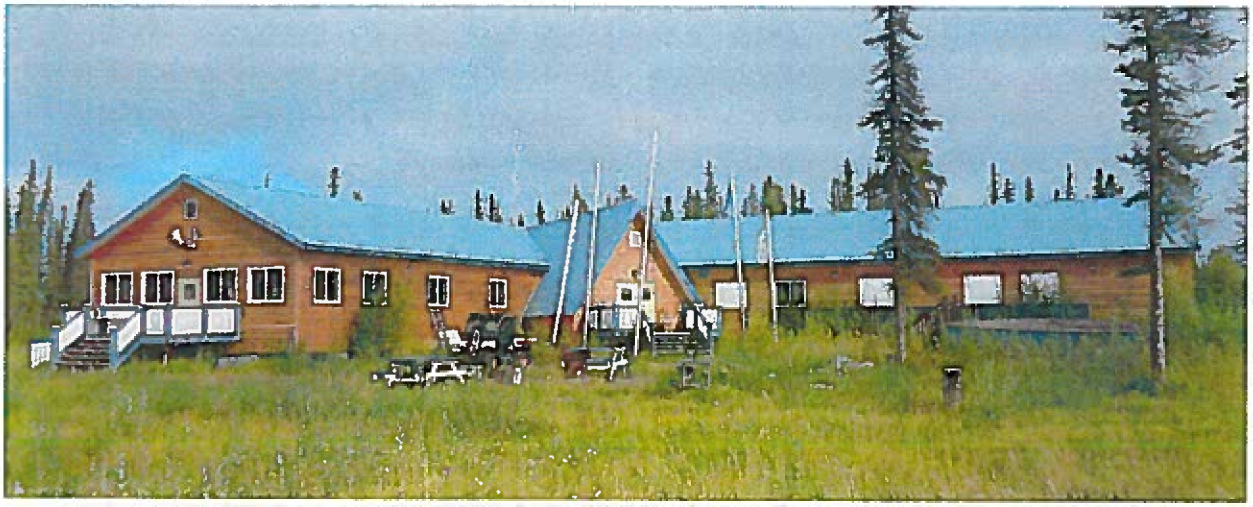
Targeted Energy Audit

Gwich'in Wellness Camp
Inuvik, NT



Prepared for:

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Executive Summary

The Gwich'in Wellness Camp is an off grid facility, consisting of a 12 double-occupancy room residence, meeting hall, commercial kitchen, separate staff cabin, diesel electricity generation and on-site water and waste water treatment facilities. It is located along the Mackenzie River near Inuvik. It was built in 2008 and has a combined total conditioned area of 900 m^2. An energy audit was requested by the Gwich'in Tribal Council as part of funding from Polar Knowledge Canada in order to reduce operating costs by reducing energy costs of the facility.

The majority of the facility is heated by three oil-fired boilers. The boilers also provide domestic hot water indirectly through a heat exchanger, which is stored in two hot water tanks with electric elements for backup. The main building ventilation is provided by four Heat Recovery Ventilators, while the kitchen facility has an exhausting range hood and a make-up air fan.

Electricity for the facility is generated using two diesel generators, a 100kW and a 75kW.

The facility has not been operated since August of 2012.

Table 1 - Facility Energy Use and Costs

Total Annual Energy Use (Electricity & Heating Oil & Propane)	4,600	GJ
Total Annual Energy Cost	$ 160,000	
Annual Electricity Consumption	190,000	kWh
Annual Peak Demand	73	kW
Annual amount of diesel fuel used for electricity generation	81,000	Liters
Annual Cost of electricity generation	$ 110,000	
Annual Heating Oil Consumption	34,000	Liters
Annual Cost of Space Heating	$ 48,000	
Annual amount of propane used in kitchen	5,300	Liters
Annual cost of propane for kitchen	$ 7,600	
Annual Water Consumption	No Data	
Annual Cost		

Recommended energy management opportunities (EMOs) in the building are listed in the table below. Some EMOs would save fuel but increase electricity, or vice versa. Expected energy increases are shown as negative.

Savings are based on the assumptions that the camp generators are operated year-round with a permanent caretaker on site, and that the lodge is occupied at half capacity for a total of 30 weeks of programming per year.

Table 2 - List of Energy Management Opportunities

#	EMO	Electricity Savings (kWh)	Oil #2 (L)	Annual Cost Savings	Estimated Capital Cost	Payback (years)
1	Install Smaller Generator	0	14,000	$19,000	$40,000	2.1
2	Install 3.6 kW Additional PV	3,700		$2,300	$14,000	6.1
3	Relocate Existing PV Panels to roof	320	0	$190	$2,000	10.5
4	Install Wood Stove in Meeting Hall	100	4,300	$6,100	$10,000	1.6
5	Install Wood Stove in Cabin	6,600		$4,000	$7,000	1.8
6	Install Hydronic Heating in Cabin	6,500	-740	$2,900	$12,000	4.1
7	Install ECM Pumps	13,000	-290	$7,800	$12,000	1.5
8	Unoccupied Temperature Setback	0	3,300	$4,700	$3,000	0.6
9	Biomass Boiler	-1,400	26,000	$10,000	$100,000	10.0
10	Demand Control Ventilation	10,000	7,000	$16,000	$47,000	2.9
11	Air Leak Sealing	72	414	$631	$1,000	1.6
12	Electric to fuel fired water heater conve	2,400	-290	$1,000	$4,300	4.3
13	Heat Recovery from Generators for DHW		910	$1,300	$15,000	11.5
14	Propane Dryers to replace Electric	3,200	-470	$1,300	$6,100	4.7
15	Install Motion Sensors on Half of Exterio	580	0	$360	$1,000	2.8
16	Switch CFL to LED Bulbs	440	-35	$220	$300	1.4
17	Occupancy Sensors on Interior Lighting	890	-70	$440	$860	2.0
18	Convert Fluorescent Lighting to LED	0	-140	$970	$10,000	10.3
19	Convert HID exterior lighting to LED	2,800	0	$1,700	$5,300	3.1
20	Free-Aire Refrigeration for Cooler	5,300		$3,200	$11,000	3.4

Recommendations

Note that the estimated savings of all measures combined may be less than the sum of savings from individual measures due to interactions between measures. A more efficient boiler, for example, results in less significant savings from new windows since fuel is being used more efficiently. The savings of all measures combined are summarized below:

Table 3 - All EMOs Combined Cost and Savings

	Electricity Savings (kWh)	Oil #2 (L)	Annual Cost Savings	Estimated Capital Cost	Payback (years)
All EMOs	55,000	54,000	$84,000	$300,000	3.6

Table 4 - All EMOs Combined Cost and Savings, excluding Biomass Boiler

	Electricity Savings (kWh)	Oil #2 (L)	Annual Cost Savings	Estimated Capital Cost	Payback (years)
All EMOs	56,000	28,000	$74,000	$200,000	2.7

To implement the recommendations in this report, the GTC is eligible for $65,000 in funding from Polar Knowledge Canada (POLAR) in the current fiscal year (2017-18), and $35,000 in the next fiscal year (2018-19). The GTC may also receive $17,500 from the Alternative Energy Technology Program (AETP) in this fiscal year, and potentially as much as $25,000 from AETP in the next fiscal year. This would reduce the estimated capital cost of all recommendations to $157,500 and shorten the simple return to 2 years.

Next Steps

Although these measures are all recommended as a package, there are a few priorities regarding which measures should be completed first.

1. Recommissioning - Since the facility has not been operated in 5 years, it would be highly advisable to do a thorough recommissioning of the facility and all the systems to ensure that they are still operable. This should be done prior to investing in improvements to the facility, as the cost of any repairs required to existing equipment should be factored into budgets before any spending on improvements. It may be possible to undertake repairs at the same time as improvement are made in order to reduce costs, and in some cases replacement of failed equipment with more efficient products may be very cost-effective.

2. Generator Downsizing – The sizing of the generators should be examined in more detail. The current generators are 100kW and 75kW, but the generator fuel log data suggests that the average load at the facility is 21kW. This means the generators are often running at low load, where they become significantly less fuel efficient, using as much as 40% more fuel to produce each kilowatt-hour of electricity as when they are fully loaded. The electrical load at the facility will also be reduced by implementing recommendations such as more efficient lighting and motors, which will further decrease the fuel efficiency of the current generators. Installing a

generator that is better sized to match to the load will result in less fuel required to produce the same amount of electricity. There is an empty generator bay that could be used for a smaller generator. The 100kW generator could also be sold to offset the cost of a new generator. Generator sizing should be determined after all other recommendations regarding energy efficiency are implemented, as changes to the electrical equipment and usage at the facility will affect the size of the generator required.

3. Staff Cabin Heating – the cabin is currently heated with electricity produced by the generators. This should be replaced with either a direct-fired heating system using diesel fuel, or connected to the hydronic (hot water) system that heats the rest of the camp. The same applies to the domestic hot water in the cabin, which is also heated by electricity. While the generators operate with a fuel efficiency of 20%-25%, a direct fired heating appliance can achieve an efficiency of 85%. In addition, a wood stove could be installed in the cabin to use locally harvested fire wood.

4. ECM Pumps – Electronically Commuted Motors are a more efficient type of electrical motor that uses less than half of the electricity of a standard induction motor. In addition, they often have smart controllers that allow the motor speed to be varied depending on the need of the system, resulting in even greater energy savings.

5. Propane dryers – both the Lodge building and the staff cabin have laundry equipment that includes an electric dryer. Similar to space heating and domestic water heating, clothes drying can be accomplished more efficiently and cheaply with direct-fired propane dryers. This will also reduce the possible peak load on the generator by a combined 12kW, allowing a smaller generator to be used.

6. Demand control ventilation – The Lodge contains four ventilation systems that serve the meeting hall, the residential wing, the washrooms and offices. It appears these systems run continuously. This results in more ventilation than is required when spaces are not occupied at maximum occupancy, which uses electricity and heating unnecessarily. It is similar to leaving lights on when no one is in a space. By controlling the ventilation systems automatically, using sensors that measure the need for fresh air, only the amount of air that is required is delivered, ensuring a healthy indoor environment using the least amount of energy.

7. LED Lighting – All lighting at the facility should be converted to Light Emitting Diode (LED). This is a more efficient form of lighting, and can result in roughly half the electricity use to produce the same amount of light as fluorescent. The interior lighting is currently a mix of linear fluorescent fixtures, and screw base fixtures in the residential wing with compact fluorescent (CFL) bulbs. Some of the interior lighting, such as in the hallway and washrooms, could be put on motion sensor control to avoid being left on during extended unoccupied periods. The exterior lights should also be converted from High Pressure Sodium (HPS) to LED, and considered for motion sensor control, as they are otherwise on whenever it is dark out. The number of exterior fixtures

seems excessive, therefore many of them could be converted to motion activated fixtures that only provide light when needed. Exit signs are currently LED.

8. Wood Stove in Meeting Hall – The meeting hall could be heated directly with a wood stove that could be fed with locally harvested wood. This would reduce the amount of diesel fuel used for heating, and would also provide a very pleasant atmosphere in the meeting room, while incorporating the traditional practice of wood heating into events held in the lodge.

9. Increase Solar PV- There is currently 1.35 kW of photovoltaic panels installed at the camp. This could be increased to produce a greater percentage of the facility's electricity during sunny periods. However, care must be taken to avoid creating an unstable condition in the isolated electricity grid if the intermittent PV resource covers a significant portion of the load, as this will negatively affect generator operation. As the amount of solar PV is increased, the installation of batteries or dump loads may be required to stabilize the system, or a control system that can automatically curtail a portion of the array to limit over-production. The installation of batteries would also allow a greater amount of PV to be installed, as any excess production during sunny times can be stored for later use. A control system to automatically stop and start the generator will be required to fully realize the benefit of greater solar penetration; otherwise the generator will continue to burn fuel at idle when not needed. The PV system should be installed with a 3 phase inverter, tied in with the generator before the step-down transformer that distributes single-phase power to the lodge building. Connecting the PV to the single-phase side, as is currently the case, may not realize the intended benefit as it can unbalance the three phases of the generator, which does not result in an energy savings. It is highly advisable that any new generator, increased PV, batteries and control system should be purchased through a single supplier as a package to ensure compatibility between components for optimum operation and reliability. Ideally, monitoring of the camp's electricity needs during a typical day of operation should be undertaken to allow the proper sizing of the PV, batteries, and genset to the actual conditions, rather than calculated or estimated.

10. Unoccupied Temperature Setback – Reducing the space temperature during unoccupied periods through the use of automatic setback thermostats.

11. Free-Aire Refrigeration for Cooler – Using outside air to keep the cooler cold during winter months using a system of fans and ducts, rather than running the chiller.

12. Biomass Boiler – A containerized biomass boiler could be tied into the existing heating system that could use cordwood or wood pellets, or ideally either one. The benefit of wood pellets is that they can be fed automatically, similar to heating oil. The benefit of cord wood is that locally harvested wood can be used, which generates local economic development or could be incorporated into on-the-land programming, but will require that someone loads the boiler manually, possibly several times per day in very cold weather.

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1. Introduction and Scope

The Gwich'in Tribal Council requested a targeted energy audit to identify cost-effective opportunities for reducing energy consumption and costs and associated greenhouse gas emissions (GHG) at the Gwich'in Wellness Camp near Inuvik, Northwest Territories. Energy efficiency and renewable energy upgrades are currently planned for the facility using funding from Polar Knowledge Canada and The Alternative Energy Technology Program administered by AEA. This audit is intended to guide investment of those funds into the most effective opportunities.

This targeted energy audit involved:

1. Reviewing building plans and analyzing operating logs to estimate energy used by the facility when operating.
2. A site visit was performed on August 15 and 16 to confirm details of installed equipment and operating procedures and to identify opportunities to reduce energy consumption and costs.
3. Preparation of cost, savings and simple payback estimates for energy management opportunities identified during the site visit.

The targeted energy audit is focused on the building's components that provide the greatest opportunity for energy efficiency upgrades and cost savings. AEA has identified the following building components to be addressed in the targeted energy audit:

1. Heating and controls
2. Ventilation and controls
3. Air Sealing
4. Hot Water and low flow devices
5. Lighting and lighting controls

Performance of the tasks described above was guided by the following assumptions:

- Analyses are based on existing room layouts, occupancy loads and work schedules.
- Estimates in this audit are Class D (+/-40%) and quotes should be obtained before commencing any work recommended in this audit report.

2. Facility Description

The Gwich'in Wellness Camp is a single-storey multi-building facility located on the shore of the Mackenzie River near Inuvik, and was built in 2008. The gross combined conditioned (heated and/or cooled) floor area of the facility is 900 m^2 (9680 ft^2), with 697 m^2 (7495 ft^2) in the main lodge building, and the remainder consisting of a 60 m^2 (650 ft^2) staff cabin, 88 m^2 (950 ft^2) generator and heating plant building, and 27 m^2 (295 ft^2) each for the water treatment plant and waste-water treatment plant buildings. The main lodge building contains a large meeting hall, a residential wing with 12 double occupancy rooms, offices, washrooms, and a kitchen and dining area. The facility has been sitting unoccupied and unused since August 2012.

The Gwich'in Wellness Camp was constructed using wood framing for the main Lodge building and the mechanical building that houses the generators and boilers. The water treatment and waste-water treatment plants are containerized units. The kitchen and dining area appears to have been constructed separately from the rest of the lodge building, and was likely shipped to site pre-fabricated. The staff cabin is also wood frame construction, but appears to be substantially older than the lodge.

Photo 1 - Gwich'in Wellness Camp

2.1. Occupancy

The generator logs show that the generators were operated 24 hours per day, year round during the 4 years that the camp operated. It is assumed there was a caretaker at site at all times, as the generator logs were filled out daily. The water use license states that the camp would be operated 'from December to the end of April', and 'from June until the end of November'. This suggest that the facility was not operated during the river break-up in May, and possibly also not during the freeze up period from late November until travel on the ice was possible in December.

The Water Use License states that the camp occupancy capacity is thirty-five (35) people. The specifications for the waste water treatment plant state the design criteria were based on 25 people. The Fire Marshall set a maximum occupancy of the meeting hall at 135 people (see Photo 14 in Appendix 1). The facility has 12 double-occupancy residential rooms, and a 2 bedroom staff cabin.

For the purposes of this report it was assumed that the facility was operational year-round with a caretaker on site, and that there was programming 30 weeks per year with an average of 12 people, or about 50% occupancy, during that time.

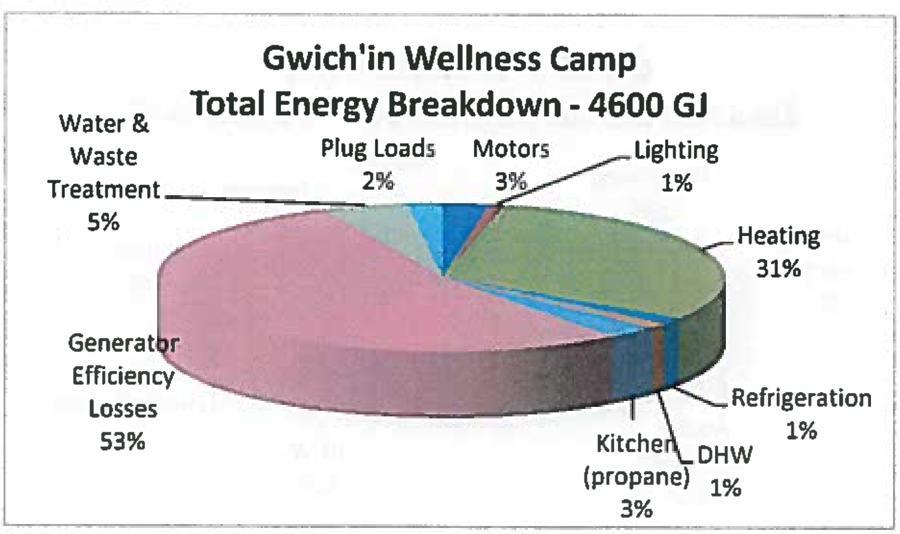
3. Energy Supply and use

3.1. Summary

An inventory of all electrical devices and heating systems was taken while on site. From this we are able to estimate the breakdown of how energy is used in the facility.

Generator fuel log data was used to determine the electricity production, energy modelling software was used to estimate the heating requirements, and historical bills were used to determine the propane use. The total energy use breakdown is shown in Figure 1.

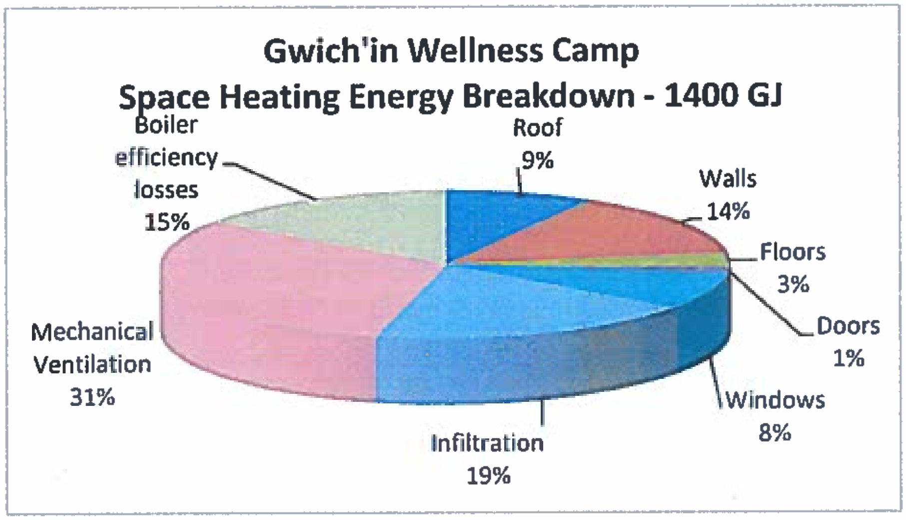
Figure 1 - Total Energy Use Breakdown



3.2. Heating fuel(s)

Diesel fuel is used for heating most of the facility, with the exception of the staff cabin which is heated with electricity. Heating for the remainder of the facility is provided by three Weil-McLain WTGO-6 oil boilers and distributed by a hydronic (hot water) distribution system.

Figure 2- Space Heating Breakdown



3.3. Electricity

Electricity is measured by consumption and demand. Consumption is the cumulative usage of electricity and it is expressed in kilowatt hours (kWh). Demand is the instantaneous power that is required for the building and is expressed in kilowatts (kW). Demand will fluctuate depending on what equipment is running. Generators will need to be sized to handle the highest demand, called the peak demand, when everything is running at once. However, most of the time the demand is much lower than the peak.

Figure 3 - Electrical Demand Breakdown

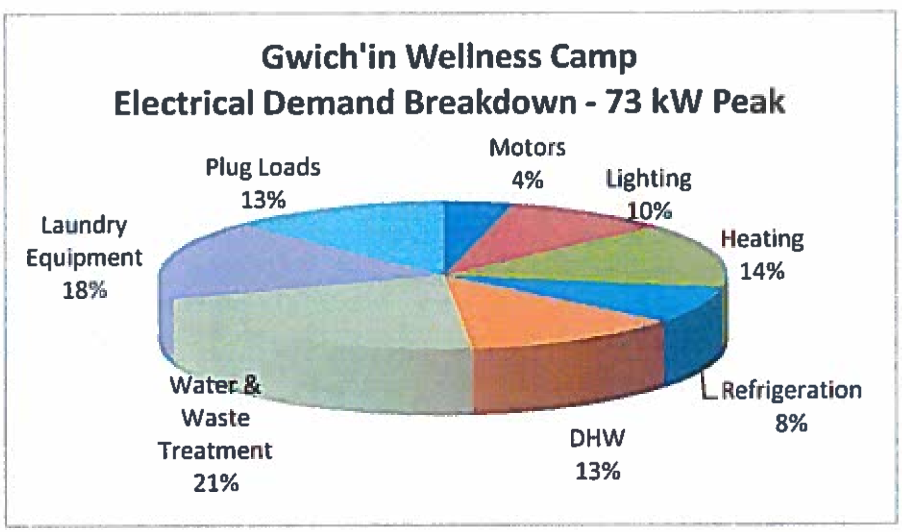
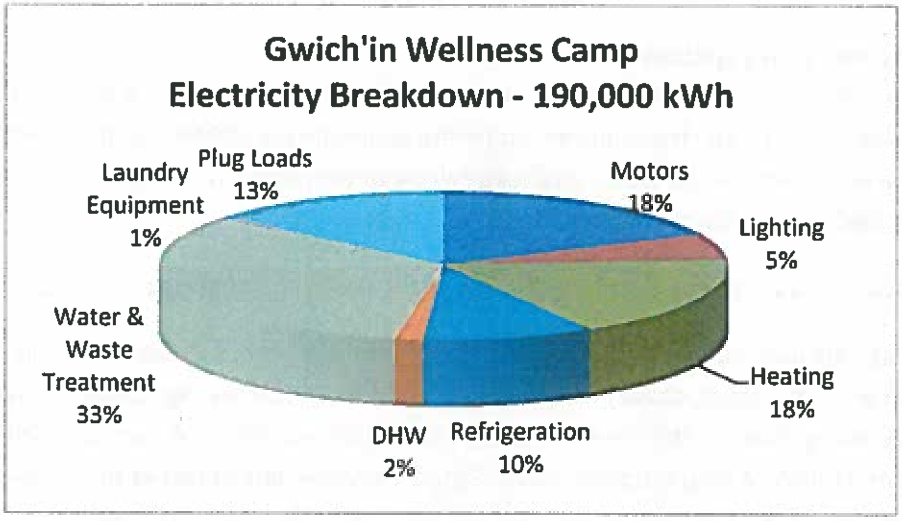


Figure 4 - Electricity Use Breakdown



3.4. Water

Potable water is provided by an on-site containerized Filterboxx water treatment plant during summer months, with raw water drawn from the Mackenzie River. According to the Water Use License, an estimated 336 cubic meters (336,000 litres) of water will be pumped from the river from June until the end of November. During winter months potable water is trucked in from Inuvik, with an estimated 420 cubic meters (420,000 litres) consumed from December until the end of April. This totals 756,000 litres per year, or an average of 2,070 litres per day.

Water is used for flushing toilets and showering in the washroom facilities, in the kitchen, and for laundry. Toilets are low flow 6 litre per flush (1.6 gal/flush).

Waste water is processed by a containerized on-site treatment plant, with solids being taken to Inuvik for disposal, while treated effluent is discharged onto the land east of the camp.

4. Power System

4.1. System description

Electricity is provided by two Detroit Diesel generators; a 100 kilowatt (kW) and a 75kW (see Photo 16 and Photo 17 in Appendix 1). Electricity produced by the generators is 208 Volt 3-phase, which is required by some equipment in the water and wastewater treatment plants. 120 Volt single phase electricity is provided to the bulk of the facility.

A 1.35kW Photovoltaic system is installed on the wall of the Lodge Building (see Photo 18 in Appendix 1)

Based on generator log data and generator specifications from the manufacturer, the daily average generator output was calculated, shown in Figure 5 in Appendix 2. The average daily production is shown in Figure 6 in Appendix 2. The overall average production was 515 kWh per day, which represents an average load of 21.5kW. A load duration curve (Figure 7 in Appendix 2) shows that 96% of days the average load is 29kW or less, and 75% of days the average load is less than 21kW or less. This suggests that the generators are oversized for the majority of the time. The small percentage of times that the load is highest will be reduced by implementing the recommendations in this report, and could be eliminated by practicing demand management, which means only running high draw equipment at times when most other things are not running.

The generator logs showed that the generators were operated in an alternating fashion, with one generator operating and while the other was shut down for anywhere from several days to several weeks between alternating. The engine hour-meters showed that the two generators were operated for a total of 19,508 hours and 15,378 hours, or a combined operation of 34,886 hours, equivalent to 3.98 years of continuous operation between the opening of the facility in 2008 and the mothballing of the facility in August 2012.

4.2. Energy Management Opportunities

4.2.1. EMO 1: Install Smaller Generator

The generators are currently oversized for the average load at the facility. As energy efficiency improvements are made to the camp, the generators will be even more oversized for the new load. A smaller generator will produce electricity more efficiently, using as much as 30% less fuel to make the same amount of electricity (see Figure 8 and Figure 9 in Appendix 2). It may be necessary to keep at least one of the larger generators for occasions when the load is unusually high, but the 100kW could possibly be sold to offset the cost of a new generator. There is an empty generator bay where a new generator could be added (see Photo 2).

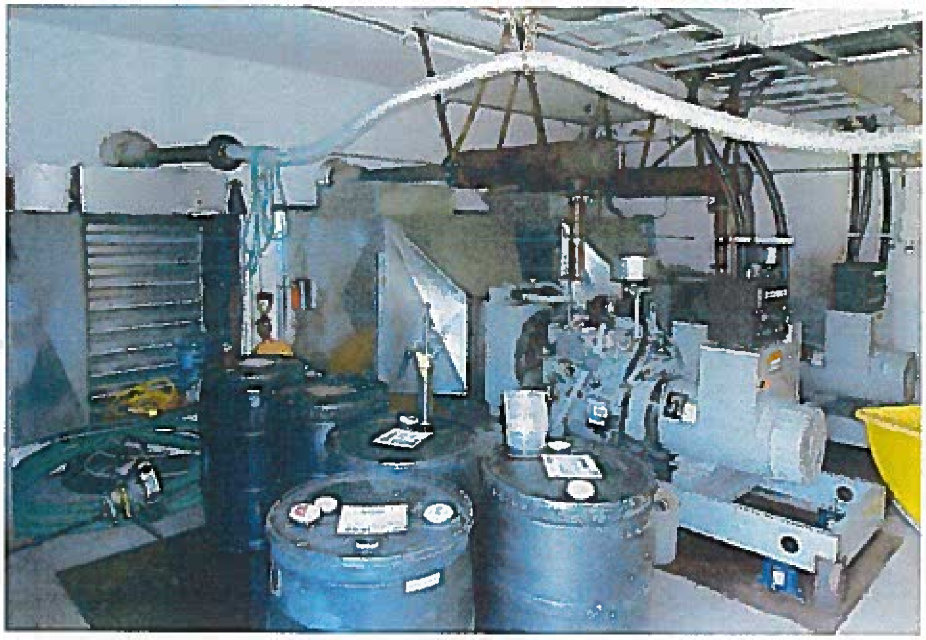


Photo 2 - Empty Generator Bay

The cost, energy savings, and simple payback of this measure are summarized below.

EMO 1: Install Smaller Generator

Estimated Savings:	**$19,000**	per year
Capital Cost:	**$40,000**	
Simple Payback:	**2.1**	years

4.2.2. EMO 2: Install 3.6 kW of Additional PV

Increasing the amount of PV panels by 3.6kW would bring the total installed to 5kW.

The existing PV is installed on a wall facing West-Southwest. In order to maximize the production of any new PV, it could be installed on the roof of the meeting hall to face South-Southeast (see Photo 3). The closer to due south that PV faces, the greater the annual production will be. The new panels could also be ground mounted to the Northwest of the lodge building far enough away to avoid shading from the building reaching the panels. The optimum tilt angle for maximum production is approximately latitude, which in Inuvik is 68 degrees from horizontal. This means tilt-up racking would be required for the PV to be roof mounted to achieve the maximum production. The roof should be assessed by a structural engineer for its ability to support the loads from the PV panels.

Photo 3 - South Face of Meeting Hall

The cost, energy savings, and simple payback of this measure are summarized below.

EMO 2: Install 3.6 kW of Additional PV

Estimated Savings:	**$2,300**	per year
Capital Cost:	**$14,000**	
Simple Payback:	**6.1**	years

4.2.3. EMO 3: Relocate Existing PV Panels

The existing PV panels are mounted on the wall of the residential wing, facing West-Southwest. This is less than optimum for a number of reasons. The first reason is that the panels are mounted low to the ground and subject to shading from vegetation and the flag poles located near the entrance (see Photo 18 in Appendix 1). Moving the panels to the roof of the meeting hall (see Photo 3) to face closer to south and point higher at the sun will increase the output by 25%, from an estimated 1260 kWh per year to 1580 kWh per year.

The cost, energy savings, and simple payback of this measure are summarized below.

EMO 3: Relocate Existing PV Panels

Estimated Savings:	**$190**	per year
Capital Cost:	**$2,000**	
Simple Payback:	**10.5**	years

5. Heating and heating controls

5.1. System description

Heating for the bulk of the facility is provided by three Weil McLean WTGO-6 oil-fired boilers (see Photo 19 in Appendix 1). Heat is circulated via two primary circulation pumps while each boiler also has a dedicated circulation pump (see Photo 20 and Photo 21 in Appendix 1).

The generator/boiler building and the water and wastewater treatment buildings are heated by unit heaters, while the main building has a combination of perimeter baseboard convectors and ceiling radiant panels.

The staff cabin is heated with electricity through several wall mount electric heaters.

5.2. Energy Management Opportunities

5.2.1. EMO 4: Install Wood Stove in Meeting Hall

The meeting hall is a large open space of 166m^2 (1790 ft^2) with a large amount of window area. The heating required for the hall could be provided by installing a wood stove in the space. This would allow the use of locally harvested wood and would also provide an opportunity to use a traditional practice of heating with wood. A wood stove also provides a very pleasant atmosphere and a place to gather around. A high efficiency catalytic wood stove such as a Blaze King will use the wood in the most efficient manner, and can also continue to burn for extended periods without being loaded.

Photo 4 - Blaze King Wood Stove

The cost, energy savings, and simple payback of this measure are summarized below:

EMO 4: Install Wood Stove in Meeting Hall

Estimated Savings:	**$6,100**	per year
Capital Cost:	**$10,000**	
Simple Payback:	**1.6**	years

5.2.2. EMO 5: Install Wood Stove in Cabin

The staff cabin appears to have had a wood stove installed in the living room at some point in the past. There is a pass-through for a chimney in the ceiling (see Photo 24 in Appendix 1). A wood stove would allow for the use of locally harvested wood instead of imported diesel fuel for heating. It is estimated that roughly half of the heating needs of the cabin could be met with a wood stove.

The cost, energy savings, and simple payback of this measure are summarized below:

EMO 5: Install Wood Stove in Cabin

Estimated Savings:	**$4,000**	per year
Capital Cost:	**$7,000**	
Simple Payback:	**1.8**	years

5.2.3. EMO 6: Install Hydronic Heating in Cabin

The staff cabin is currently heated with electric heaters (see Photo 25 and Photo 26 in Appendix 1). The electricity is produced in the generator at 20% to 25% fuel efficiency. That same fuel is burned in the boilers at 85% efficiency to produce heat. Hydronic lines are currently used to distribute heat to the lodge building and water treatment plants. Running hydronic lines to the cabin will allow the use of radiators, baseboard convectors, or a fancoil to heat the cabin. This will also mean that all the heating in the facility is tied in to one system so that if a biomass boiler is added it can provide all the heating.

The cost, energy savings, and simple payback of this measure are summarized below:

EMO 6: Install Hydronic Heating in Cabin

Estimated Savings:	**$2,900**	per year
Capital Cost:	**$12,000**	
Simple Payback:	**4.1**	years

5.2.4. EMO 7: Install ECM Pumps

The pumps that circulate the hydronic heating fluid and domestic hot water could be replaced with Variable Speed, Electronically Commutated Motor (ECM) pumps (see Photo 5), which use much less electricity than older non-ECM pumps. ECM pumps save pumping energy for circulation pumps in hydronic heating systems, such as baseboard convectors and in floor radiant, by at least 50% and usually much more compared with regular pumps. Typical pumps use a constant amount of power regardless of how much water needs to be circulated throughout the building, and are often significantly oversized. By contrast an ECM pump senses how hard it has to work to circulate the heating fluid and adjusts the flow rate accordingly. In addition, by reducing the flow, they can also increase the temperature difference between water leaving the boiler and the water returning which also saves heating fuel by increasing boiler efficiency. These pumps determine the minimal output required to achieve optimal comfort.

Photo 5 - ECM Pump

There are two large primary circulators, as well as 3 individual boiler circulators, and one circulator dedicated to each of the four ventilation units. There is also a domestic hot water recirculation pump (see Photo 20 to Photo 23 in Appendix 1). These ten pumps could be replaced with ECM pumps to reduce electricity consumption.

The cost, energy savings, and simple payback of this measure are summarized below:

EMO 7: Install ECM Pumps

Estimated Savings:	$7,800	per year
Capital Cost:	$12,000	
Simple Payback:	1.5	years

5.2.5. EMO 8: Unoccupied Temperature Setback

The temperature in the facility could be reduced during unoccupied hours. This would not only reduce heating costs but also save a small amount of electricity for operating boiler and/or furnace pumps and fans. A 5°C setback for half of each day would reduce the annual heating energy requirement of the building by about 10%. The unoccupied setting should be maintained during the period that a portion of the facility is not used. For example, all the residential rooms should be left at a lower temperature when they are not occupied. Thermostats are available with occupancy sensors that reduce the temperature automatically during unoccupied periods, or setback can be implemented with the use of Energy Star® programmable thermostats. Alternately, wireless communicating thermostats and a central controller could be installed. In that case, the settings of each thermostat can be programmed and controlled via the central controller. The cost will vary between the options, the option for non-communicating thermostats with occupancy sensors built in has been shown here.

The costs, energy savings, and simple payback of this measure are summarized below:

EMO 8: Unoccupied Temperature Setback

Estimated Savings:	$4,700	per year
Capital Cost:	$3,000	
Simple Payback:	0.6	years

5.2.6. EMO 9: Install Biomass Boiler

A biomass boiler could be installed that could burn cordwood, that could be harvested locally, or wood pellets that would have to be brought in to site, or potentially both. A containerized boiler, such as the one installed in Kakisa (see Photo 6 and Photo 7), could be transported to site complete and tied into the heating system, leaving the existing boilers in place for back up. The benefit of wood pellets is that they can be fed into the boiler in an automated manner, removing the need for someone to load the boiler with wood each day. The savings value shown includes the cost of purchasing wood pellets. If local wood is used, about 45 cords per year would be needed, and the labor required to load that much wood into the boiler would need to be considered.

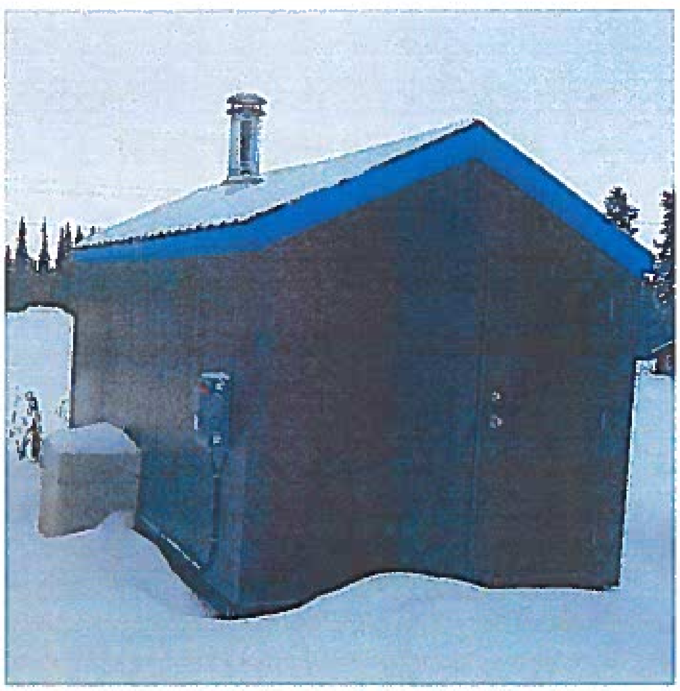


Photo 6 - Kakisa Biomass Boiler Exterior

Photo 7 - Kakisa Biomass Boiler Interior

The costs, energy savings, and simple payback of this measure are summarized below:

EMO 9: Install Biomass Boiler

Estimated Savings:	**$10,000**	per year
Capital Cost:	**$100,000**	
Simple Payback:	**10.0**	years

6. Ventilation and ventilation controls

6.1. System description

Ventilation in the main lodge building is provided by four Van EE 6LC Heat Recovery Ventilators (see Photo 27 in Appendix 1). Two serve the meeting hall; one serves the residential rooms, and one serves the washrooms and offices. It seems that the HRVs operate continuously.

The kitchen is ventilated by a rooftop commercial range exhaust fan (see Photo 28 in Appendix 1), which is combined with a make-up supply air fan (see Photo 29 in Appendix 1) that incorporates direct-fired propane heating for incoming air. It is assumed that the exhaust fan and make-up fan operate only when the kitchen facility is being used.

6.2. Energy Management Opportunities

6.2.1. EMO 10: Demand Control Ventilation

Ventilation based on maximum occupancy result in excessive energy use during times of less occupancy. It is estimated that heating fresh air for ventilation is responsible for over 30% of the heating needs in the Lodge building. Both the heat and electricity required to provide fresh air could be reduced substantially by providing only the amount of fresh air needed by the people in the space at any given time. Through the use of sensors that detect the need for fresh air, combined with variable speed control on the fan motors, the air quality is maintained while the energy use is reduced.

The costs, energy savings, and simple payback of this measure are summarized below:

EMO 10: Demand Control Ventilation

Estimated Savings:	**$16,000**	per year
Capital Cost:	**$47,000**	
Simple Payback:	**2.9**	years

7. Air sealing

7.1. Description

Cold air can leak into the building and hot air leaks out of the building through cracks and gaps in the envelope, including around doors and windows, where walls meeting floors and ceilings, and anywhere there is a penetration for plumbing, electrical, etc. that is not properly sealed.

7.2. Energy Management Opportunities

7.2.1. EMO 11: Air Leak Sealing

Uncontrolled air leakage into the building is responsible for an estimated 19% of heat loss from the facility. By sealing up gaps, such as weather stripping on doors (see Photo 8) and around penetrations in the envelope, it is estimated that this leakage can be reduced by about 10%.

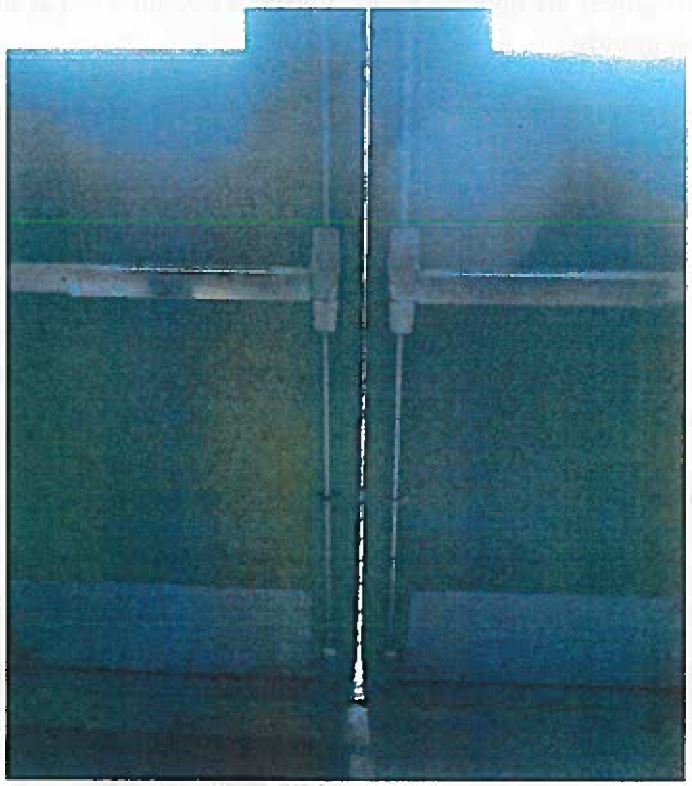


Photo 8 - Main Entry Door Gap

The costs, energy savings, and simple payback of this measure are summarized below:

EMO 11: Air Leak Sealing

Estimated Savings:	$631	per year
Capital Cost:	$1,000	
Simple Payback:	1.6	years

8. Water & Water Heating

8.1. System description

Potable water in the facility is provided by a containerized on-site water treatment plant produced by Filterboxx. The system is capable of providing 30,000 litres of potable water per day. Waste water is treated by a similar packaged system also from Filterboxx. The wastewater system is designed to handle 300 litres per person per day at an occupancy of 25 people, or a total of 7,500 litres per day.

The water license for the facility stated that the maximum water use would be 756,000 litres per year, or 2,070 litres per day on average.

Heating for domestic hot water in the Lodge is provided by a heat exchanger off the boilers, with hot water stored in two large electric tanks (see Photo 32 in Appendix 1). It is assumed the electric elements are not used as long as the boilers are operating. This precludes a warm weather shut down of the boilers during the summer months.

Heating for domestic hot water in the Lodge is provided by an electric hot water tank (see Photo 33 in Appendix 1).

8.2. Energy Management Opportunities

8.2.1. EMO 12: Electric to Fuel Fired Water Heater Conversion

The water heater in the staff cabin is currently electric. A unit of electricity energy produced by the generator is almost 4 times more expensive than an equivalent unit of heat energy produced directly using the same diesel fuel. For this reason, electricity should be used sparingly when fuel can be used instead. The electric hot water tank (see Photo 33 in Appendix 1) should be replaced with an oil-fired tank. As well, since the overall oil usage is much lower when using an oil-fired hot water tank rather than an electric, this will reduce greenhouse gas emissions.

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 12: Electric to Fuel Fired Water Heater Conversion

Estimated Savings:	**$1,000**	per year
Capital Cost:	**$4,300**	
Simple Payback:	**4.3**	years

8.2.2. EMO 13: Heat Recovery from Generators for DHW

The generators produce a large amount of heat in addition to electricity. Some of this heat radiates off the engine, some goes out the exhaust stack, and some is captured in the cooling jacket water. The latter heat is then rejected outside the building through the cooling hood (see Photo 15 in Appendix 1). Some of this waste heat could be recovered through a heat exchanger and used to heat the domestic hot water, reducing the need to burn fuel in the boilers.

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 13: Heat Recovery from Generators for DHW

Estimated Savings:	**$1,300**	per year
Capital Cost:	**$15,000**	
Simple Payback:	**11.5**	years

9. Lighting and lighting controls

9.1. System description

The interior lighting in the facility is primarily linear fluorescent fixtures in the meeting hall, offices and kitchen, as well as the mechanical buildings. Most of the fixtures use T8 fluorescent tubes, but the fixtures in the kitchen area are T12 fluorescent. There are medium screw-base fixtures with CFL bulbs in the residential hallway and rooms and the staff cabin.

The exterior lighting in the facility consists of 13 High Pressure Sodium wallpack fixtures, each 70 W (see Photo 30 in Appendix 1)

Exit signs are LED.

9.2. Energy Management Opportunities

9.2.1. EMO 14: Convert Exterior HID Lighting to LED

The exterior lights used on the building are High Intensity Discharge (HID) lamps (see Photo 31 in Appendix 1). These lights are actually quite efficient for the amount of light they give off. However, HID lamps can be replaced by lower wattage LED lamps (see Photo 9) that also don't give off as much light. This is because an LED lamp is more directional; the light shines straight down, so less light is required.

Photo 9 - Exterior LED

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 14: Convert Exterior HID Lighting to LED

Estimated Savings:	$1,700	per year
Capital Cost:	$5,300	
Simple Payback:	3.1	years

9.2.2. EMO 15: Install Motion Sensors on Half of Exterior Lighting

The exterior lighting seems excessive for a remote lodge, particularly given the cost of producing electricity on site. Some of the fixtures could incorporate motion sensors to only come on when someone was in the area, or in case of approaching wildlife if that is a concern. Alternatively, some of the exterior fixtures could be removed altogether.

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 15: Install Motion Sensors on Half of Exterior Lighting

Estimated Savings:	**$360**	per year
Capital Cost:	**$1,000**	
Simple Payback:	**2.8**	years

9.2.3. EMO 16: Switch CFL to LED bulbs

CFL bulbs can be replaced with LED bulbs that use roughly one third less electricity to make the same amount of light. LED bulbs also last longer, are more durable, and do not contain mercury.

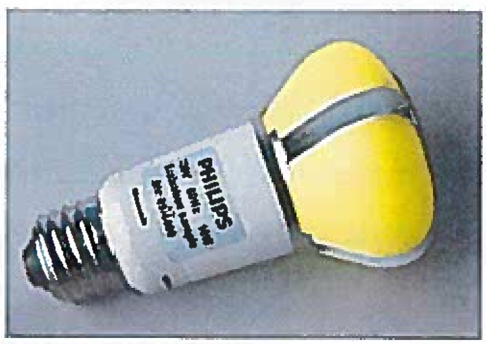


Photo 10 - LED Bulb

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 16: Switch CFL to LED bulbs

Estimated Savings:	**$220**	per year
Capital Cost:	**$300**	
Simple Payback:	**1.4**	years

9.2.4. EMO 17: Install Motion Sensors on Interior Lighting

Lighting does not need to be on when there is no one present, so motion sensors (see Photo 11) could be used to sense when the lights need to be turned on. The residential hallway and the washrooms are primary candidates for this technology, as lights in these areas can tend to be left on for extended unoccupied periods. LED lights work well with occupancy sensors, while fluorescent bulbs sometimes do not, or take time to warm up to full brightness. Installing occupancy sensors can make sense when retrofitting lighting to LED.

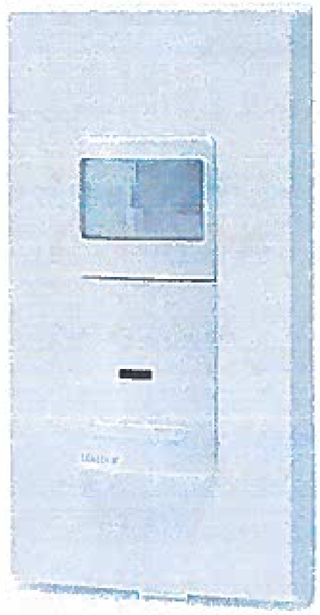


Photo 11 - Motion Sensor Light Switch

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 17: Install Motion Sensors on Interior Lighting

Estimated Savings:	**$440**	per year
Capital Cost:	**$860**	
Simple Payback:	**2.0**	years

9.2.5. EMO 18: Convert Fluorescent Lighting to LED

Tubular LED (TLED) retrofit bulbs (see Photo 12) have become a viable replacement even for T8 linear fluorescent lights, and especially for T12s which are much less efficient than T8s. TLEDs can be placed in the existing fluorescent fixture but it should be confirmed that the existing ballast will work with the LEDs. Alternatively, some LED tubes allow the ballast to be removed, which increases the electricity savings, however the work must be performed by a qualified electrician. It is recommended to replace all T8 and T12 bulbs with TLED retrofit tubes.

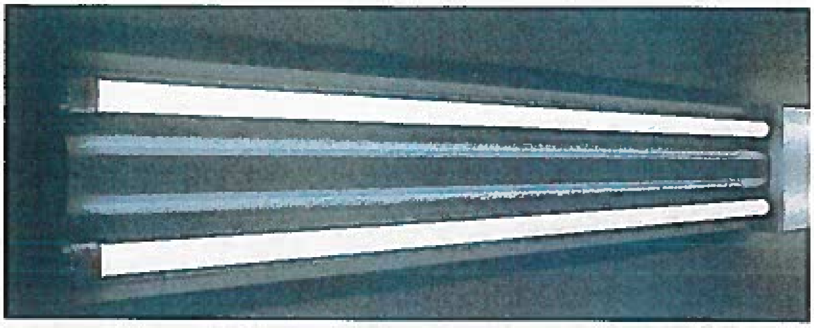


Photo 12 - Tubular LED Lamps

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 18: Convert Fluorescent Lighting to LED

Estimated Savings:	$970	per year
Capital Cost:	$10,000	
Simple Payback:	10.3	years

10. Other

10.1. Energy Management Opportunities

10.1.1. EMO 19: Replace Electric Dryers with Propane

The clothes dryers in the Lodge and staff cabin are electric (see Photo 34 and Photo 35 in Appendix 1). When operating, an electric dryer typically uses 6,000 Watts or more. This places a large load on the generator, and uses the most expensive form of energy. Switching the dryers to propane would allow the generator to be sized smaller, and also save on the cost of drying clothes. Propane is currently used in the kitchen for the cooking appliances and make up air heating.

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 19: Replace Electric Dryers with Propane

Estimated Savings:	$1,300	per year
Capital Cost:	$6,100	
Simple Payback:	4.7	years

10.1.2. EMO 20: Free-Aire Refrigeration for Cooler

The walk-in cooler adjacent to the kitchen currently uses a standard split-coil refrigeration system (see Photo 36 and Photo 37 in Appendix 1), which consumes a substantial amount of electricity to operate. A Free-aire refrigeration system (see Photo 13) uses a simple arrangement of fans and ducts to draw outside air into the cooler when the outside temperature is lower than the cooler setpoint. This reduces the amount of electricity consumed for refrigeration by an estimated one third or more.

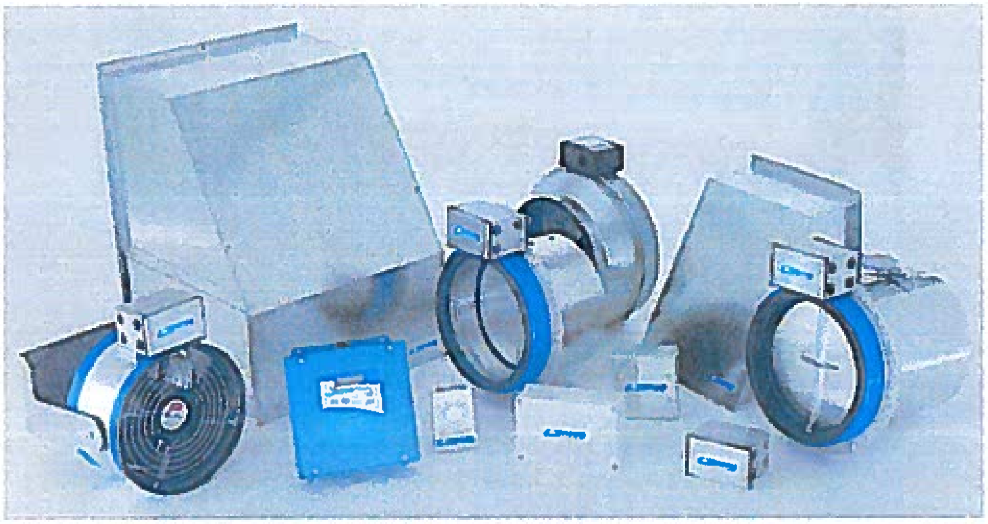


Photo 13 - Freeaire Refrigeration system

The costs, energy savings, and simple payback of this measure are summarized below.

EMO 20: Free-Aire Refrigeration for Cooler

Estimated Savings:	**$3,200**	per year
Capital Cost:	**$11,000**	
Simple Payback:	**3.4**	years

Appendices

Appendix I – Photos

Photo 14 - Maximum Occupancy Load

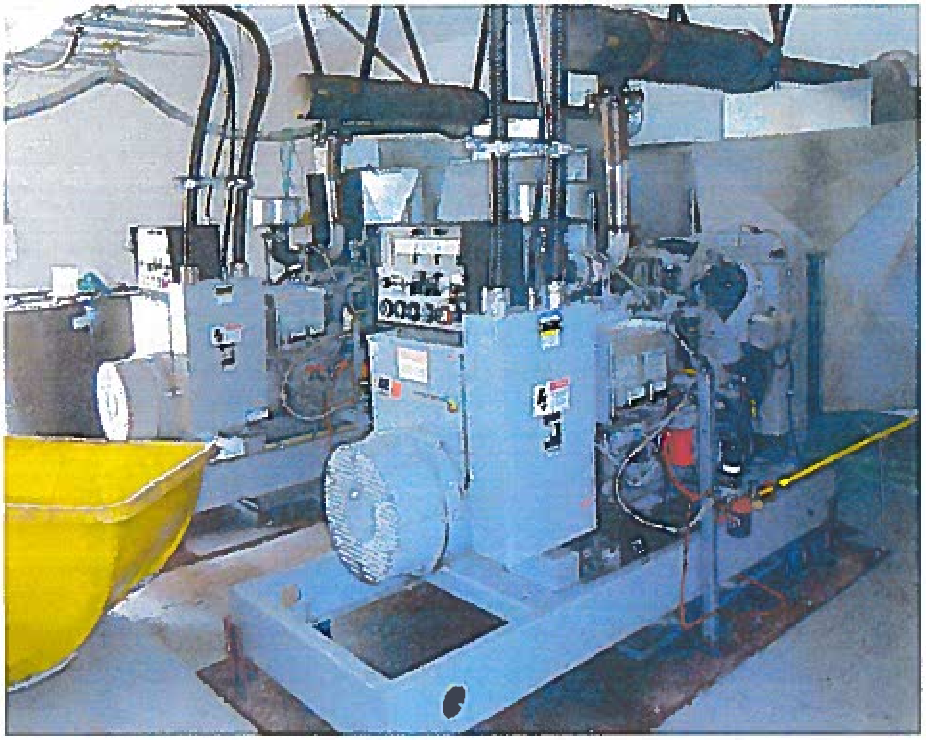


Photo 15 – Generators

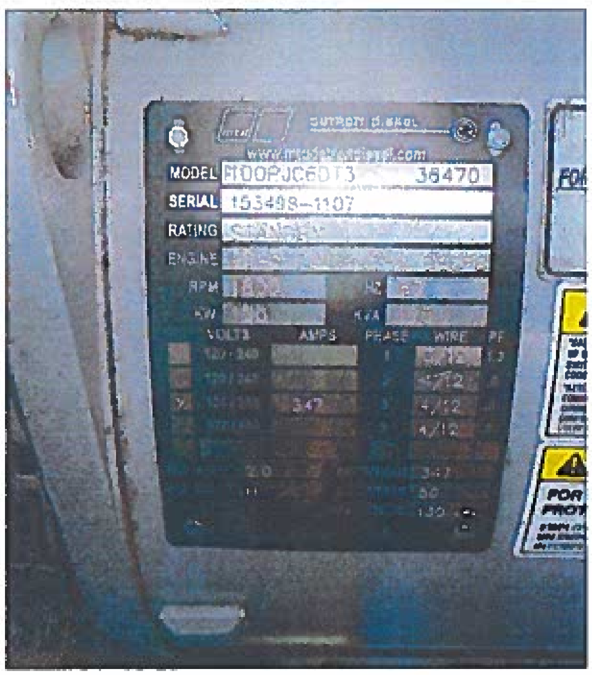


Photo 16 - 100kW Generator

Photo 19 - Oil Boilers

Photo 20 - Primary Circulation Pump

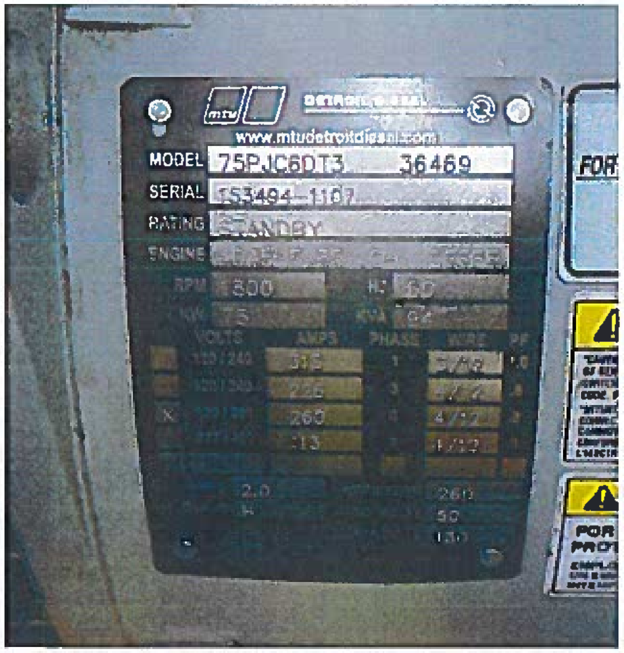


Photo 17 - 75kW Generator

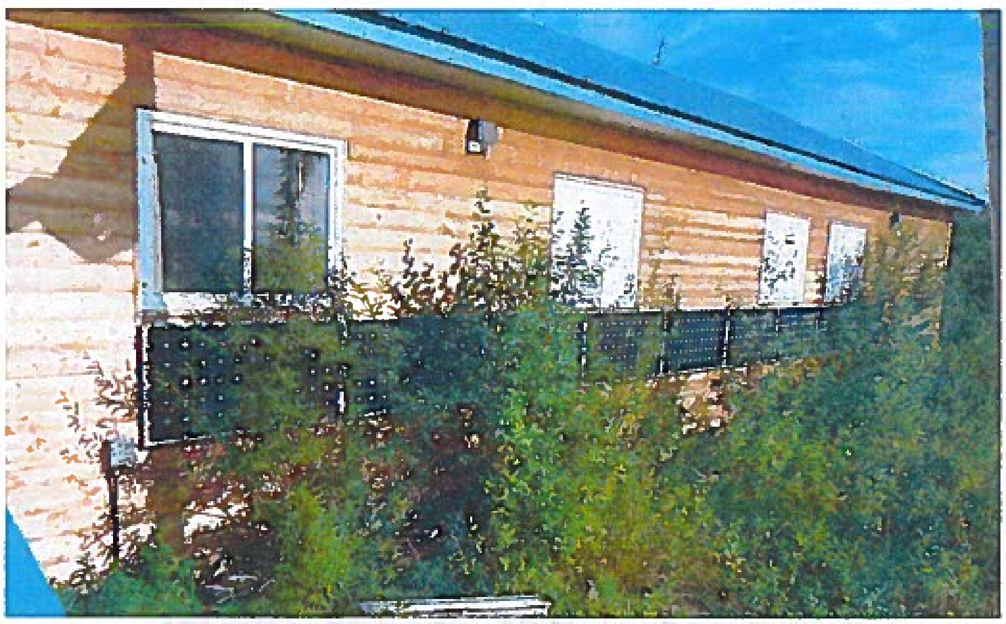


Photo 18 - Solar Photovoltaic (PV) system

Photo 21 - Boiler Circulation Pump

Photo 22 - Domestic Hot Water Circulator

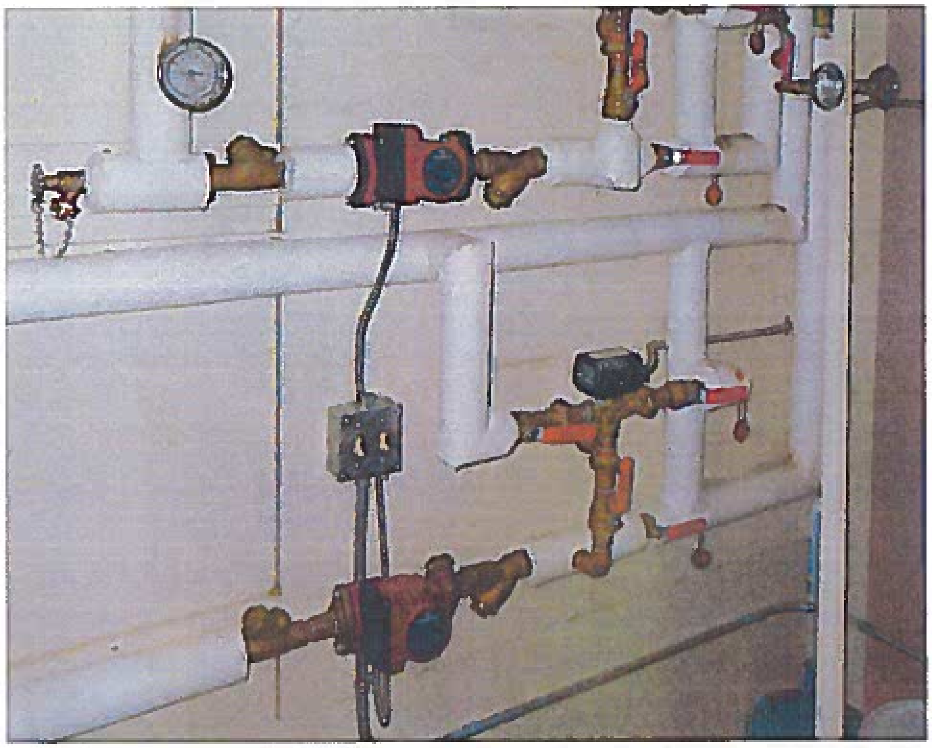


Photo 23 - HRV Circ Pumps

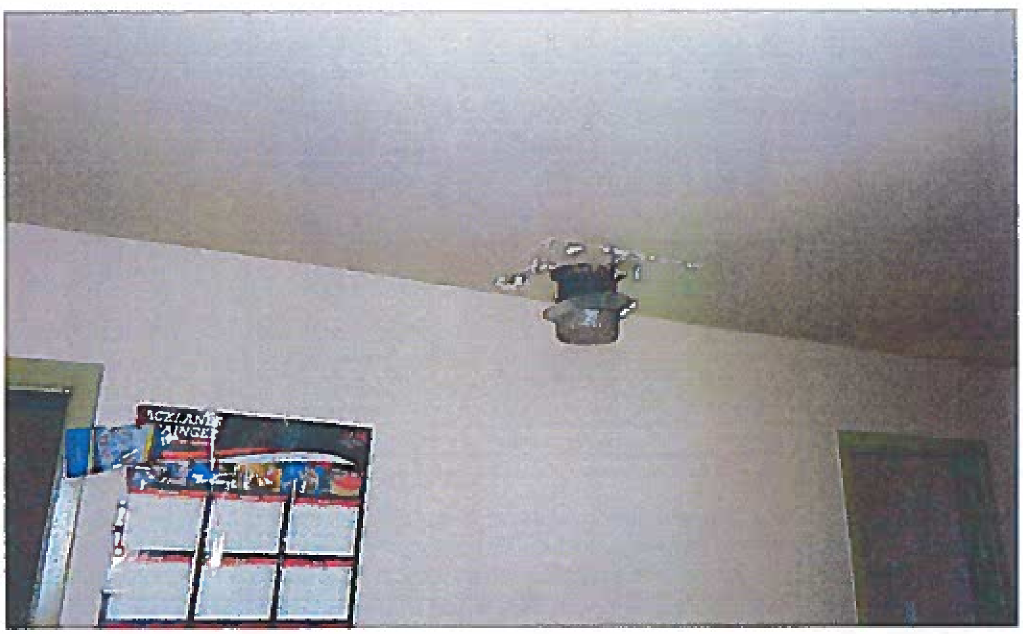


Photo 24 - Staff Cabin Wood Stove Chimney

Photo 25 - Staff Cabin Electric Heating 1

Photo 26 - Staff Cabin Electric Heating 2

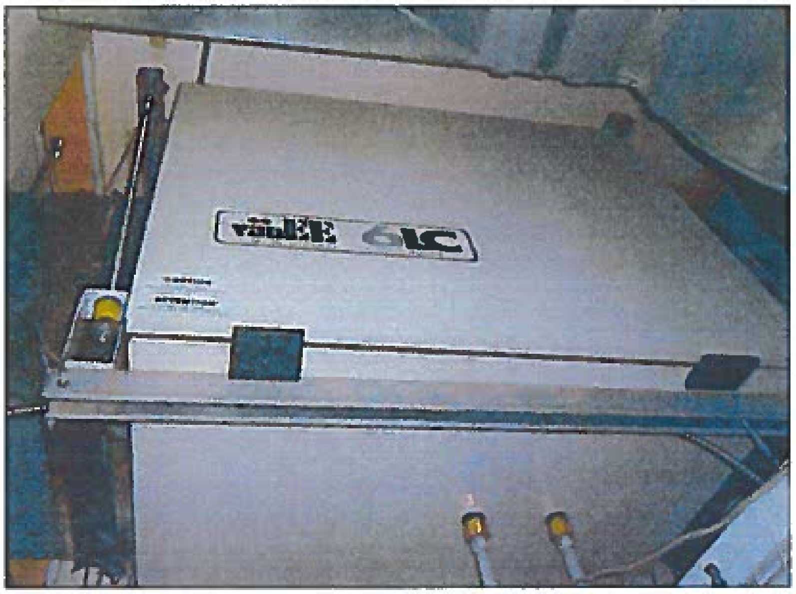


Photo 27 - Heat Recovery Ventilator

Photo 28 - Range Hood Exhaust Fan

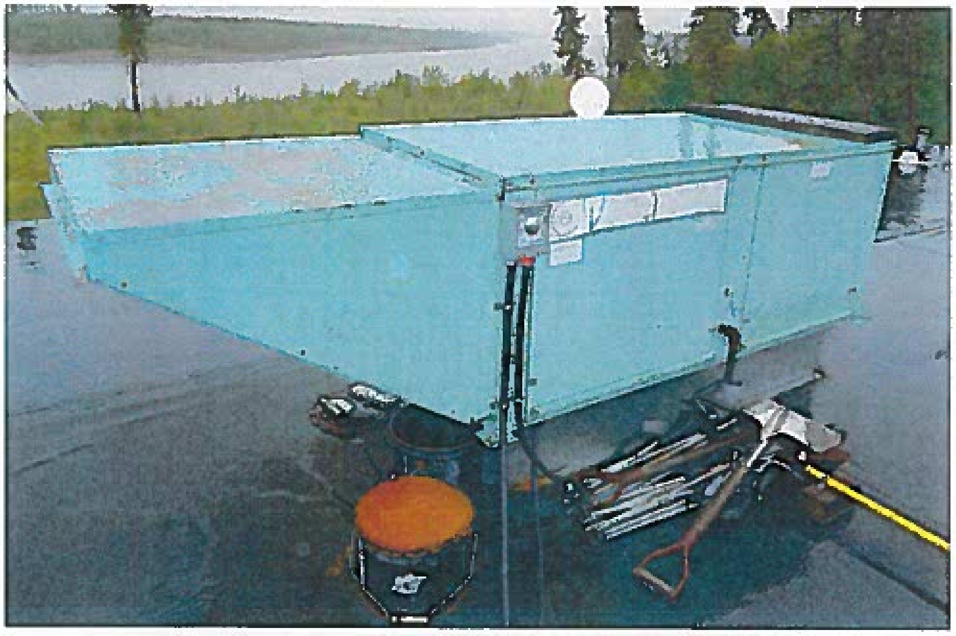


Photo 29 - Make Up Air Fan

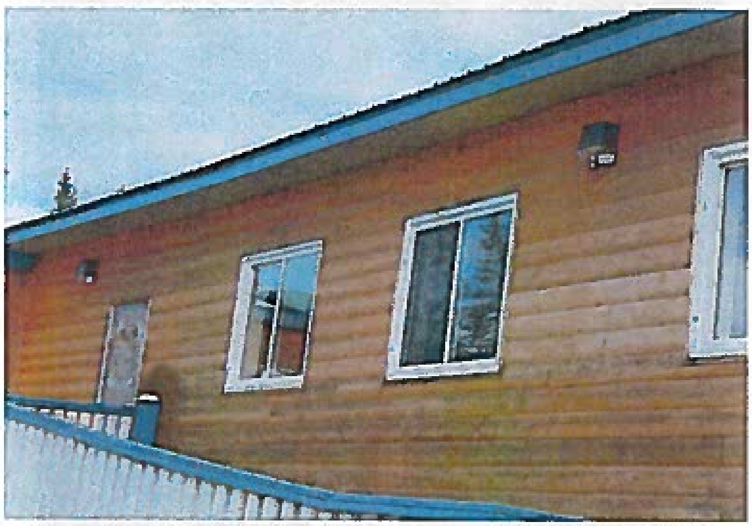


Photo 30 - Exterior HID Lighting

Photo 31 - Exterior HID Lighting

Photo 32 - Electric Hot Water Tanks

Photo 33 - Cabin Electric Hot Water Tank

Photo 34 - Lodge Laundry Machines

Photo 35 - Staff Cabin Dryer

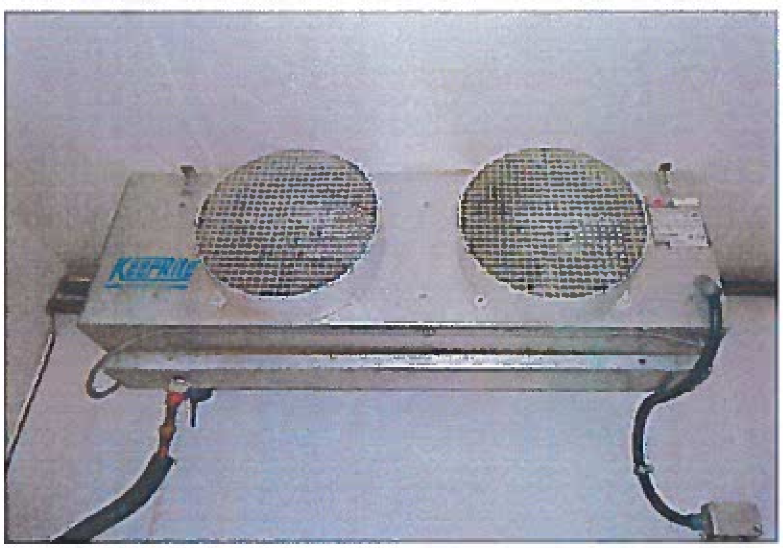


Photo 36 - Cooler Evaporator

Photo 37 - Cooler/Freezer Condensors

Appendix II – Generator Operation Log Data

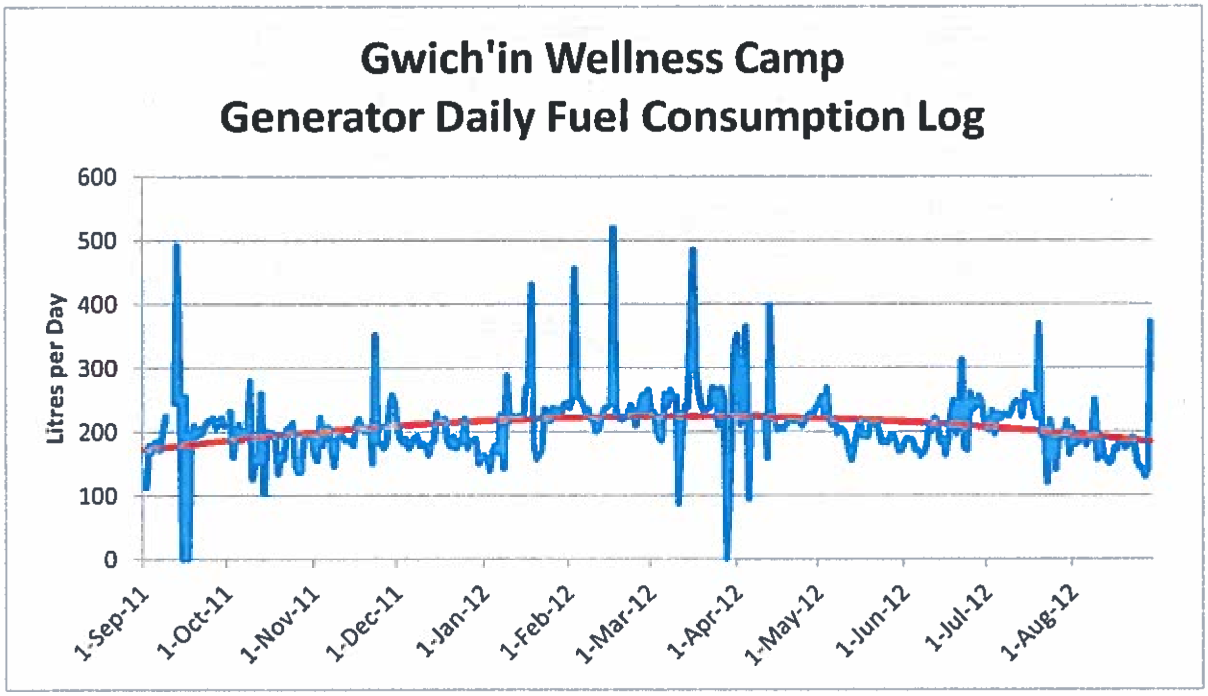


Figure 5 - Generator Daily Fuel Consumption Log

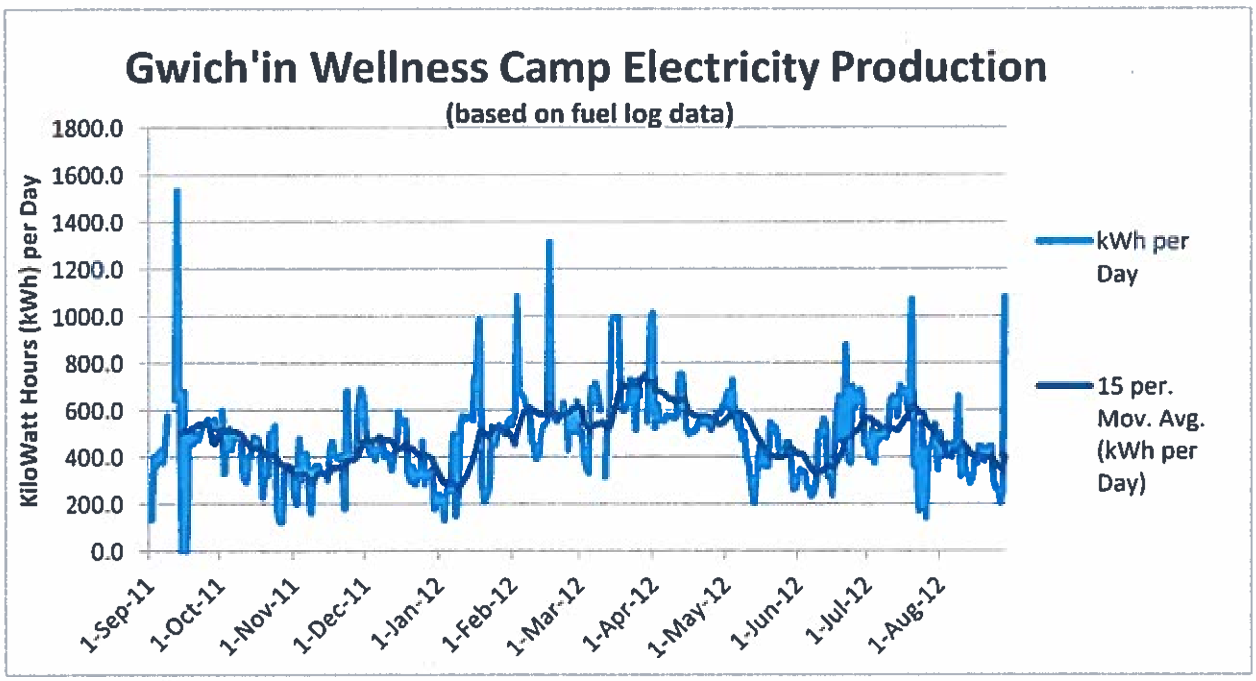


Figure 6 - Generator Daily Electricity Production

ARCTIC ENERGY ALLIANCE

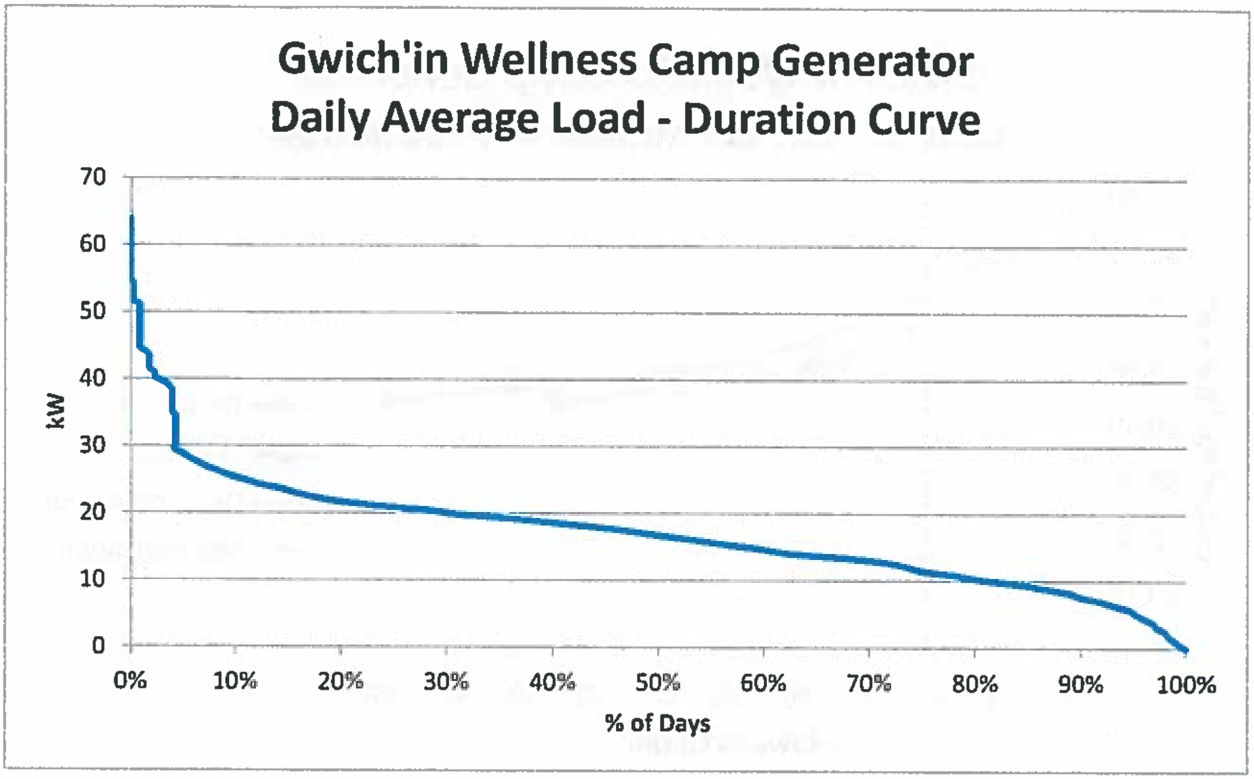


Figure 7 - Generator Load Duration Curve

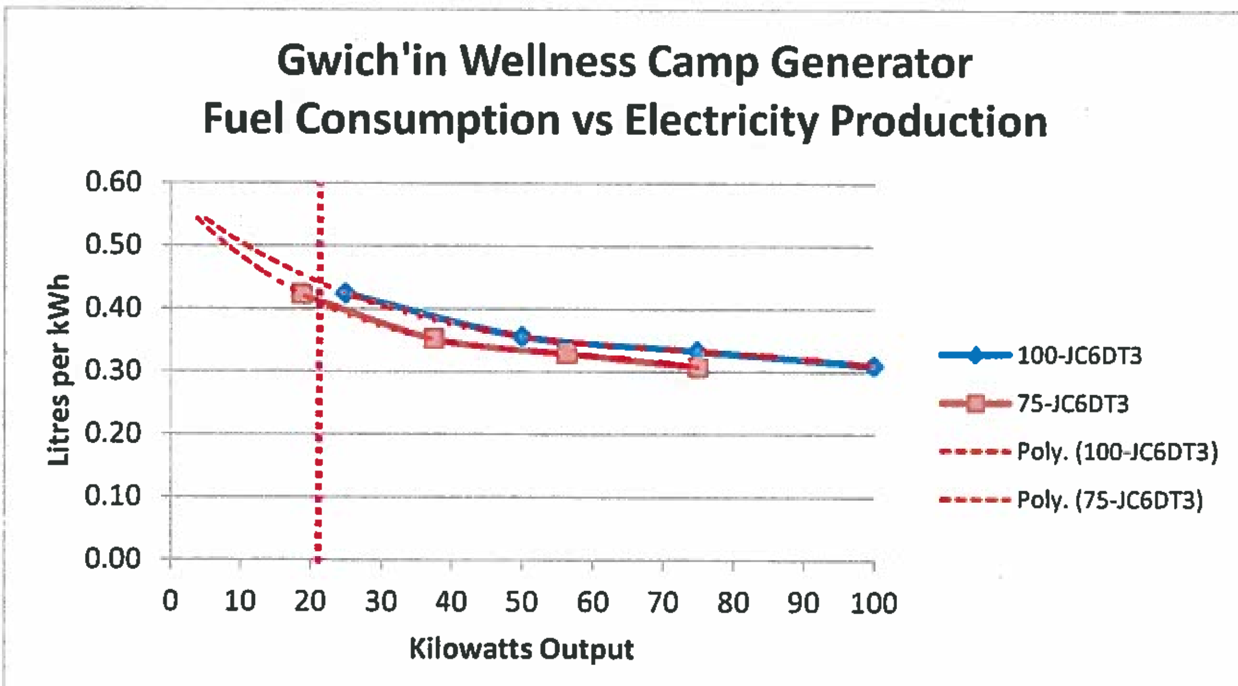


Figure 8 - Generator Fuel Consumption vs Electricity Production

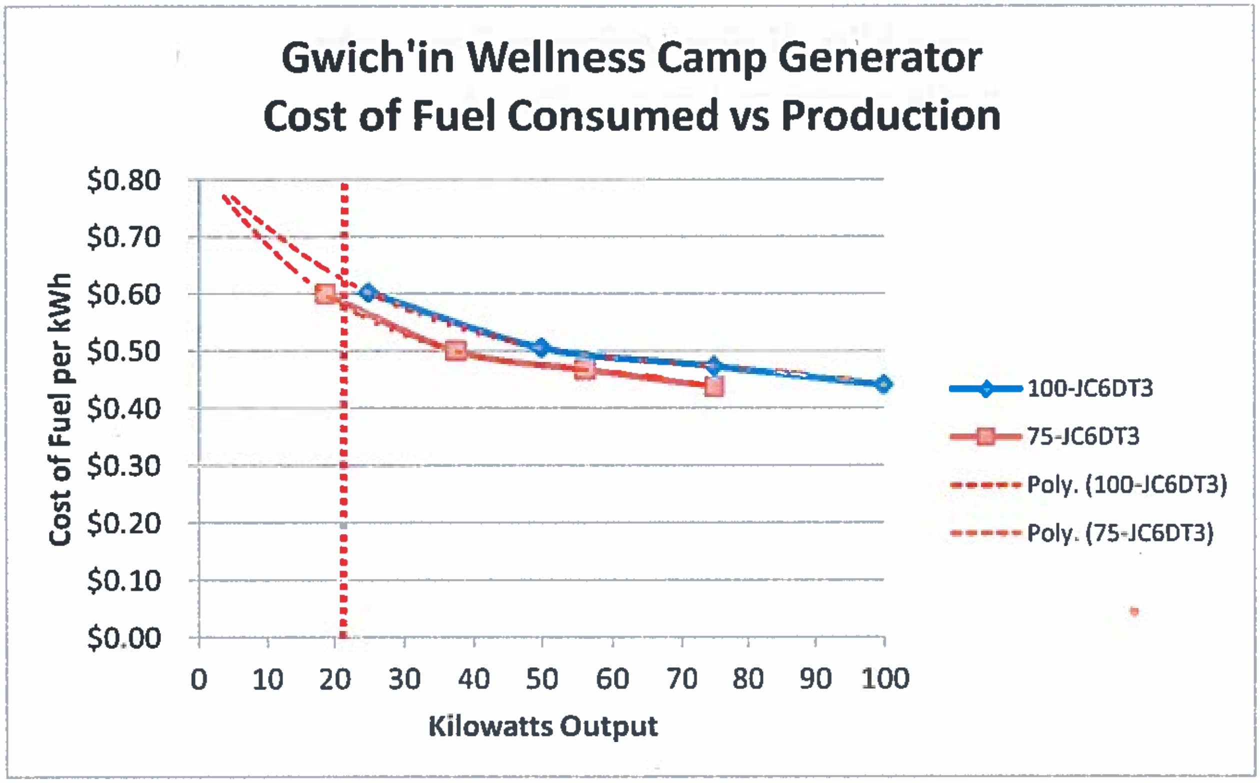


Figure 9 - Generator Cost of Electricity Production vs Output