Raven Recycling Biomass Fuel Study

Final Report

March 2017

Introduction

In February of 2016, Raven Recycling collaborated with ACS Mechanical Systems with the support of Yukon Government's EMR Energy Branch and the Cold Climate Innovation Centre to purchase an Austrian-built Hargassner Wood Chip/ Pellet boiler. The project served as a pilot to investigate alternative heating in the Yukon. The boiler is fueled by biomass, an energy source that the Yukon has in abundance.

The project demonstrated the viability of biomass heating in the territory. The results of the project are available to people interested in using biomass as a source of heat in other Yukon buildings. The project tested different sources of biomass and sizes of chip to discover which were the most efficient and the best value. Tours of the facility were available to those interested.

By comparing previous year's fuel bills with the costs of operating the woodchip boiler, Raven determined what cost savings are possible when using biomass, including the costs of chipping. We also experimented with a variety of fuel sources, chippers and chip sizes to produce a chip type that was most suitable for the Hargassner machine.

All monitoring and data collection occurred between the installation of the boiler in January 2016 to the end of the pilot on March 14, 2017.

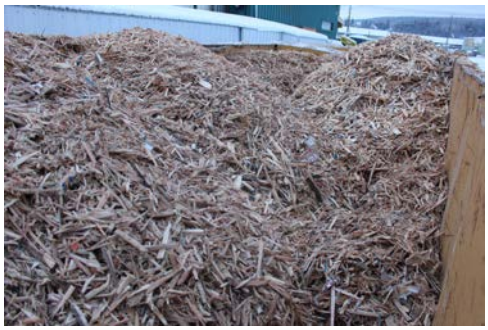
Project Set up

Chris Schmidt owner of ACS Mechanical travelled to Quebec to learn installation techniques and regular maintenance procedures specific to Hargassner boilers. He installed the boiler in Raven's yard in late January of 2016 with minimal difficulties.

Bomac Construction built both the boiler and chip storage rooms in January 2016. The boiler room measured 10 x 10 x 8, it was reinforced for weight, insulated and had a metal floor. It was built with double doors and a hole for the auger system. The chip storage room measured 7 x 7.5 x 9, it was also insulated, reinforced for weight with a metal floor and the bottom portion of the room was lined with Teflon sheeting for the sweeper arms. It was built with a side loading chute, an entrance for maintenance, and a hole for the auger. It holds on average up to 160 cubic feet of chips.

Findings:

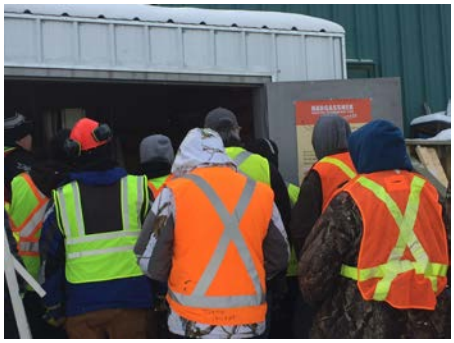
Fuel source



From 2015 through 2017 we produced a variety of chips using different sources of wood and various chippers. Although we have burned some of the chips we produced, we have yet to produce the most suitable chip. See appendix A. We were unsuccessful in using wood waste from pallets because nails could not be removed. It continues to be our goal to use pallets and wood waste as our biomass source.

We were unable to consistently assess or document the humidity levels. The humidity gauge was not always available to us. We were also unable to measure the heat produced by the biomass system, as the appropriate gauges were not installed on the machine. A heat meter has been ordered and could be used effectively once the other variables around chip quality are controlled.

Tours-to-date



We have had several tours from school groups to community members who were interested in implementing similar heating systems in their communities. Upon inspection of our facility, and a thorough explanation of the pilot and the boiler's potential, the Village of Teslin has purchased 10 Hargassner boilers. Haines Junction is considering doing the same.

Raven produced posters and banners for educational purposes. The posters responded to the three most often asked questions: How does the boiler work? What is biomass? How much does it cost? The posters are permanently located in the boiler room. The banner is available for community events.

Financials-to-date

Attached is the Financial Spreadsheet comparing the budget to actual project expenditures to March 14, 2017. A Fund Allocation Detail Report produced by Raven's bookkeeping department is also attached.

Data Collection

Raven developed two data spreadsheets. The first measures the daily volume of wood chips, outside temperature and the time it took to load them; the second records the liters and cost of fuel oil used before and after the wood chip boiler was installed.

Daily Volume of Chips

Starting in October of 2016 we began to collect data on the volume of chips we loaded daily into the boiler and the number of minutes it took. The boiler used an average of 8.74 cubic yards of material per day that took Raven staff an average of 13 minutes to load. The data is available for further analysis to inform future decision-making.

Fuel Oil Comparison

Raven kept the original fuel oil boiler system to use as back up for the new boiler system. We were concerned that the wood chip boiler may not be large enough to heat our building when the temperatures were low. Our building is 11,200 square feet in size and as it is not sealed nor well insulated, it is not energy efficient. We also leave large warehouse doors open for a length of time on a daily basis for operational purposes.

During the pilot period, our wood chip boiler did not work continuously. It was not operating a number of times for a variety of reasons: 1) while being repaired, 2) when we did not have proper chips to burn or 3) when we ran out of chips. During cold weather (- 30 and below), the oil burner kicked in to supplement the heat generated by the biomass boiler.

In comparing the cost of heating Raven with oil or biomass, we found that our fuel oil expenditures this winter (July 2016 to March 2017) were significantly less than the previous two winters, however we did have to purchase and chip wood. The net cost of buying heating oil, buying biomass fuel, chipping the wood product resulted in no cost savings over the last three years. See chart below. However, next year we expect our heating costs to be lower as we won't be purchasing pellets nor wood to chip. Please see attached spreadsheet named 'Raven Fuel Data' for further information. It includes high/low temperatures for each month and the average liters of fuel oil consumed.

winter months	fuel oil	wood	chipper rental	pellets / chips	total cost	comments
July to May	$	$	$	$	$	
2016-17	9,621	3,777	3,365	9,075	25,838	missing April and May fuel oil
2015-16	22,369	550	1,200	280	24,399	
2014-15	26,070				26,070	

Another variable that may have had an impact on our heating costs to March 2017 are modifications we made in fall of 2016 when we rebuilt the doors of the warehouse to accommodate a new baler. At the same time we fixed the door seals and the doors were open less often than in previous years.

Hargassner Boiler

ACS Mechanical reports that the Hargassner manual was easy to read and had an excellent trouble shooting section that proved useful. ACS Mechanical was also pleased with the support provided by Hargassner representatives in Canada.

The Hargassner boiler was responsive to the variety of fuel sources and chips that were used over the period of this pilot. The safety mechanisms worked as required; in one case the boiler shut down when a door was accidentally left open.

Conclusion

Suitable chip size is approximately 2 inches in order for the auger to operate uninterrupted. Wood chips need to be dry and not green for the boiler to reignite after it has gone through sleep mode. We were unable to measure the heat production in GJ or closely monitor the moisture levels of the wood chips.

We saw less utility cost savings over the second winter than we expected because we purchased wood, pellets and rented chippers. We anticipate that over the next winter, we will realize significant cost savings.

Overall, our observations have shown us that the boiler operates independently with very little user input or maintenance but is very dependent upon the quality of the chips. When the wood is not wet, is chipped cleanly, and the size of the chips are small enough to ensure there are no oversize pieces, we expect to spend little to no time fixing jams or cleaning out rocks.

Both Raven Recycling and ACS Mechanical were pleased with the pilot and its results. Given the challenges we faced with chip quality, the Hargassner was more efficient and flexible than we had originally expected. We would highly recommend this boiler for use in the Yukon.

Future considerations for Raven

Although we were not able to produce the ideal chip, we are currently working with Bear Creek Logging who has invested in a new grinder with a 2-inch screen. This grinder will also remove the nails from pallets and clean construction waste by way of a magnetic conveyor.

We estimate we would need 60 tonnes of chips per year. If we had the storage capacity this volume of material could easily be chipped once per year. Our goal is to increase storage capacity to contain one years' worth of material.

We will run the wood chips collected in the fall of 2015 (currently stored in 3, 40 yard containers) through Bear Creek Logging's screen to remove the nails. We will also access free pallets and clean construction waste as a fuel source when we have a proven method of removing nails.

Appendix A

Throughout the fall of 2015 Raven employees, Ralph Charlton and Danny Lewis, worked towards producing a suitable wood chip that would be of the appropriate size to travel through the auger system and then combust/ burn in the combustion chamber.

Winter 2015/16

The **first set of chips** were made from wooden pallets that were collected in Raven's yard during a 5-month period (August to November 2015). The pallets were chipped using Castle Rock Enterprise's tub grinder; 21 tonnes of chips were produced in 2.5 hours.

The chips produced from the pallets were a good size for the Hargassner system but there were too many nails left in the material for the boiler to operate. Although the nails moved easily through the front end of the system, (the infeed auger and the combustion chamber) they ended up clogging the ash auger system at the end of the process. Apart from the nail issue the pallets produced a high quality chip as they were dry and a hard wood that burned efficiently.

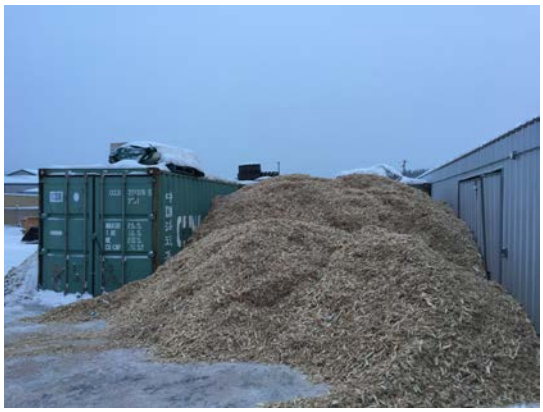
The **second set of chips** were made from firewood using a 9-inch wood chipper from MacPherson Rentals. These chips were too inconsistent in size and would jam the infeed auger.

The **third set of chips** were purchased from a local woodcutter. This material ranged in size from sawdust to branches and had a great deal of green needles and small diameter twigs mixed in with the chips. As the twigs were green, they got stuck in the infeed auger because they were pliable; they bent rather than broke which created small "dams".

Before the first winter ended, we tried **a fourth option** - a sawdust material (under an inch) obtained from Hurlburt Enterprises. The bulk of this material ended up being too wet (over 35% moisture level) which prevented the boiler from re-igniting the chips. The drier sawdust worked fine.

Summer 2016

A bunker was built to store the wood chips beside the chip storage hopper. We enclosed a 20ft x 20ft asphalt pad between two used sea cans and an existing wall. Our intention was to have the bunker covered with a tent before the snow fell so the chips would stay dry as is recommended. Unfortunately, the tent was not erected for a number of reasons. This resulted in wet wood chips that significantly decreased the efficiency of the boiler and created several issues around the boilers

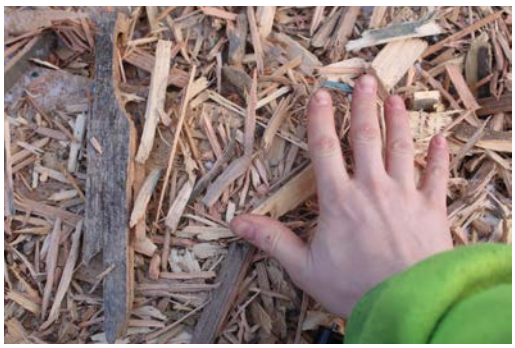


operation. This experience led to a good understanding of how much moisture the boiler can manage in its fuel source and the importance of chip quality.

Fall 2016

We had issues finding and producing consistent sized chips from local forestry sources so in the interim, we purchased wood pellets from a local supplier. Despite an initial concern from Chris about switching to pellets and not adjusting the boiler settings, we had no issues with the pellets or the boiler's efficiency with one exception. When the boiler would wake from a sleep cycle, it would not re-ignite the pellets as they were too dense to catch fire. Chris tells us that if there had been two igniters on the machine, this would likely not have been an issue.

Winter 2016/17



In the early winter, we purchased whole logs and log slabs from two different local woodcutters. We again had the biomass chipped by Castle Rock's Enterprise tub grinder as it was the most suitable chipper that was available locally.

This product was stored in the new bunker and although we burned it for the rest of the winter we encountered a number of problems. The first was with the size of the chips, the second was that the chips got wet and the third was rocks in the chips.

When the weather was consistently cold the boiler ran dependably and we only had issues with the chip size. Chipping whole logs with the Castle Rock tub grinder produced the occasional chip that were too large to go through the auger system. Screening the product would have solved this problem.

It was during the warmer days or when the temperatures fluctuated that the moisture in the chips caused difficulties. On warmer days the boiler shut down or entered sleep mode when heat wasn't required. The wet chips would not re-ignite after a shutdown and the auger would repeatedly shut down the entire system due to overfilling. We rectified the situation by emptying all the wet chips out of the chamber and putting a few handfuls of dry chips in that would ignite. Once the system ignited it could handle the wet chips. Thus on the warmer days someone had to do this on a daily basis requiring more staff time and attention. The wet chips also burned inefficiently thus burning more chips which produced noticeably more ash.

We also experimented by mixing pellets with the wood chips which allowed the machine to run continuously through the temperature fluctuations. The only issue became the larger wood pieces and, on occasion, some rocks that would jam the cleaning grate in the chamber. We believe the rocks were introduced during the chipping process when Castle Rock's excavator picked up logs from the ground.

The ash box needed emptying approximately once a week, with slight variation depending on material ie. wood chips, sawdust, pellets, or a combination.