.3.2 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.

4.3.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 54,000
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 1,756
PAYBACK (years)	30.8

4.3.4 Impact on Operations and Maintenance

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

4.3.5 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.

4.4 ECM 4 – IMPLEMENT CHILLER UPGRADE

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.

4.4.1 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	Mechanical Room
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.

4.4.2 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.

4.4.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 146,100

MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 367
PAYBACK (years)	397.8

Due to the extended payback of this measure, it is recommended to complete the upgrade as part of capital planning activities.

4.4.4 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.

4.4.5 Risk Analysis

This is a low risk measure as existing chiller will be replaced on a like for like basis.

4.5 ECM 5 – 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.

4.5.1 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.

4.5.2 Methodology of Savings Calculations

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

4.5.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 5,700
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 543
PAYBACK (years)	10.5

4.5.4 Impact on Operations and Maintenance

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

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.

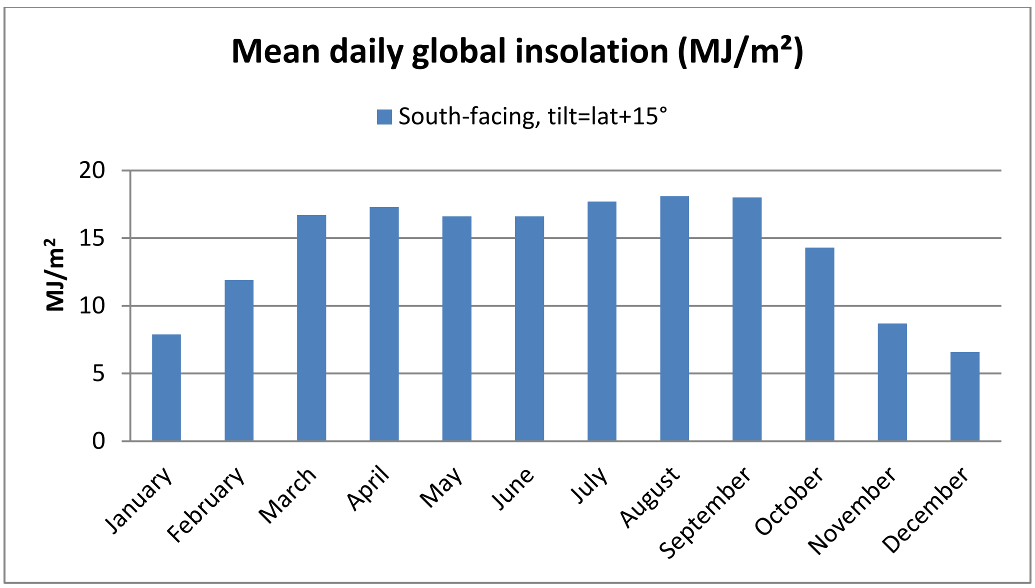

Figure 4.18 Graph of Solar Radiation in Kamloops BC

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

There are no retrofits currently planned for this building, other than preventative maintenance measures.

5.2 PROCUREMENT POLICY

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

5.3 STAFF TRAINING AND OCCUPANT AWARENESS

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

5.4 RECOMISSIONING & SYSTEM BALANCING

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

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 11: 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	Replace Air Handler & MUA units	712	$ 7,116	6,264	$ 501	-	$ -	$ 382,300	$ 7,618	50.2	35.8
ECM 2	Kitchen Exhaust and MUA	-	$ -	11,151	$ 892	-	$ -	$ 172,400	$ 892	193.3	0.3
ECM 3	RTU replacement	34	$ 339	11,055	$ 884	-	$ -	$ 143,080	$ 1,223	117.0	2.0
ECM 4	Chiller Upgrade	-	$ -	4,591	$ 367	-	$ -	$ 146,100	$ 367	397.8	0.1
ECM 5	Insulate DHW & SH pipes	54	$ 543	-	$ -	-	$ -	$ -	$ -	#DIV/0!	2.7
ECM 6	Solar PV	-	$ -	219,000	$ 17,520	50	$ 6,978	$ 98,100	$ 24,498	4.0	5.7
TOTAL		**800**	**7,999**	**252,060**	**20,165**	**50**	**6,978**	**941,980**	**34,598**	**27**	**47**

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 12 below demonstrates the potential improvement from the existing BEPI.

Table 12: 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	415,684	33,250	3,366	33,660	1,350,687	71,400	179	727
Reference Building (Academic)								**280**
Post retrofit	163,624	$6,112	2,566	$25,661	876,440	$31,773	133	471
Savings	61%	82%	24%	24%	35%	55%	26%	35%

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 179 tonnes/year[7].

Table 13: Emissions Reductions Associated with the ECMs Recommended

EMISSIONS REDUCTIONS						
	Electricity		Natural Gas		Total	
Total Energy Saved	252,060	kWh/yr	800	Gj	474,247	ekWh
Total CO_2e Emissions Saved	7	tonnes/yr	40	tonnes/yr	47	tonnes/yr

The emissions savings projection of 133 tonnes per year equates to approximately 26% 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 Culinary Arts 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 1,859m^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 air Handling and Makeup Air Units	✓
	ECM 2	Replace Kitchen Exhaust and Makeup Air Unit	✓
	ECM 3	Install New Rooftop Unit	✓
	ECM 4	Implement Chiller Upgrade	✓
	ECM 5	Insulate Hot Water/ DHW Distribution Pipework	✓
	ECM 6	Solar PV	✓

It is anticipated that should all of the selected measures be implemented, there would be annual savings in utilities of approximately $35,000 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 47 tonnes (equivalent to around 26% of current emissions).

Total Investment	Total Cost Savings	Payback	Total Natural Gas Savings (GJ)	Total Electricity Savings (kWh)	CO_2 Reduction (Tons)
$942,000[8]	$34,600	24	800	252,000	47

[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 (2013 – 2015)

	Annual Electricity Utility Records (kWh)								
	2013			2014			2015		
	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.
Jan	40,384	31	1,303	37,329	31	1,204	39,343	31	1,269
Feb	38,348	28	1,370	35,200	28	1,257	34,972	28	1,249
Mar	42,694	31	1,377	39,316	31	1,268	40,970	31	1,322
Apr	40,179	30	1,339	34,324	30	1,144	36,145	30	1,205
May	29,873	31	964	26,763	31	863	27,102	31	874
Jun	27,063	30	902	22,943	30	765	27,868	30	929
Jul	25,565	31	825	27,767	31	896	24,358	31	786
Aug	30,269	31	976	27,444	31	885	28,491	31	919
Sept	39,566	30	1,319	39,051	30	1,302	37,154	30	1,238
Oct	42,148	31	1,360	43,373	31	1,399	42,737	31	1,379
Nov	39,929	30	1,331	42,665	30	1,422	40,776	30	1,359
Dec	35,537	31	1,146	36,111	31	1,165	35,768	31	1,154
Total	**431,555**			**412,286**			**415,684**		

	Annual Natural Gas Utility Records (GJ)								
	2011			2012			2013		
	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.
Jan	621	31	20	552	31	18	461	31	15
Feb	415	28	15	584	28	21	375	28	13
Mar	416	31	13	477	31	15	358	31	12
Apr	312	30	10	312	30	10	307	30	10
May	114	31	4	123	31	4	122	31	4
Jun	73	30	2	62	30	2	60	30	2
Jul	42	31	1	31	31	1	40	31	1.3
Aug	36	31	1	33	31	1	38	31	1.2
Sept	163	30	5	201	30	7	207	30	7
Oct	406	31	13	294	31	9	350	31	11
Nov	551	30	18	511	30	17	538	30	18
Dec	541	31	17	472	31	15	510	31	16
Total	**3,692**			**3,652**			**3,366**		