Thompson Rivers University Science Building Energy Assessment

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Sign-off Sheet

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Diego Mandelbaum

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Executive Summary

Thompson Rivers University (TRU), commissioned Stantec to conduct a detailed energy assessment at its Science building located at the TRU Kamloops Campus, British Columbia, to identify energy conservation opportunities. A site visit was conducted on November 24^{th} & 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 10,325m^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 $60,000 at a rate of $10.00 per GJ for natural gas and $0.08 per kilowatt hour for electricity and a reduction in GHG emissions of around 78 tonnes (equivalent to around 34% of current emissions).

Total Investment	**Total Cost Savings**	**Payback**	**Total Natural Gas Savings (GJ)**	**Total Electricty Savings (kWh)**	**CO_2 Reduction (Tons)**
$1,504,000[1]	$59,900	26	1,030	499,000	761

The annual average utility consumption for this facility in 2013 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 (2013)								
	Electricity (kWh)	**Electricity Cost ($)**	**Natural Gas (GJ)**	**Natural Gas Cost ($)**	**Total ekWh**	**Total Cost ($)**	**GHG Emissions (tonnes)**	**BEPI ($ekWh/m^2/yr$)**
Existing	1,146,753	$91,740	3,853	$38,530	2,217,030	$135,839	223	215
Reference Building (Academic) 280								
Post Retrofit	647,854	$44,850	2,822	$28,222	1,431,798	$73,072	158	139
Savings	44%	51%	27%	27%	35%	46%	29%	35%

[1] Total investment is total material & labour cost

		Measure	Recommended for Implementation
Mechanical & Electrical Measures	ECM 1A	Replace Air Handling & Makeup Air Units	✓
	ECM 1B	Implement Exhaust heat Recovery by Installing a Runaround Loop	✓
	ECM 2	Replace Fluid Coolers (CT-1 & CT-2) & Heat Pumps	✓
	ECM 3	Insulate Hot water/DHW distribution Pipework	✓
	ECM 4	Install Solar Film on Glazing	✓
	ECM 5	Install Solar Domestic Hot Water Heater	×
	ECM 6	Install 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 1A	Replace Air Handlers	463	$ 4,629	106,916	$ 8,553	-	$ 579	$ 543,000	$ 13,761	39.5	26.0
ECM 1B	Refurbish Existing AHUs & Implement Heat Recovery	326	$ 3,953	-	$ -	-	$ -	$ 190,700	$ 3,953	48.2	16.3
ECM 2	Replace Heat Pumps & Fluid Cooler	-	$ -	134,152	$ 10,732	-	$ -	$ 426,783	$ 10,732	39.8	0.3
ECM 3	Pipework Insulation	54	$ 970	-	$ -	-	$ -	$ 5,700	$ 970	5.9	2.7
ECM 4	Glazing Film	187	$ 1,872	38,831	$ 3,106	-	$ -	$ 240,100	$ 4,978	48.2	10.4
ECM 5	Solar DHW										
ECM 6	Solar PV	-	$ -	219,000	$ 17,520	6,978	$ 6,978	$ 98,100	$ 24,498	4.0	5.7
TOTAL		**1,031**	**11,423**	**498,899**	**39,912**	**6,978**	**7,557**	**1,504,383**	**58,893**	**26**	**61**

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

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

1.2 PROCESS

1.2.1 Site Visits

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

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

1.2.2 Utility Analysis

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

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

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

1.2.3 Utility Rates

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

Table 1 Marginal Energy Rates 2015

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 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 Science building was originally built in 1980 and is comprised of a 3-storey structure with a gross floor area of 10,325m^2. The building gets its name from the fact it is home to students of science, natural resource sciences, nursing and respiratory therapy.

The building incorporates two computer labs (S 232, S 275), study spaces, lecture and lab classrooms, lecture halls, faculty offices, research labs and a coffee/snack shop.

Administration offices for the Faculty of Science and the School of Nursing are both located on the second floor.

Figure 2.1: Building Exterior & Typical Lab Space

2.1.2 Site Details

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

Table 2 Site Characteristics

Item	**Value**	**Units**
Site Area	10,325	m^2
Weather data source	www.degreedays.net	[Base 16°C]
HDD	2,953	°C day/year
CDD	644	°C day/year

Figure 2.2 TRU Kamloops Campus Layout

2.1.3 Occupancy

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

Table 3 Typical Occupancy Schedule

	Monday - Friday	Saturday	Sunday/Holiday Occupancy
Labs	07:00AM – 10:00PM	-	-
Offices	07:00AM – 6:00PM	Intermittent	Intermittent
Classrooms / Common Areas	24/7	-	-

2.2 BUILDING ENVELOPE

A summary of building envelope components is presented below.

Table 4: Building Envelope Descriptions

Assembly	Description	Image
Walls	Walls are generally curtain wall construction. In general, the vision portions have a thermal resistance of R2; spandrel panels have a thermal performance of R5 while opaque walls have thermal resistance values of R-20.	
Fenestration	Building fenestration typically comprises double glazed units. Window and door systems are typically constructed in aluminum frame. Installation of a low-e solar film may be considered that will reduce heating loads in winter and cooling loads in summer.	
Roof	The building roof is flat construction with non-permeable membrane over steel and timber deck. The roof is in good condition parts with no signs of water ingress through membrane failure. Insulation is typically limited to 25mm rigid polystyrene.	

2.2.1 Envelope Thermal Analysis

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

In general, the building envelope is performing adequately, with no areas of concern identified. Analysis revealed increased heat transfer at glazing mullions and at the vision portions of glazing elements.

It was noted that addition of solar film may be an effective option to reduce heating, and cooling loads while also reducing glare within south and west facing spaces.

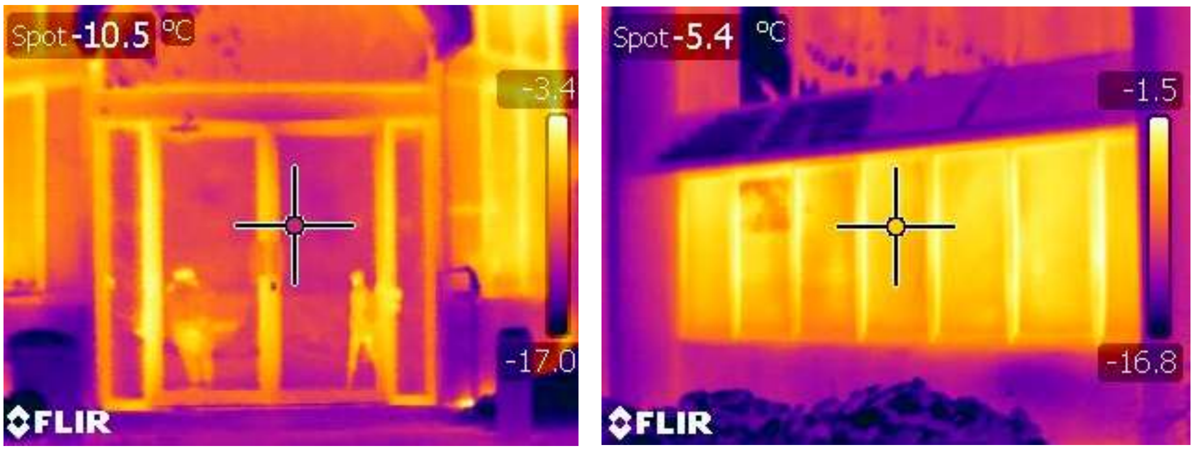


Figure 2.3: Main Building Entrance & Fenestration Thermographic Inspection

2.3 LIGHTING

Building lighting was not in the scope of this study.

2.4 MECHANICAL SYSTEMS

2.4.1 Ventilation

The building ventilation system is comprised of outdoor air supply and makeup air unit systems. The outdoor air supply units (SF-101 & SF-102) located on the east and west wing of the building roof incorporate glycol heating coils and duct outdoor air to heat pump closets located on the three building levels.

A makeup air unit (SF-103) provides makeup air for the fume hoods located in the building labs. The MAU heats the incoming air (as required) before distributing it to VAV boxes located throughout the building. Once makeup air is required in a lab, the VAV box opens to discharge air through ceiling mounted diffusers. Static control bypass dampers relieve supply air to the bypass plenum as required maintaining a constant duct static pressure. On review of the DDC system it was noted that the supply fan static pressure setpoint was 500Pa.

Figure 2.4: Makeup Air Unit & Air Handling Unit (SF-102)

Table 5: Ventilation System Inventory

Unit	Location	Service	Motor Size	Capacity (L/S)[4]
SF-101	Roof	Supply air to HP cabinets	5.0HP	1,745
SF-102	Roof	Supply air to HP cabinets	5.0HP	3,035
SF-103	Roof	Fume Hood Fan Supply	7.5 HP	4,500
SF-104	Roof	Make-up Air to labs	-	-

[4] From balancing report

AH-1	Mech. Room	Make-up Air to labs	-	-

On review of air handling operation schedule, it was noted that typical SF-101 & 102 hours of operation are daily from 07.45am until 12.30am. The makeup air unit is enabled 24/7.

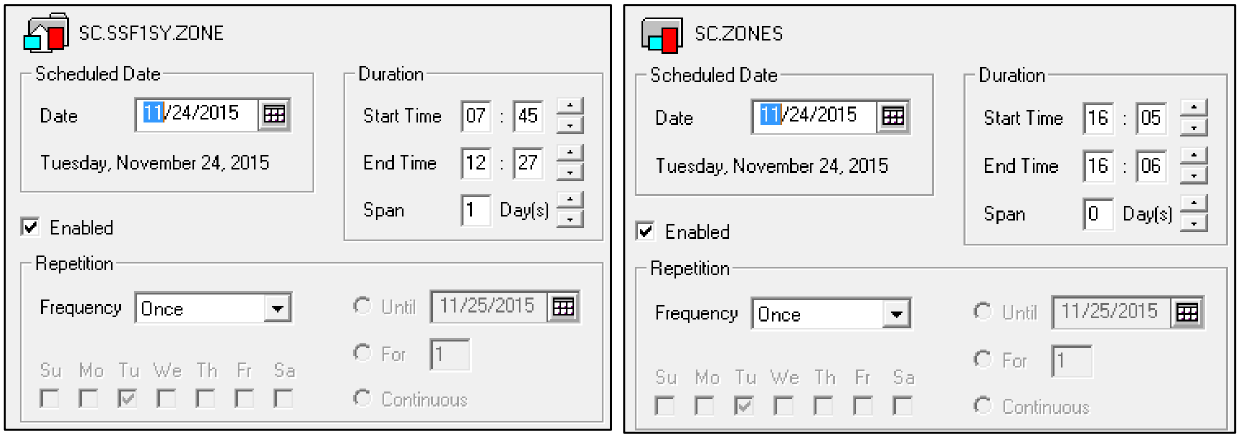


Figure 2.5: SF-101 Operation Schedule from DDC

A number of exhaust fans are installed on the building roof which serves the fume hood exhaust systems in the labs. Manual controls on the fume hoods enable the exhaust fans as required.

Figure 2.6: Lab Exhaust Fans and Fume Hoods

2.4.2 Heating

There are two boiler plants in the Science Building. On site heating is generated using two 'De Dietrich' condensing natural gas boilers and two high efficiency Aerco boilers. Each of the De Dietrich boilers has a specified gross input of 1,017MBH and output of 962MBH and a thermal efficiency of 95%. The Aerco boilers each have an input capacity of 802 MBH each. A heat pump system installed in the building provides heating through terminal units distributed throughout the facility. The boiler injects heat into the heat pump glycol loop as required.

Pump P-102 circulates heating water through the boiler and heat exchanger, while a 3-way valve allows heating water to pass directly to the heating water return. Pump P-3 & P-4 circulates heating water to east & west wing wall fin convectors, radiant panels, force flow heater. P-5 & P-6 circulates heating water through the heating coil in SF-101 & SF-102.

Table 6: Boiler Specification

Manufacturer	Model Number	Input (MBH)	Output (MBH)	Rated eff.	Manufactured
De Dietrich	310 ECO	1,017	962	~95%	2012

Figure 2.7: Existing De Dietrich Natural Gas Condensing Boilers & Circulation Pump P4

Hot water generated by the boilers serve three main end uses:

- Hot water supply to the heat exchanger / glycol loop
- Hot water supply to the air handling unit heating coils
- Hot water supply to the wallfin convectors / radiant panels

Figure 2.8: Wallfin Convectors in Stairwells

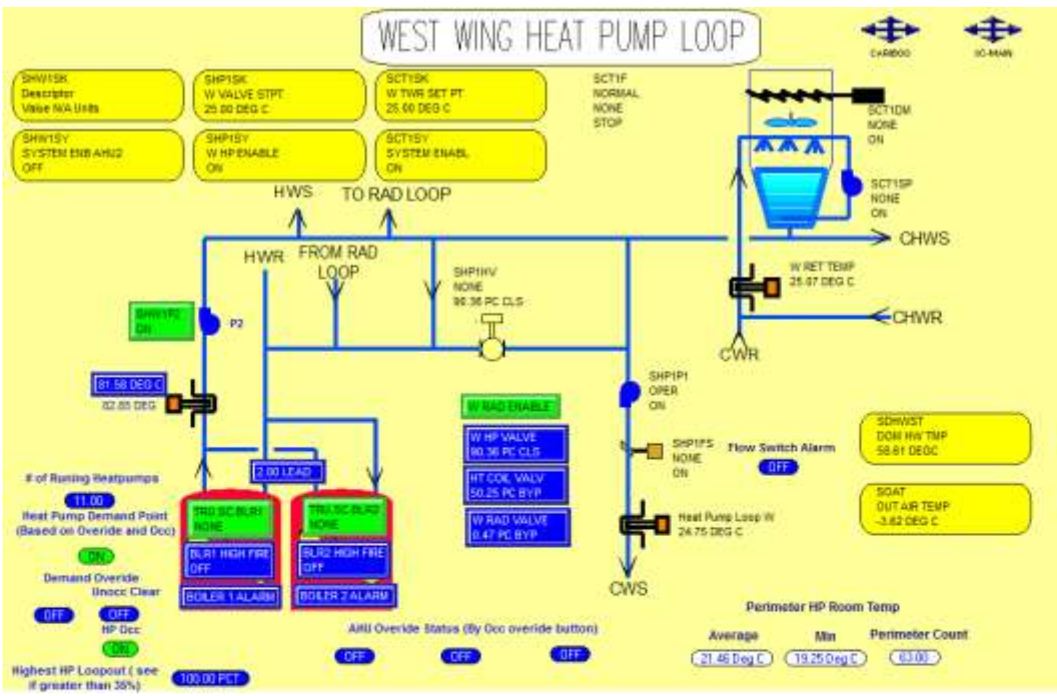


Figure 2.9: DDC Graphic of West Wing Heat Pump Loop

2.4.1 Domestic Hot Water

Domestic Hot Water at the facility is generated by a "A.O Smith" natural gas fired domestic hot water heater. See table below for heater specification. Domestic hot water once generated is stored in two domestic hot water storage tanks, also located in the boiler room. It was noted that the hot water heater did not incorporate a vent damper and that much of the hot water distribution pipework is uninsulated.

Table 7: DHW Heater Specification

Manufacturer / Model #	Input (MBH)	Storage Capacity	Rated eff.	Photo

A.O. Smith / HW - 399	399	400 USG total. 2 storage tanks at 200USG each.	80%	

2.4.2 Cooling

A heat pump system has been installed in the building to provide cooling through terminal units distributed throughout the facility. Heat is rejected from the system using cooling towers located on the building roof. The cooling towers are disabled and drained during the winter season. Both units are currently being replaced.

Figure 2.10: Fluid Cooler(s) located on roof

2.4.1 Building Controls System

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

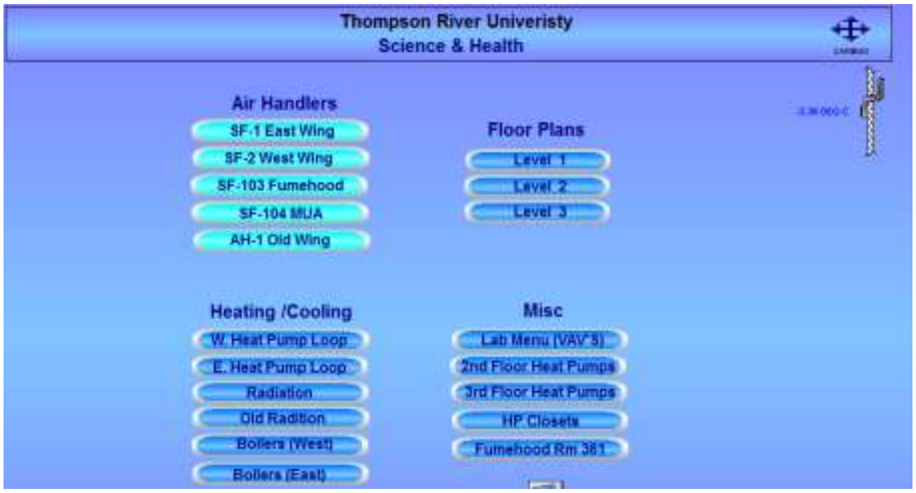


Figure 2.11: Home Screen DDC Graphic

2.5 ELECTRICAL EQUIPMENT

2.5.1 Incoming Power Supply

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

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

2.5.1 Emergency Generators

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

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

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

3.0 BUILDING ENERGY ANALYSIS

3.1 CURRENT ENERGY USE

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

Natural Gas	Natural gas utility data was supplied by TRU for the years 2011 – 2012 as there has been a failure with the pulse metering system at this site. Natural gas consumption is attributable to building heating, and domestic hot water generation.
Electricity	Electrical utility data was extracted from the Pulse Energy system provided for the facility for 2012-2015

3.1.1 Electricity Consumption

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

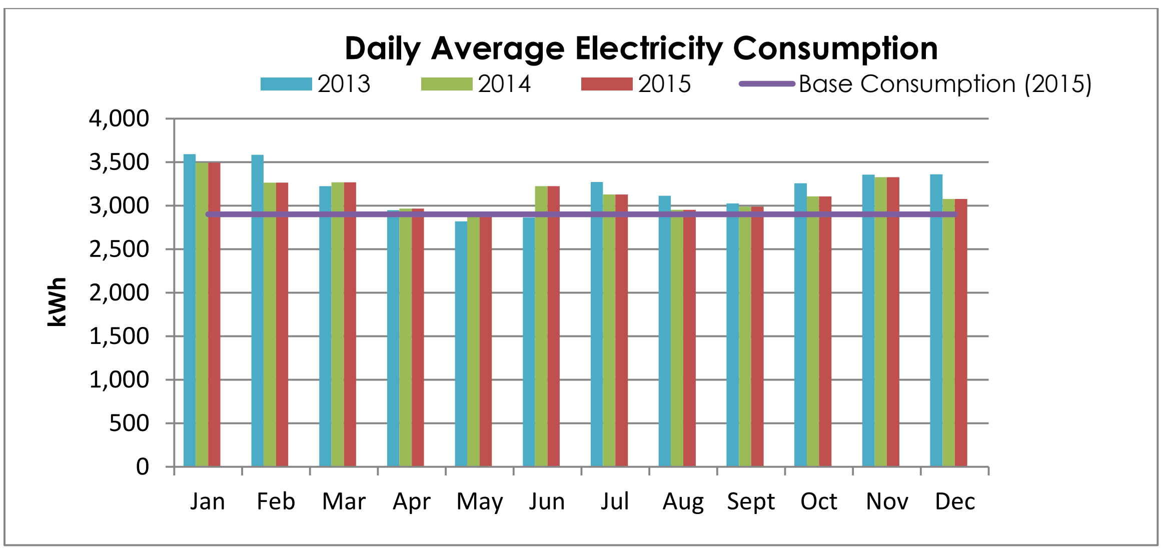


Figure 3.1: Average daily non-heating electricity consumption for 2012–2015

The daily lowest electricity consumption in 2015 for the facility is 2,903kWh and occurs in May. The building has a relatively consistent consumption profile throughout the year with an increase in electricity consumption during winter months (November - April) attributable to increased operation of building lighting systems and increased student occupancy. Increased electricity consumption during summer periods (June & July) can be attributed to the operation of the fluid cooler.

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

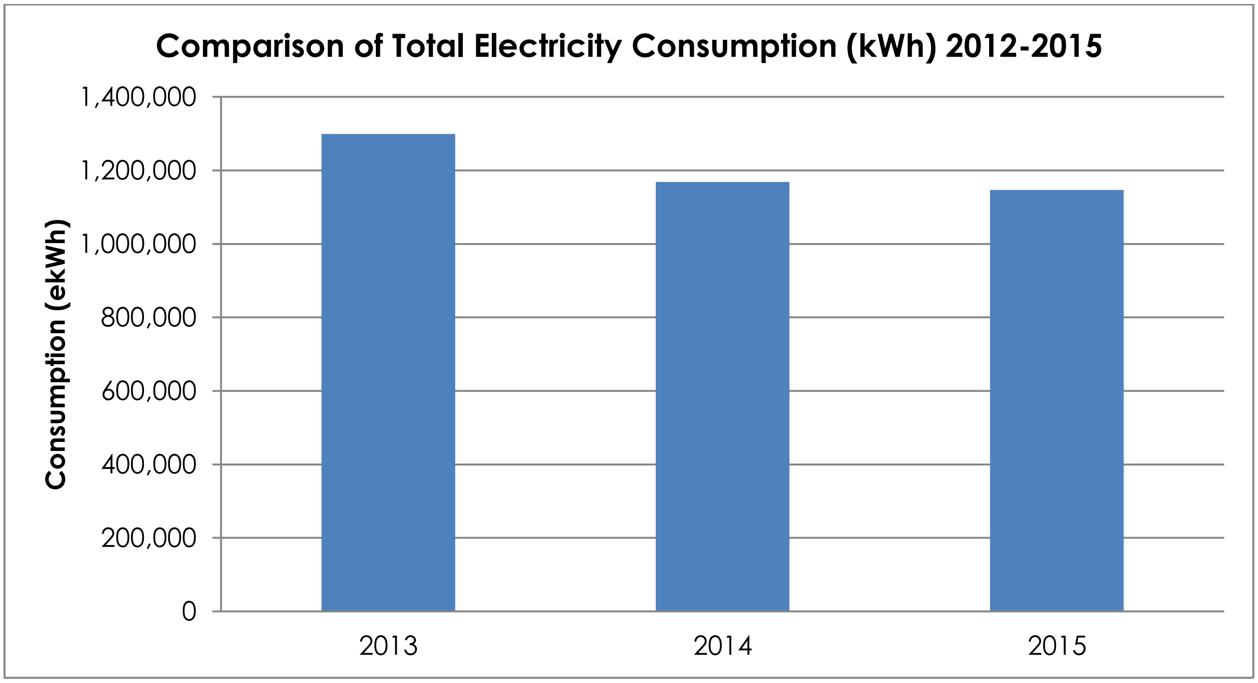


Figure 3.2: Total electricity consumption comparison 2012-2015

3.1.2 Electricity Demand

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

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

The lowest monthly electricity demand in 2015 occurs in May, and was 231kW.

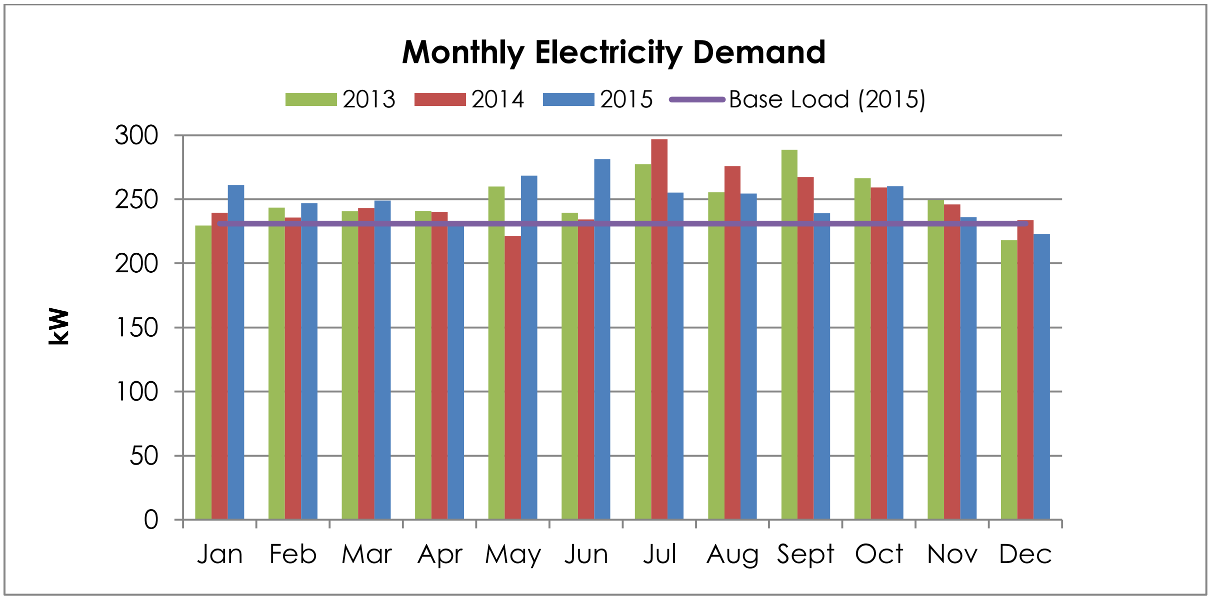


Figure 3.3: Building Demand Profile (2012-2015)

3.1.3 Natural Gas Consumption

Natural gas utility data was supplied by TRU for April 2011 – September 2012. There has been a failure with the pulse metering system at this site and more current data was not available at the time of writing this report.

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.

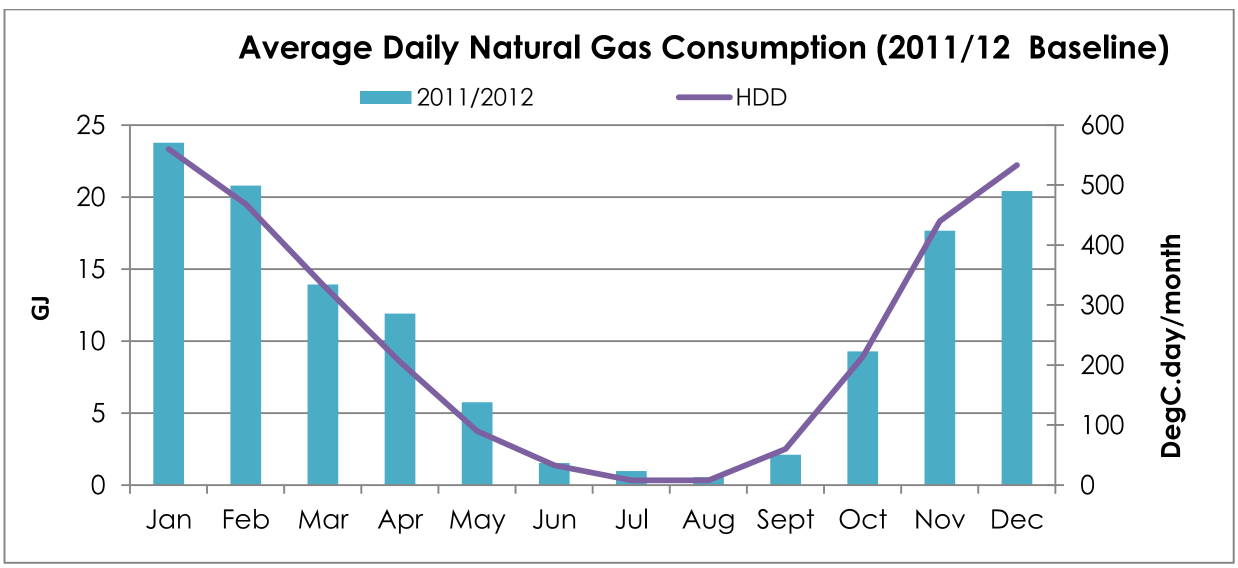


Figure 3.4: Average daily Natural Gas consumption and heating degree-days (2011/2012)

The natural gas intensity profile is reflective of a facility with a significant weather dependent load. Natural gas consumption peaks during colder winter conditions and is reduced during the summer. Peak consumption in 2012 was recorded in January at 24 GJ/day with summer base load of around 1 GJ/Day. Consumption of 1GJ/Day in July and August 2015 can be attributed to the domestic hot water loads in the building.

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 Science and Health Sciences;

Table 8: BEPI for Science Building

BUILDING ENERGY PERFORMANCE INDEX (2015)								
	Electricity Cons. (kWh)	Electricity Cost ($)	Natural Gas Cons. (GJ)	Natural Gas Cost ($)	Total ekWh	Total Cost[5]	GHG Emissions (tonnes)	BEPI $kWh/m^2/yr$
Existing	1,146,753	91,740	3,893	38,930	2,228,143	136,290	225	216

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

3.2 ENERGY END-USE ANALYSIS

3.2.1 Total Energy Breakdown

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

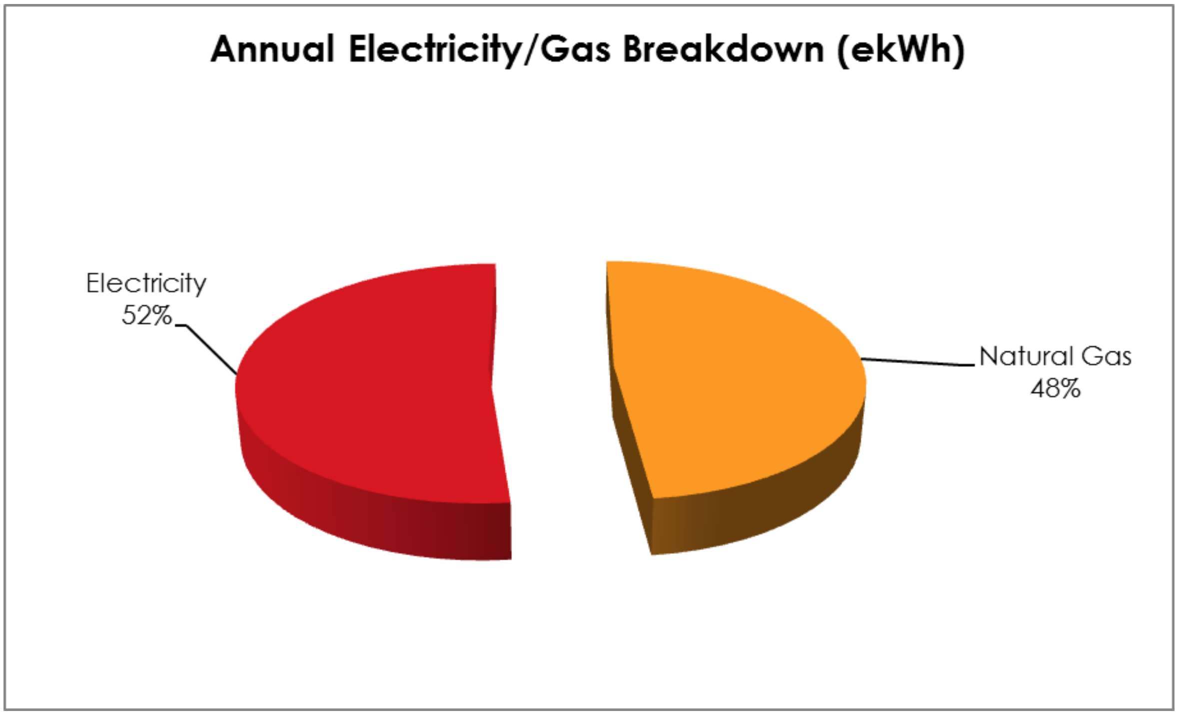


Figure 3.5: Breakdown of Energy Consumption by Fuel type

3.2.2 Electricity

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

The largest electrical consuming equipment/process is the heat pumps and lighting. Heat Pump operation accounts for almost 33% of total building electricity consumption, with lighting accounting for almost 29%. The distributed heat pumps have such a significant load as they are the primary sources of heating and cooling the building.

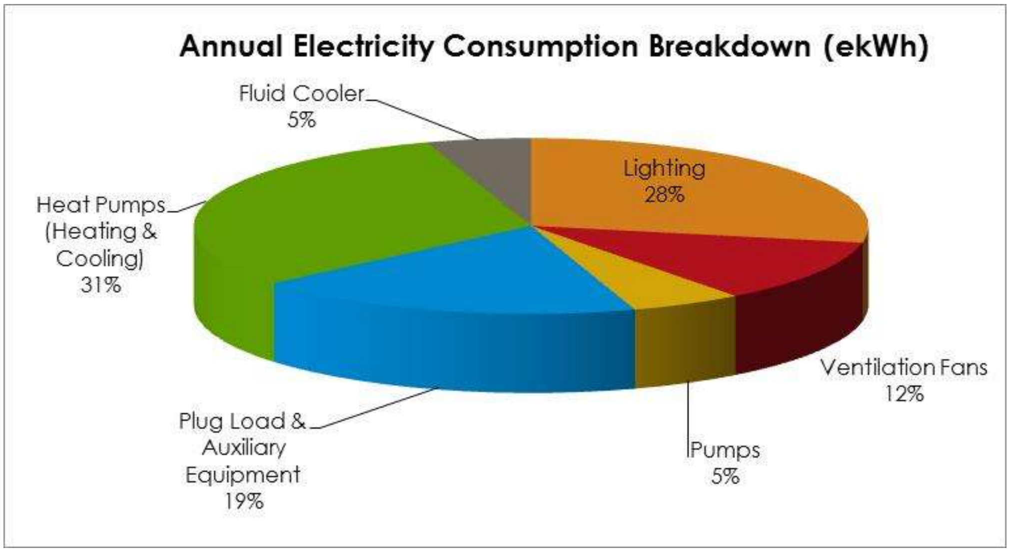


Figure 3.6: Breakdown of Electricity Consumption in kWh (2015)

3.2.3 Natural Gas (Heating)

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

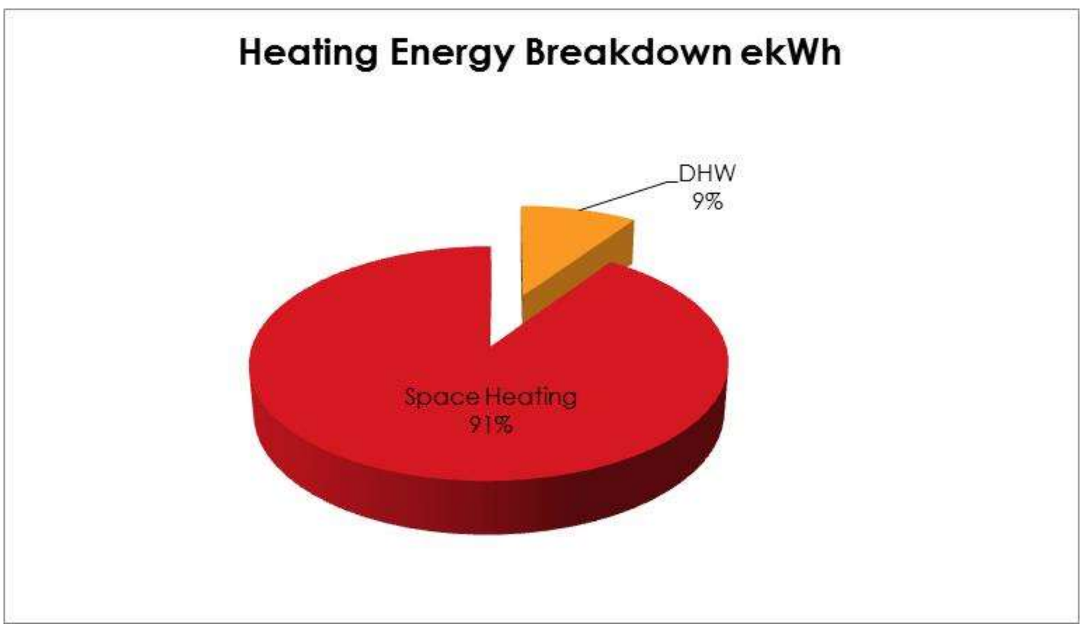


Figure 3.7: Natural Gas End Use Profile (2011/12)

4.0 ENERGY CONSERVATION MEASURES

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

4.1 ECM 1A – REPLACE AIR HANDLING AND MAKEUP AIR UNITS

A “Mark Hot” air handling unit (AH-1) provides makeup air to the old wing. The outdoor air damper is interlocked with the unit supply fan and incorporates a variable frequency drive. The unit has a heating coil to condition outdoor air prior to supply to the building. There are few details on the unit, and it is not referenced in the operations and maintenance manuals. It is anticipated that this unit was installed in the 1980s and as such is past its useful life.

A direct gas fired engineered air makeup air unit (SF-104) is installed on the building roof and provides makeup air to the building. The unit is older vintage and should be considered for replacement.

Figure 8: AH-1 and SF-104

Additionally, outdoor air supply units (SF-101 & SF-102) located on the east and west wing of the building roof which supply outdoor air to heat pump closets located on the three building levels are approaching 25 years’ operating life. As such, they should be considered for replacement.

Figure 9: Air Handling Units SF-101 & SF-102

Acceptable concentrations for Carbon Dioxide in occupied spaces are defined by ASHRAE62.1. In general, concentrations in the range of 800 to 1000 ppm are acceptable. On review of the DDC system, Carbon Dioxide levels in the building were noted to range from 400-700PPM.

Reduction of outdoor air volumes, especially in winter months, will reduce natural gas consumption. On replacement of the air handling units, the ventilation strategy should be reviewed to ensure outdoor air volumes reflect occupant requirements.

4.1.1 Scope of Work

It is proposed that all older vintage air handling and makeup air units be replaced with high efficiency alternatives, as per below;

Outline	Description
Baseline equipment	Four (4) units as profiled in the ECM introduction.
Upgrade Description	Replace the four (4) units with high efficiency units, complete with variable frequency drives.
Affected area in building	Units are located on the roof and mechanical room. Roof units will be replaced on a like for like basis and as such should not require structural/support upgrades.
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 low risk.

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
- Natural gas combustion efficiency improvements in the new direct fired units
- Reduced outdoor air supply volume, correlated to occupant demand

4.1.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
BASELINE COST	$(130,000)
TOTAL RETROFIT COST	$ 543,000
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 13,800
PAYBACK (years)	40

4.1.4 Impact on Operations and Maintenance

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

4.1.5 Risk Analysis

There is minimal risk with implementing this measure.

4.2 ECM 1B – IMPLEMENT EXHAUST HEAT RECOVERY BY INSTALLING RUNAROUND LOOP

The Science and Health Science Building contains a number of labs, with integrated fume hood exhaust to remove harmful substances in the air as a byproduct of lab assignments. A significant amount of energy is lost to the atmosphere as the fans exhaust 100% room air at temperatures of 21-24°C. There is potential to reduce this heat loss by implementing heat recovery in the form of a run-around coil.

A run-around coil is typically comprised of finned-tube copper coils, located in the exhaust and incoming air streams, connected by a pipe through which a water/glycol solution is pumped. Although not as efficient as heat wheel technology, the main advantage of run-around coils are that the supply and exhaust streams are separated, thus avoiding contamination. Multiple supply and exhaust systems can also be connected on the same loop.

It is difficult to recover heat in the current exhaust arrangement, however if ECM-1A were to implemented, it would be a good opportunity to install a common plenum and recover heat from this to the new makeup air and rooftop units.

Figure 10: Fume hood exhaust and fans

4.2.1 Scope of Work

The scope of work will involve the decommissioning and replacement of the existing exhaust fans with new common exhaust fan/plenum located at each existing fan assembly. A run-around coil will be installed from the exhaust air plenum to the air intake of the new makeup air and rooftop units.

The new makeup air units described in ECM-1A will be specified with the ability to incorporate runaround coil.

Outline	Description
Baseline equipment	Fume hoods are exhausted on an individual basis, with no heat recovery.
Upgrade Description	In line with ECM-1, makeup air and rooftop unit replacement, the fume hood exhaust fans will be consolidated into a common exhaust plenum and run around coil installed to recover heat back to the new supply air units. An air damper will be installed at each fume hood exhaust location.
Affected area in building	Roof
Service life	25 years
Non energy benefits	n/a
Risk assessment	This is a relatively low risk upgrade, however will require detailed engineering design to ensure exhaust air volumes are maintained (as per design intent) at the fume hoods.

4.2.2 Methodology of Savings Calculations

Savings have been based on an estimated run-around coil heat recovery effectiveness of 40%. 30 year average outdoor air temperature information for Kamloops was used to calculate baseline energy consumption based on assumed hours of operation and exhaust air volumes taken from the original TAB reports.

4.2.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 190,700
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 3,953
PAYBACK (years)	48

4.2.4 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 exhaust fans have reached their end of life.

4.2.5 Risk Analysis

This is a low risk measure as existing heat pumps will be replaced on a like for like basis. A full system recommissioning exercise should be completed once the measure has been implemented.

4.3 ECM 2 – REPLACE FLUID COOLERS (CT-1 & CT-2) & HEAT PUMPS

Distributed heat pumps located in the building provide zonal heating and cooling. In summer, the heat pumps operate to cool the facility, and reject heat from the heat pump loop through two fluid coolers located on the building roof.

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

Figure 11: Cooling Towers located on the building roof

4.3.1 Scope of Work

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

Outline	Description
Baseline equipment	Two Fluid coolers and distributed water source heat pump system.
Upgrade Description	Upgrade the existing heat pumps and fluid cooler with a high efficiency unit.
Affected area in building	Distributed heat pumps located throughout the facility and fluid cooler on the building roof.

Service life	25 years
Non energy benefits	n/a
Risk assessment	This is a relatively low risk upgrade, as equipment will be replaced on a like for like basis. The heat pumps should be replaced during a period when the building has minimal occupancy, as there will be reduced ventilation and heating/cooling in the building during this time.

4.3.2 Methodology of Savings Calculations

Savings have been based on improved compressor efficiencies achieved through retrofitting the older units with new high efficiency units. Average EER of the existing units is 9 and new EER average is 14.1.

4.3.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 426,800
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 10,700
PAYBACK (years)	40

4.3.4 Impact on Operations and Maintenance

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

4.3.5 Risk Analysis

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

4.4 ECM 3 – INSULATE HOT WATER/DHW DISTRIBUTION PIPEWORK

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

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

4.4.1 Scope of Work

Outline	Description
Baseline Equipment	Existing hot water pipework is missing insulation in many areas, and some pipework which is insulated is seeing the insulation fail and tear away.
Upgrade Description	It is proposed the all hot water pipework undergo an insulation retrofit. Insulation should be fibre-glass pipe wrap with install thickness based on pipe diameter.
Affected Area in Building	Boiler/Mechanical Room
Service Life	20 years

Non Energy Benefits	Improved temperature conditions in the boiler room for maintenance staff.
Risk Assessment	There is minimal risk associated with the implementation of this measure.

4.4.2 Methodology of Savings Calculations

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

4.4.3 Cost, Saving and Payback

The anticipated savings are as follows;

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

4.4.4 Impact on Operations and Maintenance

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

4.5 ECM 4 – INSTALL SOLAR FILM ON GLAZING

Solar films such as low-e coatings and tinting is commonly added to glazing to improve performance from an energy, glare or aesthetic perspective. In the case of the science building, it appears that no film was installaed at the time of construction. Rather than replacing the glass, a cost effective option is to install a film on the interior surface. Interior mounted glazing films have design service life of fifteen to twenty years and have a proven track record.

4.5.1 Scope of Work

Outline	Description
Baseline equipment	The existing glazing system on the Science Building is double glazed clear insulated glazing units (IGU) within an aluminum frame.
Upgrade Description	It is proposed to install a glazing film on the interior of the IGUs. Installation of a low-e glazing film will reduce heat loss in winter, and heat gain in summer as well as reducing glare on south and west facing glass.
Affected area in building	It is proposed to install the glazing film on the interior surface of all glazing
Service life	The service life for this measure will be 20 years.
Non energy benefits	In addition to reduced heating and cooling energy, installation of the film reduces glare into spaces.
Risk assessment	There is little risk associated with implementation of this measure.

4.5.2 Methodology of Savings Calculations

Savings are calculated by running an energy model on one square meter of glass in the Kelowna weather region. The simulation is run for clear double glazed and clear low e glass, and accounting for the efficiency of the boiler and cooling equipment

4.5.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 240,100
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 4978

PAYBACK (years)	48

4.5.4 Impact on Operations and Maintenance

It assumed that there will be a positive impact on operations and maintenance through implementation of this measure as operating hours for heating and cooling equipment will be reduced.

4.5.5 Risk Analysis

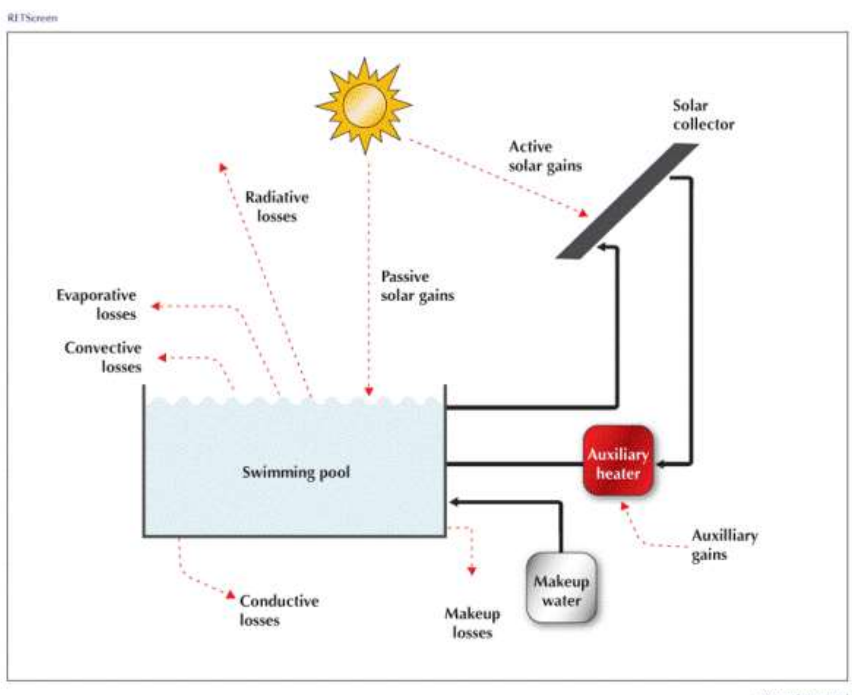
This is a low risk measure.

4.6 ECM 5 – INSTALL SOLAR DOMESTIC 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.



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The Science 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

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

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

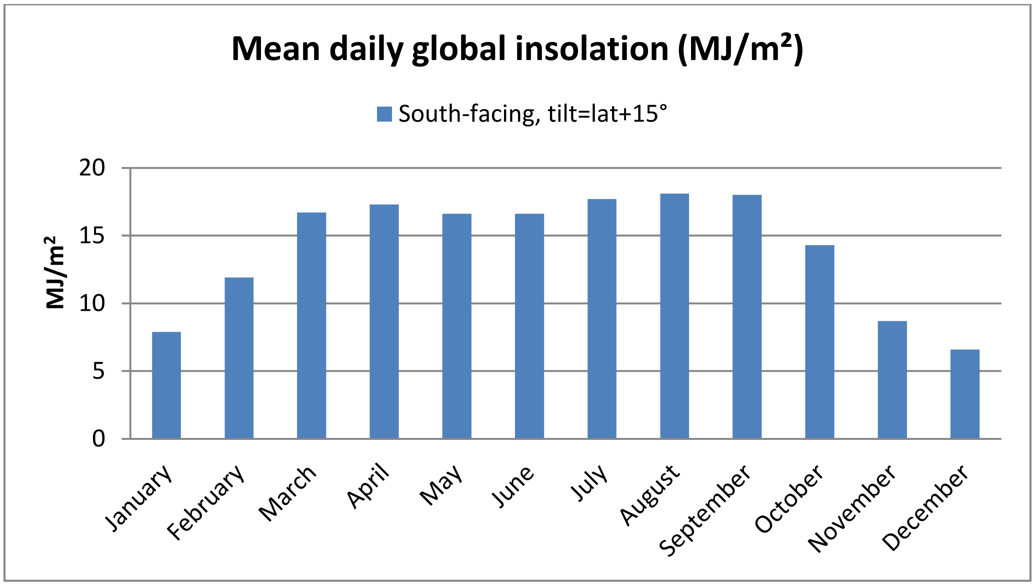

Figure 4.12: Graph of Solar Radiation in Kamloops BC

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.

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	$ 105,300
MAINTENANCE SAVINGS	-
TOTAL ENERGY SAVINGS	$ 1,040
PAYBACK (years)	104

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.

4.7 ECM 6 – SOLAR PV INSTALLATION

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

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

It is proposed that 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.

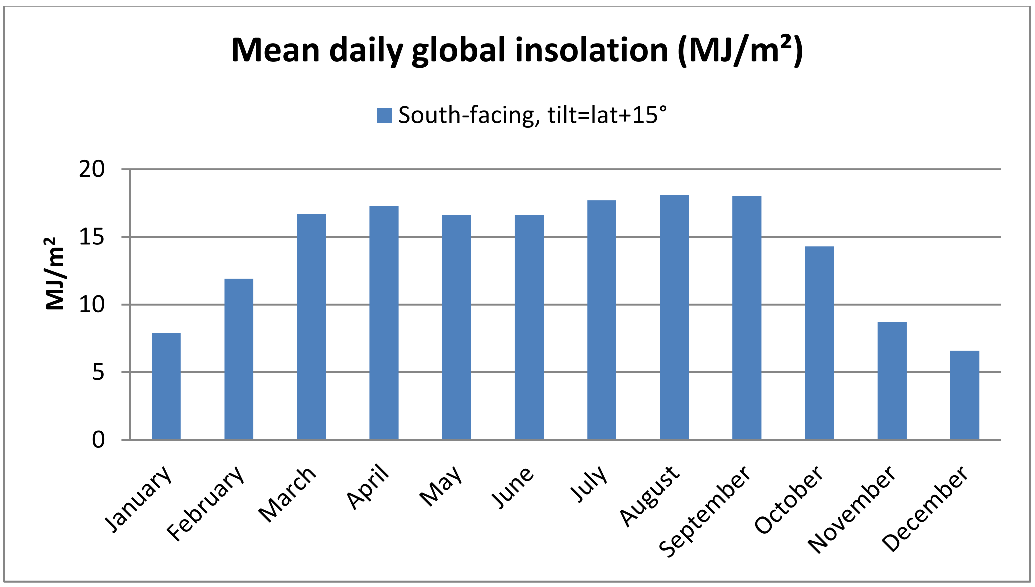

Figure 4.13 Graph of Solar Radiation in Kamloops BC

4.7.1 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 is a maturing technology, however have been in operation internationally for decades.

4.7.2 Methodology of Savings Calculations

Savings have been calculated by performing a RETScreen analysis.

4.7.3 Cost, Saving and Payback

The anticipated savings are as follows;

SIMPLE PAYBACK	
TOTAL RETROFIT COST	$ 98,100
TOTAL SAVINGS	$ 24,498
PAYBACK (years)	**4**

4.7.4 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.

4.7.5 Risk Analysis

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

5.0 BUILDING MANAGEMENT AND BEHAVIORAL OPPORTUNITIES

5.1 BUILDING ENERGY MANAGEMENT SYSTEM

The existing building controls system at the facility is pneumatic; and much of the hardware has exceeded its useful life. Additionally, replacement parts are increasingly difficult and expensive to source. As such, it is recommended that TRU migrate the controls system (Hardware) to a fully electronic system. At the same time, it is recommended that the controls software to be updated.

By moving to a fully electronic system, the air compressor can be decommissioned resulting in direct energy savings. Additional benefits include:

- Operations and maintenance savings as old actuators will not require replacement
- The ability to create multi-trends is much more straightforward in newer DDC controls
- Additional energy monitoring and reporting software can make it easier to evaluate building energy performance

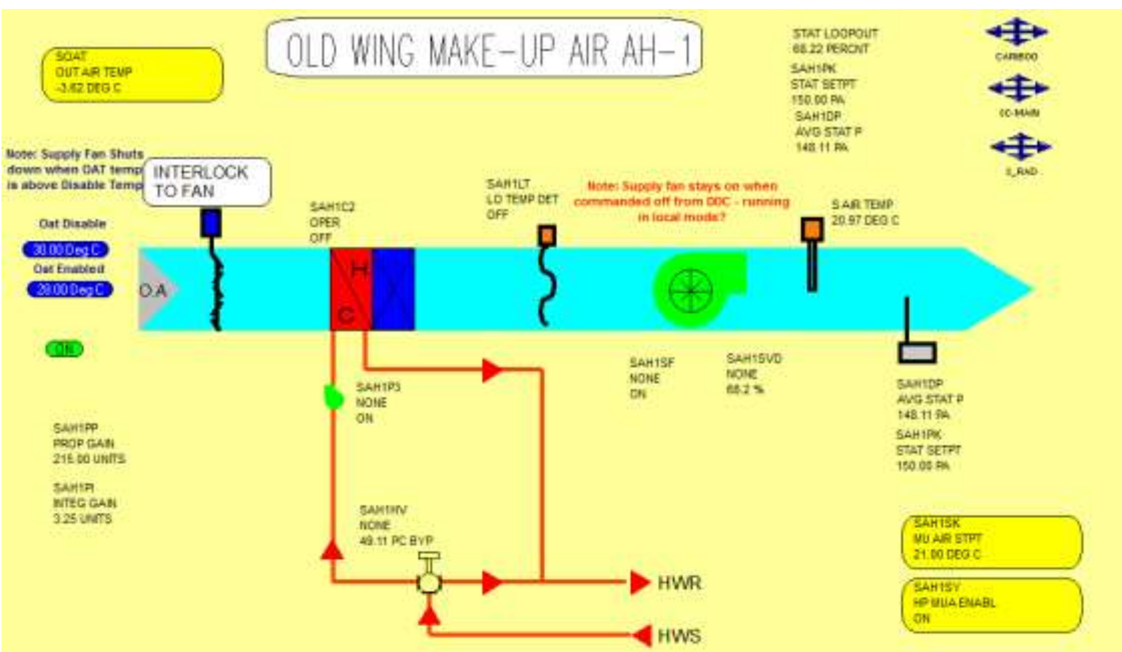

Figure 14: Existing DDC Graphical output (AH-1)

Estimated costs for this work have been estimated at $80,000-$100,000.

5.2 FURTHER UPGRADES

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

5.3 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.

5.4 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.

5.5 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 1A	Replace Air Handlers	463	$ 4,629	106,916	$ 8,553	-	$ 579	$ 543,000	$ 13,761	39.5	26.0
ECM 1B	Refurbish Existing AHUs & Implement Heat Recovery	326	$ 3,953	-	$ -	-	$ -	$ 190,700	$ 3,953	48.2	16.3
ECM 2	Replace Heat Pumps & Fluid Cooler	-	$ -	134,152	$ 10,732	-	$ -	$ 426,783	$ 10,732	39.8	0.3
ECM 3	Pipework Insulation	54	$ 970	-	$ -	-	$ -	$ 5,700	$ 970	5.9	2.7
ECM 4	Glazing Film	187	$ 1,872	38,831	$ 3,106	-	$ -	$ 240,100	$ 4,978	48.2	10.4
ECM 5	Solar DHW										
ECM 6	Solar PV	-	$ -	219,000	$ 17,520	6,978	$ 6,978	$ 98,100	$ 24,498	4.0	5.7
TOTAL		**1,031**	**11,423**	**498,899**	**39,912**	**6,978**	**7,557**	**1,504,383**	**58,893**	**26**	**61**

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	1,146,753	$91,740	3,853	$38,530	2,217,030	$135,839	223	215
Reference Building (Academic) 280								
Post Retrofit	647,854	$44,850	2,822	$28,222	1,431,798	$73,072	158	139
Savings	44%	51%	27%	27%	35%	46%	29%	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 223 tonnes/year[7].

Table 11: Emissions Reductions Associated with the ECMs Recommended

EMISSIONS REDUCTIONS						
	Electricity		Natural Gas		Total	
Total Energy Saved	498,899	kWh/yr	1,031	Gj	785,232	ekWh
Total CO_2e Emissions Saved	13	tonnes/yr	52	tonnes/yr	65	tonnes/yr

The emissions savings projection of 158 tonnes per year equates to approximately 34% 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 Science and Health Science 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 10,325m^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 1A	Replace Air Handling & Makeup Air Units	✓
	ECM 1B	Implement Exhaust heat Recovery by Installing a Runaround Loop	✓
	ECM 2	Replace Fluid Coolers (CT-1 & CT-2) & Heat Pumps	✓
	ECM 3	Insulate Hot water/DHW distribution Pipework	✓
	ECM 4	Install Solar Film on Glazing	✓
	ECM 5	Install Solar Domestic Hot Water Heater	×
	ECM 6	Install Solar PV	✓

It is anticipated that should all of the selected measures be implemented, there would be annual savings in utilities of approximately $60,000 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 78 tonnes (equivalent to around 36% of current emissions).

Total Investment	Total Cost Savings	Payback	Total Natural Gas Savings (GJ)	Total Electricty Savings (kWh)	CO_2 Reduction (Tons)
$1,504,000[8]	$58,900	26	1,031	499,000	78

[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 Natural Gas Utility Records (GJ)								
	2013			2014			2015		
	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.
Jan	737	31	24	737	31	24	737	31	24
Feb	582	28	21	582	28	21	582	28	21
Mar	432	31	14	432	31	14	432	31	14
Apr	319	30	11	319	30	11	319	30	11
May	176	31	6	176	31	6	176	31	6
Jun	46	30	2	46	30	2	46	30	2
Jul	30	31	1	30	31	1	30	31	1
Aug	17	31	1	17	31	1	17	31	1
Sept	63	30	2	63	30	2	63	30	2
Oct	288	31	9	288	31	9	288	31	9
Nov	530	30	18	530	30	18	530	30	18
Dec	633	31	20	633	31	20	633	31	20
Total	3,853			3,853			3,853		

	Annual Electricity Consumption Utility Records (kWh)								
	2011			2012			2013		
	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.	Monthly	Period Days	Daily Avg.
Jan	113,407	31	3,658	111,382	31	3,593	108,244	31	3,492
Feb	100,284	28	3,582	100,369	28	3,585	91,453	28	3,266
Mar	102,148	31	3,295	100,006	31	3,226	101,293	31	3,268
Apr	90,566	30	3,019	88,447	30	2,948	89,007	30	2,967
May	97,564	31	3,147	87,425	31	2,820	90,005	31	2,903
Jun	105,066	30	3,502	85,946	30	2,865	96,794	30	3,226
Jul	121,274	31	3,912	101,495	31	3,274	97,039	31	3,130
Aug	113,615	31	3,665	96,606	31	3,116	91,556	31	2,953
Sept	115,503	30	3,850	90,786	30	3,026	89,710	30	2,990
Oct	114,647	31	3,698	101,058	31	3,260	96,380	31	3,109
Nov	115,804	30	3,860	100,711	30	3,357	99,854	30	3,328
Dec	109,554	31	3,534	104,173	31	3,360	95,420	31	3,078
Total	1,299,000			1,168,000			1,147,000		