Preliminary Report on Energy Efficiency in Commercial Buildings at Old Crow, Yukon

A report for the **Vuntut Gwitchin First Nation**
By the Pembina Institute

Prepared For the
Vuntut Gwitchin First Nation and
Yukon Territorial Government, Property Management Services.
By the Pembina Institute

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About the Pembina Institute

The Pembina Institute is an independent, citizen-based organization involved in environmental education, research, public policy development and client confidential environmental consulting services. Its mandate is to develop and promote policies and practices that lead to environmental protection, resource conservation, and environmentally sound and sustainable energy and resource management. The mission of the Pembina Institute is to implement holistic and practical solutions for a sustainable world. Incorporated in 1985, the Institute's head office is in Drayton Valley, Alberta with offices in Ottawa and Calgary and employees in Edmonton, Saskatoon, Vancouver, and other locations across Canada.

The Institute' Eco-Solutions Group provides strategic planning and advisory services in the area of environmentally sustainable business strategy, climate change risk and opportunity management, and applied eco-efficiency, as well as practical tools and analysis for incorporating environmental concerns into business decision-making and "operationalizing" eco-efficiency. Community energy planning and life-cycle value assessment are core elements of this service.

For more information on the Pembina Institute's work, and details of the capabilities and services offered by the Institute's Eco-Solutions Group, please visit our website at http://**www.pembina.org**, or contact:

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Table of Contents

Introduction

The purpose of this report is to do a preliminary investigation of the energy efficiency potential of various commercial and government buildings in Old Crow, Yukon. The Vuntut Gwitchin First Nation (VGFN) is investigating a number of energy alternatives and conservation measures to address high energy costs and environmental concerns. The Pembina Institute is involved in several projects to help facilitate the implementation of these energy alternatives, including a residential energy efficiency program, a commercial/institutional energy efficiency program, a district heating system, and a wind turbine. Current Pembina Institute projects are focusing on residential energy efficiency and district heating, while wind power is being studied by Yukon Energy Corporation.

This report provides a preliminary investigation of energy efficiency opportunities in commercial and institutional buildings in Old Crow. The information provided in this report was collected in conjunction with the district heating system (DHS) study due to the overlapping nature of that project with commercial energy efficiency. A companion report for the VGFN provides recommendations on proceeding with several energy efficiency retrofits.

Utility Information

As part of the DHS study, fuel consumption data was obtained for the various buildings under consideration. This data turned out to be fairly sketchy and incomplete, with missing data, poorly kept records, and oil tanks serving multiple buildings. Because of this, the building fuel consumption data should be used with caution. As part of the DHS study, theoretical energy consumption will be calculated for comparison with the bill data, but this work is not yet complete. Very little electrical data was gathered, as it was not required for the DHS study. As part of a more detailed study, more complete utility data should be obtained if possible.

Building fuel use data is as follows:

Table 1 – Old Crow Commercial and Institutional Sector Building Energy Consumption

Building	Owner	Area	Fuel Consumption			Elec Consumption	
		ft²	L oil	ekWh	ekWh/ft²	kWh	kWh/ft²
Maint. Garage	YTG	5,100	35,165	379,782	74.5		
3 Bay Garage	YTG	2,200	12,770	137,916	62.7		
Teacher's Residence	YTG	2,500	20,134	217,447	87.0		
Nurse Station	YTG	7,440	27,000	291,600	39.2		
RCMP Barracks	Federal	2,500	5,198	56,139	22.5	22,060	8.8
RCMP Old Barracks	Federal	3,250	6,757	72,980	22.5	52,566	16.2
RCMP Duplex	Federal	3,600	7,485	80,840	22.5	24,208	6.7
RCMP Garage/Shed	Federal	750	1,559	16,842	22.5	2,986	4.0
Northern Store	VGFN/Northern	2,500	5,946	64,217	25.7	90,000	36.0
Community Hall	VGFN	4,000	8,000	86,400	21.6		
Youth Centre	VGFN	1,900	3,480	37,584	19.8		
Admin Building	VGFN	7,500	10,123	109,328	14.6		
Yukon College	YTG	2,000	8,559	92,437	46.2		

Note: 1. One oil tank serves all 4 RCMP buildings. Data pro-rated evenly.
2. ekWh = equivalent kWh. Fuel use converted to kWh for comparison with electric in same units

Fuel consumption ranges from 14.6 to 87.0 ekWh/ft². Electrical consumption ranges from 4.0 to 36.0 kWh/ft² for the five buildings with electrical data. None of these buildings are electrically heated. The wide range of consumption is to be expected given the different types and condition of the buildings. Generally, the two garages have very high consumption due to their large volumes and high infiltration through doors. The Northern Store's high electrical consumption can be attributed to a high lighting density and refrigeration equipment. The admin building's low energy use is due to it being the newest and best constructed building. None of the buildings' energy use seems exceptionally high given the extreme climate. This is due to the simple systems and relatively short hours of use of the buildings. Rate structures for electricity supply are given in Appendix A.

Site Survey and Discussion

The site survey was done in conjunction with the site visit for the DHS study. As such, the emphasis was placed on gathering information relevant to the DHS, rather than energy efficiency. However, many of the observations from the site visit overlap with energy efficiency and some additional information was gathered where it could be easily obtained. The site survey summaries for each building can be found in Appendix B.

YTG Maintenance Garage

The maintenance garage is used to store graders and other maintenance vehicles, as well as provide workshop space. This is the highest fuel use building of those surveyed, although the consumption estimate is very rough as it had to be estimated from a tank that serves both vehicles and heating needs. This high energy use can be attributed to a number of things. First, the high ceiling and large volume of a garage results in more building envelope per floor area, and this in turn will result in higher consumption per square foot of floor space. However, the building also has relatively poor insulation and high air infiltration (i.e., indoor draft). The walls and roof are R20 and were prefabricated off site. R20 is a fairly low insulation level for Old Crow, and staff speculate that the insulation may have settled in the walls, further reducing its R value. Door insulation is also fairly poor. Infiltration is high due to bay doors and large open areas that allow air to flow from one side to the other. When the building was first occupied, ceiling fans had to be installed to push hot air down and prevent freezing at low levels in the building.

Heating is by oil-fired direct radiant heaters. This is fairly common in large work areas like garages, as radiant heating can keep occupants warm without maintaining as high indoor air temperatures. They also work well for keeping people warm when exposed to the outdoors (ie. when bay doors are open) without having to overheat the space to compensate. However, radiant heating works best when used in conjunction with another forced air type heating system, as radiant heating is difficult to control. Radiant heaters are designed to heat people directly, not to heat the air. The units in this building are controlled by a room thermostat, which is not setback at night, meaning that it is maintaining the same temperature of approximately 22 degrees for 24 hours a day. In order to heat the air they must first heat objects in the room, which would include the vehicles that come and go . And according to staff, the bay doors are never left open in winter while doing work. The radiant heaters may not be any more efficient than any other type of heating for this situation.

Lighting is metal halide, which is quite efficient. The space does not appear overlit given the need to do maintenance work. Light switches are conveniently located and are turned off at night.

Potential Energy Conservation Measures

Doors should have improved weather stripping. If possible, improve the seal on the bay doors. Additional wall insulation could be added although it may be difficult to retrofit easily and cost effectively.

As part of the DHS the radiant heaters will likely be replaced by unit heaters, which use a fan to blow hot air through a heating coil directly into the space. This may improve control and efficiency. New programmable thermostats (or a small automatic control panel if required for the DHS) should be installed to set back temperatures at night. Generally, the main garage area should be kept at slightly lower temperatures (~ 18 - 20°C) than the office areas. Or alternatively, temperatures could be kept even lower with an override button installed that would raise the temperature for 2 - 3 hours when pushed.

3 Bay Garage

The 3 Bay Garage is used to store the water truck and fire truck. It consists of 1 narrow bay, currently unused, two wider bays for the trucks, and a storage area. Although not as high in fuel use as the maintenance garage, this is still a fairly energy intensive building. Similar to the maintenance garage, the large volume and bay doors are partly responsible for this high usage. This garage is much better insulated but still has high levels of air leakage around poorly fitting doors.

The lighting is excessively bright, although many lamps are burned out. Light switches are in each bay individually rather than in a common place, meaning lights tend to get left on when the space is unoccupied.

Heating is provided by unit heaters, which is a simple and effective way of heating this type of space. The thermostats need calibration and are set excessively high. There is no night setback capability. An old experimental heat pump system installed several years ago is no longer used, but the fan continues to run needlessly. A storage room air handling unit and extra unit heater in the small bay are no longer used.

Potential Energy Conservation Measures

Additional weather stripping and sealing should be used around the doors to reduce infiltration.

The fluorescent lighting should be replaced with T8 lamps and electronic ballasts. Occupancy sensors could be installed to turn off lights in unoccupied bays (and also reduce space temperatures) but they may not work effectively with the trucks in the way. A simpler and likely more effective method of insuring lights are turned off would be to re-wire the switching so that a master switch at the door will turn off all lights when somebody leaves.

As part of the DHS the oil fired unit heaters will likely be replaced by hot water unit heaters. New programmable thermostats (or a small DDC panel if required for the DHS) should be installed to set back temperatures at night. Generally, the building can be kept at lower temperatures (~ 18 - 20°C) than it is currently. Or alternatively, temperatures could be kept even lower with an override button installed that would raise the temperature for 2 - 3 hours when pushed. The heat pump fan should be turned off and disconnected.

Teacher's Residence

The Teacher's Residence consists of two residential units joined together as a duplex. A blower test was performed on these buildings to determine air leakage. The tests indicated that in the west unit the air leakage rate was 3.1 air changes per hour, which is considered fairly low. But on the east unit the air barrier has been compromised during repair work and infiltration is much higher at 6.3 AC/hr. Insulation levels appear reasonable. Lighting is all residential style incandescent.

Heating is provided by a common boiler for both buildings and hot water distribution and radiation. There is also a fireplace in each unit?, but this is only used in very cold weather by the east unit and not at all by the west unit. The boiler is located in a separate boiler/water shed adjacent to the east unit. Thermostats do not automatically set back temperatures at night.

Potential Energy Conservation Measures

The air barrier that was damaged in the east unit should be repaired/replaced. Additional weather stripping and sealing could be used around doors and windows. The lightbulbs should be replaced with compact fluorescent. New programmable thermostats should be installed to set back temperatures at night.

Nursing Station

The Nursing Station is a two storey building with the nursing station downstairs and apartments for three people upstairs. The energy use is fairly low for a medical facility, but this is due to the simple mechanical systems, low volumes of outside air coming in, and the residential component. Given these conditions, the fuel use is one of the highest in the community. Construction appears to be good with high levels of insulation. Staff complained of drafts but no signs of outside air infiltration could be found. However, a blower test was performed and found high levels of air leakage at 7.7 AC/hr at 50 Pa. It is suspected that the leakage may be in the crawl space. Complicating the issue is generally poor temperature control throughout the building due to an insufficient number and poorly located thermostats.

Lighting downstairs is linear fluorescent with 34W T12 lamps. Replacement ballasts are energy saving magnetic. Upstairs is all incandescent.

Heating is provided by three forced air furnaces. Two serve the downstairs, one north and one south, while the third serves the upstairs. Each furnace has its own thermostat, but the zoning system is poor. The downstairs furnaces serve both perimeter and interior areas with the thermostat located on the interior. This leads to cold exterior zones. And the upstairs furnace serves both north and south zones. On sunny days the south side can be very hot while the north is extremely cold. Staff open windows in sub-zero weather to try and balance the temperatures. The upstairs furnace has the outside air damper closed, causing the space to be stuffy, which in turn is another reason for staff to open windows.

Potential Energy Conservation Measures

An attempt should be made to locate sources of air leakage in the crawl space and other areas, and to seal these leaks. The fluorescent lighting should be converted to T8 with electronic ballasts. The incandescent lighting upstairs should be replaced with compact fluorescent.

If this building becomes part of the DHS, it will be necessary to add hot water coils to the supply air ducts. At that time, adding an additional coil to split the upstairs into north and south zones should be considered. New programmable thermostats should be installed to set back temperatures at night, although with an override button to bring the heat back on when pushed would be necessary for times when the medical facilities are used after hours. Although there are no energy savings associated with it, and perhaps an energy increase, relocating the downstairs thermostats to exterior zones would likely improve occupant comfort and reduce complaints.

RCMP

The RCMP buildings consist of the barracks, the old barracks (now two residences), a duplex, and a garage and shed. The old barracks date back to 1960, while the new barracks and duplex are from 1988. There are no staff complaints on the heating and energy systems in the barracks, which seem well

constructed and insulated, but several complaints of cold drafts in the residences. Lighting is linear fluorescent in the barracks and incandescent in the residences. Heating is provided by forced air furnaces in all the buildings, none of which have setback thermostats.

Potential Energy Conservation Measures

An analysis of building air leakage should be done in the residential buildings and leaks caulked and sealed. The fluorescent lighting should be converted to T8 with electronic ballasts. The incandescent lighting should be replaced with compact fluorescent. New programmable thermostats should be installed to set back temperatures at night, with an override button in the barracks to bring the heat back on for after hours use. In the garage, the temperature should simply be set lower (15 - 18°C) at all times.

Northern Store

The Northern Store is a retail space of poor construction quality. Insulation is poor and there are large cracks and gaps in the walls with high air infiltration. Doors fit poorly and infiltration is high. However, this has not been a comfort concern to occupants and fuel bills are low because of the large amount of heat being rejected into the space by refrigerated cases. A considerable amount of cooling is required in summer to maintain indoor temperatures. A major expansion is planned for this summer, which will result in significant changes to the existing building and removal of the refrigerated cases.

Lighting is strip fluorescent. Light levels are very high as is commonly found in low-end retail. Heating is provided by one oil furnace. The thermostat is very poorly located in a back storage room and doesn't appear to be calibrated.

Potential Energy Conservation Measures

As such a significant renovation is underway, there is no point in performing an energy conservation retrofit at this time. However, if not done as part of the expansion, the building envelope should be sealed, lighting converted to T8 with electronic ballasts, and a programmable thermostat installed to set back temperatures at night.

Community Hall

The Community Hall is an open hall with a small kitchen at the back. The structure has log walls with wood frame walls above 8 feet. The logs are caulked between them, but there are gaps between the log and the frame structure that allow significant air leakage. There is also lots of leakage around doors and The open plan also encourages air infiltration. A blower test was performed and indicated very high levels of infiltration at 17.1 AC/hr @ 50 Pa. Lighting is fluorescent and the space does not appear overlit. Heating is by one furnace with thermostat in main hall.

Potential Energy Conservation Measures

All gaps should be caulked and sealed to reduce infiltration. Doors should be weather-stripped and sealed. Lighting should be converted to T8 with electronic ballasts, and motion sensors could be installed to insure lights are turned off when occupants leave. A programmable thermostat should be installed to set back temperatures when the building is not being used, and during daytime temperatures could be kept at

a lower level (18 - 20°C) until an override button is pressed to raise the temperature for a predetermined length of time.

Youth Centre

The Youth/Recreation Centre is a largely open plan building with log walls to 8 feet and wood frame construction above that level. The logs are caulked between them, but there are gaps between the log and the frame structure that allow significant air leakage. Windows and doors are also poorly sealed and the open plan encourages infiltration.

Lighting in the main recreation area is by suspended fixtures with round metal shades. These have been converted to hard wired compact fluorescent, but done very poorly. The tubes protrude well below the fixture, and because this is a games room, the tubes tend to get broken, which many of them were. Other areas have linear fluorescent.

Heating is by one furnace that supplies downstairs and returns from a large grille on the mezzanine level. Heat tends to rise up to the mezzanine level, causing it to overheat while the lower recreation area is left cold. Recently, an exhaust fan was installed to remove warm air from the mezzanine and supply it to the septic shed, which had experienced problems with freezing. This has solved some of the overheating problems in the Youth Centre and the freezing problem in the shed. But it will mean increased infiltration as that exhausted air will need to be made up.

Potential Energy Conservation Measures

All gaps should be caulked and sealed to reduce infiltration. Doors and operable windows should be weather-stripped and sealed. Linear fluorescent lighting should be converted to T8 with electronic ballasts. An attempt should be made to find a shorter compact fluorescent that will go in the suspended fixtures. A programmable thermostat should be installed to set back temperatures at night and when the building is not in use. Although exhausting air to the septic shed is not particularly efficient, it may be the only reasonable way of heating the septic shed, other than using electric. Reducing infiltration downstairs should help reduce the amount of overheating on the mezzanine. In this case the exhaust could be turned off except in cold weather when there is a risk of freezing in the shed.

Administration Building

This is one of the newest buildings in Old Crow, and is well constructed to modern standards. The fuel use is surprisingly low, probably due to short, regular business operating hours and good insulation, although there is some confusion about which bills belong to this building. Lighting throughout is T8 with electronic ballasts, and the space does not appear overlit. There are no potlights used, which further improves efficiency relative to typical office buildings.

Heating is by two oil fired boilers that serve perimeter hot water radiation, radiant panels, and a variable air volume (VAV) reheat fan ventilation system. The fan system is a bypass VAV, meaning that excess air is dumped into the ceiling plenum (attic) when the VAV box closes to reduce flow. Because of this, the fan runs at a constant volume. Static pressure seems fairly high for a system of this size at 1060 Pa. In addition, the air balance indicates an air volume and static pressure higher than design. Supply air temperature is adjusted based on outside air temperature, but only ranges from 13 - 16°C, being set to 13°

whenever outdoor temperatures are above freezing. Outside air minimum was designed for 18% but balanced to 30%.

For cooling there is a split system condensing unit (explain) and DX coil, which located the mechanical refrigeration equipment on the roof, away from the air handler, and provides a cooling coil in the air handler. This unit is very large (20 tons) for a building of this size. The oversizing, combined with cold supply air temperatures, likely result in excessive cooling in summer and reheating to maintain normal building temperatures. Staff confirmed this although it is difficult to know how bad the problem is.

There is a direct digital control (DDC) system that automatically controls all mechanical equipment, including scheduling. At the time of the site visit, the fan system was running past 7:00 pm when most staff leave at 4:30. But it is not known how long the systems actually run. A warning light on the DDC system indicated a heating control failure which was causing both primary heating pumps to run when only one should.

Potential Energy Conservation Measures

Password access to the DDC system should be obtained and the heating failure checked out and fixed. Schedules should be checked and reset to match the building hours more closely. The supply air temperature schedule should be adjusted to provide warmer temperatures in winter and not be reset to 13° above outdoor air until warmer outdoor conditions are present. It is recommended that the cooling be locked out until later in the season as well. Finally, the fan should be re-sheaved and rebalanced to design supply air quantities and minimum outdoor air percentage.

The system could be converted to true VAV by closing the bypasses on the VAV boxes and adding pressure sensors and variable speed drives. This would allow the fan to only supply the required volume of air and save fan energy when not running at full volume. This will save energy but will be somewhat expensive and make the system more. It is suspected that the bypass system was chosen originally to maintain simplicity.

Yukon College

This building has one of the higher fuel consumptions on a square footage basis. It is fairly new and seems to be well constructed. Although staff do not complain that the building is drafty, a blower test indicated fairly high levels of infiltration at 6.7 AC/hr at 50 Pa. But this may have been distorted by a large exhaust shaft through the roof from the back room that was a major source of air leakage.

Lighting in this building is largely by linear fluorescent fixtures that are custom made and contain 4 lamps. There are a large number of burned out lamps, but if all lamps were working this space would be significantly overlit

Heating is by an oil fired boiler that serves a perimeter hot water radiation system and a constant volume air ventilation unit. The boiler can be controlled by a wall switch and is sometimes turned off by staff when the building overheats. If done too often, this could shorten the life span of the boiler. The air handling unit has a manual outside air damper with a winter and summer position indicated. The winter position appears to be fully closed which could cause air quality problems. Supply air temperature is controlled by means of a duct temperature sensor set to 70°F. There is a timeclock to control the operation of the air handling unit and also the exhaust fan, but the timeclock does not have any regular pattern of hours set and was off by just over 1.5 days, meaning the air handler comes on at completely random

hours. The thermostats controlling the heating have notices to keep them at 15°C, although not all of them were. They also have a fairly wide deadband setting, meaning the temperature band around the setpoint during which the temperature is allowed to float without bringing on the heat. So the temperature may swing significantly. There is a wood stove in the entry, but according to staff it is seldom used except in very cold weather.

Staff complain that temperature control is very erratic, often far too hot or too cold. Windows were open at the time of the site visit, in spite of the -10°C weather. This is not surprising given the problems with control of the air handler and radiation.

Potential Energy Conservation Measures

Additional caulking and weather stripping could be done to improve air leakage, although it is suspected that air infiltration is not normally as bad as the blower test indicated. The lighting should be changed to T8 with electronic ballasts, and the number of lamps in the fixtures reduced to three or perhaps two.

While on site, the timeclock was reset to a more appropriate schedule, but this schedule should be confirmed and fine tuned. The duct sensor setpoint in the air handler was changed to 60°F, which should help prevent overheating. The thermostats were set to 21°C and the deadband reduced to make them more responsive. Hopefully this should improve temperature control and reduce staff complaints.

Appendix A – Rate Structures

Appendix B – Building Heating Surveys