Thompson Rivers University
ASHRAE Level 1 Energy Study

Energy Study for:

Trades and Technology (TT) and Industrial Training and Technology Centre (ITTC)

Attention:

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1.1 Overview and Facility Use

The Trades and Technology (TT) and Industrial Training and Technology Centre (ITTC) Buildings are located on Thompson Rivers University Campus in Kamloops, British Columbia. They were constructed in 1997 and 2018 respectively. The gross conditioned square footage of both buildings is 15,907 m^2 (171,159 ft^2). The TT building is a two-level building and houses workshops, various trades classrooms, common rooms, a café and offices. The ITTC building is a three-level building and houses workshops, classrooms, labs offices, student lounges and common spaces. It also has a communications room.

1.1.1 Physical condition and window type

The ITTC building is new and is in excellent condition. The TT building has been well maintained and is in good condition. The windows in both buildings are double paned.

1.2 Mechanical Systems

1.2.1 Ventilation

Ventilation for the buildings is as follows:

<u>TT:</u>

- AHU-1, AHU-2 and AHU-3 are mixed air, variable volume units that supply air to the building's classrooms and common spaces via variable air volume boxes (VAVs). The three units are equipped with chilled water-cooling coils, and indirect gas fired burners. Transfer fans transfer air from the hallway to workshops on Level 2.
- FC-1 is a mixed air, constant volume single zone unit that serves an old telecommunication room that has been repurposed as a classroom. It has hot water heating and chilled water cooling.
- MUA-1 is a 100% outdoor air, variable air volume unit that serves the welding room. It has an indirect fired gas burner.
- RTU-15 is a constant volume, mixed air unit with indirect fired gas heating and direct expansion cooling. It provides conditioned air to the workshops via constant volume diffusers.

<u>ITTC:</u>

- AHU-4 is a 100% outdoor air unit, variable volume unit with a heat recovery wheel, hot water heating coil and direct expansion cooling. It provides conditioned air to the entire building via VAVs in the spaces.
- FCU-1 is a mixed air, constant volume unit with chilled water cooling. It provides cooling to the level 2 electrical room.
- FCU-2 is a mixed air, constant volume unit with chilled water cooling. It provides cooling to the level 3 communications room.
- There are four water source heat pumps that serve the student lounge, study spaces and lockers. These heat pumps are only enabled for cooling and based on the schematics are only connected to the chilled water loop. They have been installed in areas with a high latent cooling load. They receive air directly from AHU-4.

1.2.2 Cooling

- There are two chillers, one for ITTC and one for TT.

- The chiller in ITTC (CH-2) works with a condensing unit (CU-1) to provide cooling for the active chilled beams and heat pumps in the building.
- The chiller in TT (CH-1), which was replaced in 2019, serves cooling coils in AHU-1 to 3, and FC-1.

1.2.3 Heating

- The ITTC and TT building share heating water, other than that the buildings are separate. The heating water for the 2 buildings can be fed by either:
  - 6 non-condensing gas boilers in the Trades building (all original to building except 1)
  - 2 electric boilers for ITTC (new). These are used most of the time.
- These boilers provide heating water to the following systems:
  - Heating coils in AHU-4 and terminal VAVs in ITTC and TT
  - Hot water perimeter radiation and ceiling radiant panels in ITTC
  - Force flow heaters, unit heaters in both ITTC and TT
- There is one additional boiler in the power engineering shop that they use for teaching, they are hoping to tie this boiler into the heating loop. It is also non-condensing.
- There used to be a boiler for humidification but it has been decommissioned due to smells (there was a chemical in steam system to keep it clean, when went through ducts caused smells, complaints); They are no longer providing humidification to TT.
- Additional Heating for the buildings is provided by the following:
  - Gas fired heating in AHU-1,2,3, MUA-1 and RTU-15
  - Gas Fired unit heaters provide heating to the automotive, carpentry, electrical workshops, tech transfer and the tool room in TT.
  - Heat recovery wheel in AHU-4

1.2.4 Domestic Hot Water

Domestic hot water (DHW) for TT and ITTC is separate.

- ITTC has 2 electric DHW heaters (DHW-1/2)
- TT has 2 non-condensing gas DHW heaters (HWT-1/2). These are from 2010 (HWT-1), 2016 (HWT-2). Operations believes these are significantly oversized and that a they could be 60-gallon rather than 80.

1.3 Lighting System

Lighting for both buildings is 100% LED except for a few fluorescents in the TT building shops. These are only used for short intervals so there are no plans to replace these currently as it is estimated the savings will be minimal. However, TRU is currently in the process of replacing all lighting on campus with LED so they will likely be replaced eventually.

1.4 Control Equipment

Both the TT and ITTC building are on a Siemens BAS. However, the boiler rooms and mechanical rooms have just been switched from a Siemens BAS to an Automated Logic system. The remaining devices in both buildings will be switched over in the near future. SES and Care Systems are currently in the process of implementing the recommendations from the 2020 Fortis Bundle B study and are hoping to integrate the remainder of the building switchover as part of this work. It should be noted that the remainder of the control devices in the TT building are original to the building and are going to need to be replaced soon.

1.5 Energy Analysis

1.5.1 Energy Use Profile

Figure 1 presents the building's electrical consumption since 2016. The electricity consumption increased significantly in February of 2019 when the electric boilers in the ITTC building were installed. These boilers now provide heating for all the TT and ITTC building heating water systems. This creates a seasonal profile with a peak in the colder winter months when the heating systems are most active. This is the most recent energy data available for both buildings. Only electrical data from February 2019 onwards was used to calculate the baseline.

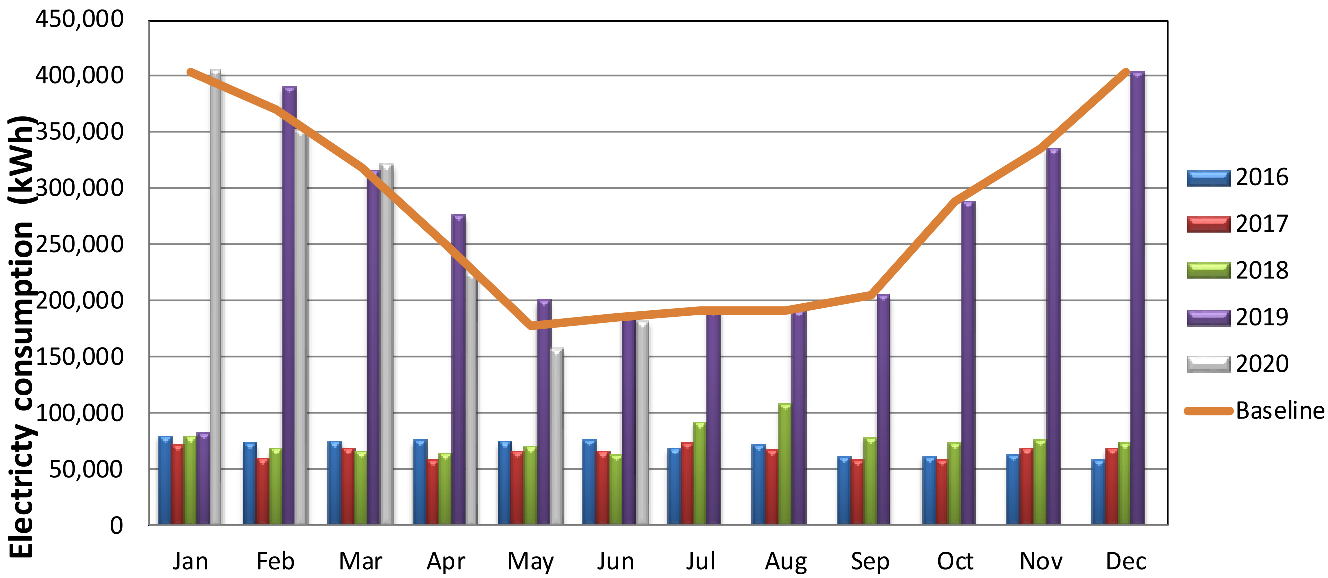

Figure 1: Monthly Electricity Consumption

Natural gas data from January 2016 through February 2020 is presented in Figure 2. However, only data from February 2019 onwards was used for this analysis as this was when the electrical boilers were installed in the ITTC building. This caused a significant reduction in the buildings' overall gas usage. The gas boilers in the TT building are now only used as backup when the electric boilers go down This is the most recent gas data available for both buildings.

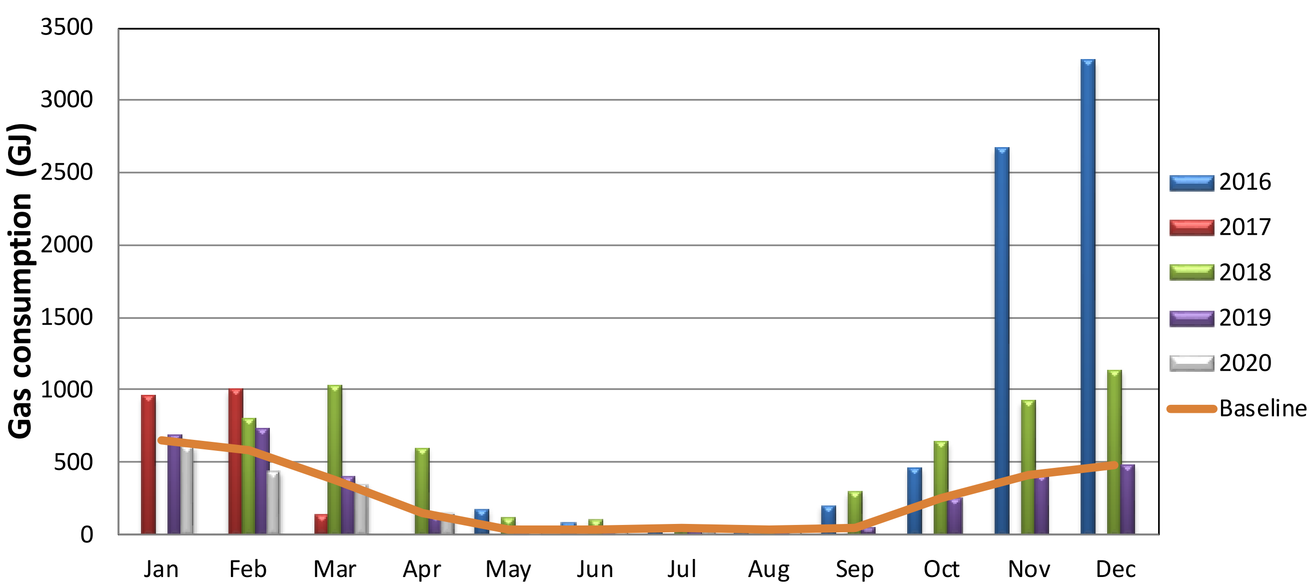

Figure 2: Monthly Gas Consumption

1.5.2 Energy Intensity Analysis

A summary of the baseline energy consumption and the corresponding costs and energy intensity for the facility is presented in Table 1. The combined Energy Use Intensity (EUI) for both buildings is 946 MJ/m^2.

Table 1: Summary of Baseline Energy Data

Utility	Energy Use (GJ)	EUI (MJ/m2)	Cost ($)	Cost ($/ft2)
Gas	3,095	195	$46,419	$0.27
Electricity	11,961	752	$210,370	$1.23
Electricity	**15,056**	**946**	**$256,790**	**$1.50**

1.5.3 Energy End Use Breakdown

The estimated breakdown of electricity consumption by building system is presented in Figure 3.

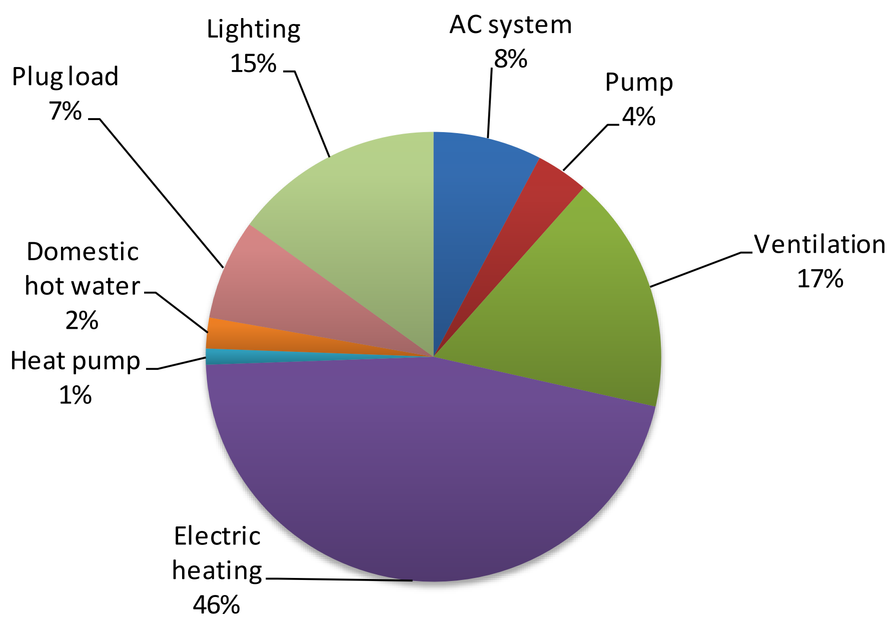

Figure 3: Electricity Consumption

The estimated breakdown of gas consumption by building system is presented in Figure 4. Supplemental heating comprises unit heaters and infrared heaters throughout the buildings.

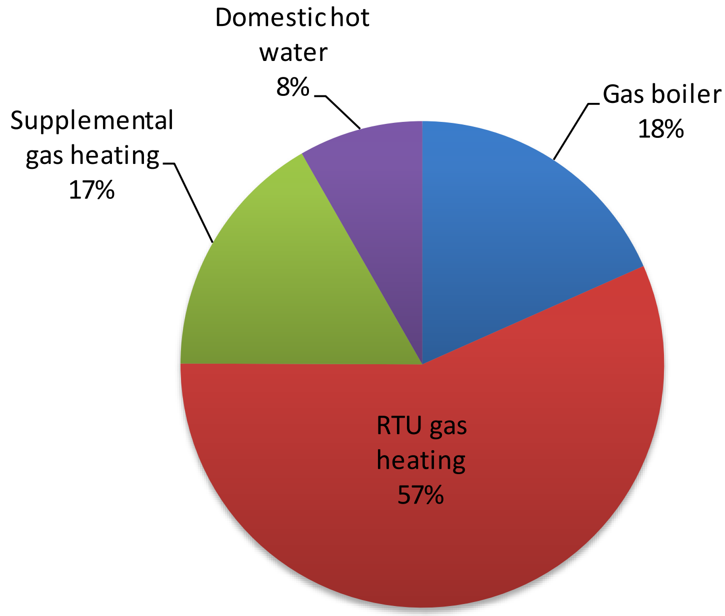

Figure 4: Gas Consumption

The estimated percentage of total energy consumption by building system is presented in Figure 5.

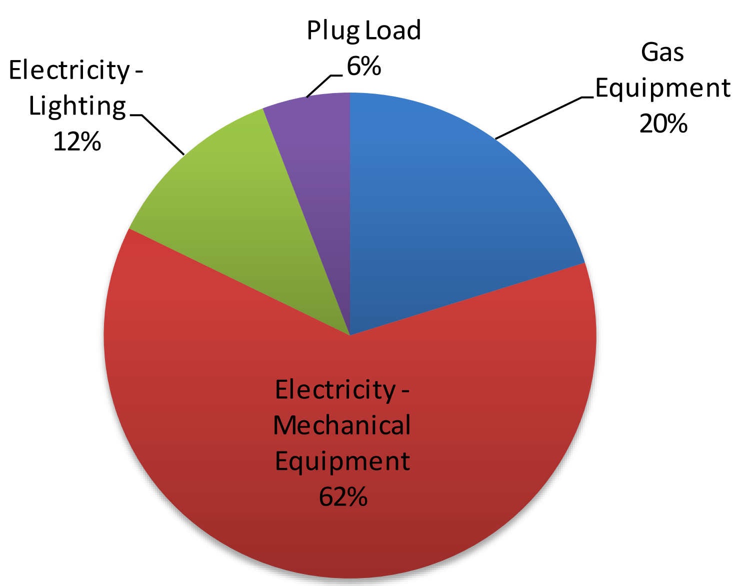

Figure 5: Total Energy Breakdown

2. Conservation Opportunities

The primary objective of this study was to identify and analyse energy conservation opportunities at the TT and ITTC buildings. The rate schedules used in this analysis for financial savings estimates are presented in Table 2. The financial savings estimates include goods and services tax (GST) and provincial sales tax (PST). For Greenhouse Gas estimates, we have used emissions factors of 0.010 kg CO_2e / kWh of electricity in BC, and 49.87 kg CO_2e / GJ for gas.

It should be noted that the paybacks for the measures consider the carbon tax escalation provided by the federal government.

Table 2: Rate Schedules

Utility	Rate
Electricity	
Marginal Demand Charge	$12.26 / kW (inc taxes)
Marginal Consumption	$0.063 / kWh (inc taxes)
Gas	
Recent Gas Consumption	$15.00 / GJ (inc taxes)

A number of potential conservation opportunities have been analyzed. A detailed explanation as well as an estimated cost and energy saving potential are summarized for these projects. As many of these measures are mutually exclusive, it does not make sense to present the total savings if all measures are implemented. The individual measure savings can be found in Table 3.

2.1 Energy Conservation Measures

A summary of the analysis for the measures is presented in Table 3. Detailed descriptions for each project are presented below. The analysis for these measures does not include any incentives from BC Hydro or Fortis BC. Based on conversations with Stantec, it is unlikely that either the TT or the ITTC buildings will be connected to the district energy plant.

Table 3: Measure Summary

Item	Description	Base Case Cost	Incremental Cost	Total Cost	Effective Payback	NPV	Annual Savings				
							$	GJ	kW	kWh	GHG
1.1	Building Commissioning		$13,000	$13,000	3.0	11,900	$3,000	20	142	16,000	1.2
1.2	Welding Efs		$35,000	$35,000	6.0	5,900	$4,800	130	36	37,300	6.8
1.3	TT DHW Upgrade	$34,000	$7,300	$41,300	7.0	2,400	$820	50			2.5
1.4	AHUs and Boiler Upgrade	$63,000	$75,000	$138,000	8.0	12,000	$6,800	450			22.4
1.5	Condensing Boiler	$18,000	$12,000	$30,000	4.0	17,000	$2,300	150			7.5
1.6	Gas Absorption Heat Pump	$18,000	$105,000	$123,000	26.0	(76,000)	$2,300	150			7.5
1.7	Renewable Natural Gas						($2,250)				10.2

2.1.1 Building Commissioning

The TT and ITTC building mechanical and boiler rooms have just been switched from a Siemens BAS to an Automated Logic platform. SES and Care Systems are currently in the process of implementing the selected measures from the Fortis 2021 Bundle B study. It is likely that the remainder of the building systems will be considered for switchover at this time. Based on conversations with both Care Systems and the operations team, a commissioning for the building switchover will not be completed as part of the switchover scope. Given TRU's past experience with these BAS switchovers, we recommend doing a full building commissioning once the entire building is switched onto the Automated Logic system. While this measure will likely provide energy savings, the main purpose is to ensure the building is functioning as intended after the systems are switched over.

During this commissioning we also recommend the following:

- Implementing a supply air pressure (SAP) reset for AHU-1,2, 3 and 4.
- Ensuring that holiday scheduling is in place for all relevant units. Integrating the space schedules with the classroom scheduling software could be investigated at this point.
- The heat pumps in ITTC have reversing valves and therefore can be used for both heating and cooling, but currently are only used for cooling. We recommend investigating whether there is a demand for heating in those spaces when the chiller is operating. If so, the heat pumps could pull heat from the chilled water line. No savings were claimed for this as the terminal units are not currently visible on BAS so the feasibility of this measure could not be confirmed.

2.1.2 Welding EFs

The Welding shop in the original TT building, is equipped with nine large EFs that remove fumes from the approximately 50 welding booths. It also has a single gas fired MUA that provides supply air to the space. The MUA along with eight of the EFs have recently been replaced (2020) with new VSD models. Previously, there was an issue with the system removing too much air without having enough make up air. Larger supply ducts from the MUA were recently installed to combat this issue and seem to be working. The welding shop is currently scheduled from Monday to Friday, 7:00 am – 5:00 pm. Currently all EFs are running at 100% and the MUA is operating to a fixed supply air pressure (SAP) during scheduled hours. The VSD speeds are not trended for any units. If the occupants wish to use this shop afterhours, they have to call operations to request the systems to be turned on. This system seems to be working, however, there are still some complaints with the exhaust system.

We recommend installing a pressure sensor for each of the VSD EFs and controlling their speed to a static pressure SP. This will cause the fan speed to modulate based on the number of welding booths in use and will prevent the fans from pulling too much air and creating issues. An SAP SP should also be added to the MUA to modulate its VSD in order to ensure the space is not being over or under pressurized. This measure will need to be implemented in conjunction with occupancy to turn on only the welding booths that are in use. Based on conversations with operations, most if not all booths are occupied during the occupied schedule so there may not be much savings available for this measure. This measure requires additional investigation and consultation to determine the optimal solution to combine energy savings, ease of operation and safety.

2.1.3 TT DHW

The TT has 2 non-condensing gas DHW heaters (HWT-1/2). These are from 2010 (HWT-1), 2016 (HWT-2). Operations believes these are significantly oversized and that a they could be 60-gallon rather than 80. This has been confirmed with the gas modelling. We recommend replacing these units with high efficiency condensing models and resizing them to meet that actual DHW requirements of the building.

2.1.4 AHUs and Boiler Upgrades

AHU-1,2, and 3, located in the TT building, are gas fired units with chilled water-cooling coils. These units are located in the ground floor mechanical room of the TT building. Based on the documentation provided, the AHUs are original to the building and have past their recommended service life. It has been noted that this building is unlikely to be connected to the district energy system.

This measure recommends replacing the gas fired portion of all three units with hot water heating coils that can be fed directly from the boilers. Since the boilers are in the same mechanical room, it makes sense to connect them. There is no trending available for the existing gas boilers, but based on observations of the BAS, it appears that one of boilers is always operating. This measure assumes that two new condensing boilers are installed to replace the existing low efficiency gas fired units as these boilers are also past their recommended service life. The new condensing boilers selected were larger than the existing boilers as they will now be providing heating water to the building systems and the three AHUs. However, based on the gas usage of the building, these AHU gas heating sections are oversized. Incremental costing was used for the analysis of this measure as both the AHUs and the boilers are due to be replaced. It should be noted that heating water coils often have a larger pressure drop than gas heating sections so the sizes of the AHU fans will need to be evaluated as part of this measure.

2.1.5 Condensing Boiler Upgrade

After the installation of the 2 electric boilers in the ITTC building, the six non-condensing boilers in the TT building were meant to be used very rarely. While the electric boilers have sufficient capacity to supply all of the TT and ITTC buildings, they often go down and the gas boilers are then used as backup. These gas boilers are standard efficiency and have past their recommended service life. Although no trending is available for these boilers, based on observations of the BAS during April 2022, one of boilers (B-2) was always operating. The gas boilers are staged based on demand so it's likely that only one boiler was operating as the demand was low at this time.

This measure recommends replacing one of these old boilers with a new high efficiency condensing boiler. This can then be the primary boiler that would be the first gas boiler staged on when the electric boilers are down. The increased efficiency of the condensing boiler will result in energy savings. The heating water return temperature should be minimized to maximize efficiency gains. Depending how frequently the gas boilers are used, it may make sense to install two condensing boilers, however based conversations with facilities, the electric boiler bugs have been reduced and they are not down as often so the gas savings opportunity here is likely not enough for two condensing boilers to make financial sense.

We feel that measure 2.1.4 would be a better option as it would ensure that the gas boilers are used enough to merit the condensing boiler upgrade.

2.1.6 Gas Absorption Heat Pump

After the installation of the 2 electric boilers in the ITTC building, the six non-condensing boilers in the TT building were meant to be used very rarely. While the electric boilers have sufficient capacity to supply all of the TT and ITTC buildings, they often go down and the gas boilers are then used as backup. These gas boilers are standard efficiency and have past their recommended service life. Although no trending is available for these boilers, based on observations of the BAS during April 2022, one of boilers (B-2) was always operating. The gas boilers are staged based on demand so it's likely that only one boiler was operating as the demand was low at this time.

This measure recommends replacing one of these old boilers with a new gas absorption heat pump. Gas absorption heat pumps provide higher efficiencies that condensing boilers, but have limitations on the heating water supply temperature (HWST) that can be provided. The current HWST appears to hover around 67°C, in order for the heat pump to be effective, this will need to be lowered to approximately 55°C. Based on the terminal devices in this building, we believe this will be possible, but more investigation will need to be done to ensure the radiant heating in the ITTC building can handle lower temperatures. Although the existing boilers are being used quite often, based on conversations with operations staff, the goal is to use the gas boilers only as back up. If this is the case, this measure will not make financial sense.

2.1.7 Renewable Natural Gas

FortisBC offers Renewable Natural Gas (RNG), or biomethane, as an alternative to non-renewable natural gas. This presents an easy path to reducing GHG emissions. The cost of RNG is approximately 1.5 times the cost of non-renewable natural gas, however, there is no additional cost for implementing this measure, given that RNG is delivered using existing FortisBC infrastructure. The analysis of this measure assumes the remaining natural gas used for DHW in the TT building is converted to RNG however, there are options for converting any portion (5%, 10%, 25%, 50%, 100%) of the total gas consumption to RNG. The cost per tonne would be the same regardless of the portion converted. Given the plans for this building, renewable natural gas may be the best option to offset emissions in this facility in the short term.

3. Disclaimer

This document was prepared by SES Consulting Inc. for Thompson Rivers University. The scope was to perform a Level 1 Energy Study at this site. An initial investigation has been performed to estimate the probable costs and savings associated with each project. Further detailed design work will be required for project implementation. Any estimates of probable cost are made on the basis of SES's judgment and experience. SES makes no warranty, express or implied, that cost of the work will not vary from the SES's estimate of probable cost. SES accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.