Waste Wood Chipping & Fuel Procurement Report for 20kW GEK Wood Gasification System

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1. Overview

a. What is Wood Gasification?

Most biomass can be turned into fuel or electricity - wood is no different. In its simplest form, wood gasification converts woody biomass into a burnable gas (syn-gas) that can be combusted in an industrial engine to create electricity. Wood is 'cooked' at high heat, with very low oxygen to produce gas from the wood. Next, that gas is combusted, since it can burn at a much higher temperature than the wood itself. This 'syn-gas' has less energy than the same volume of natural gas but may be used in similar applications.

In many parts of the world, wood waste from forestry operations is simply burned in open piles (slash-piles), contributing to rising CO2 levels. Gasifying this wood to produce electricity is much more useful, efficient, and cleaner than simply burning wood.

Various forms of wood can often be found as a 'waste-product' from certain types of industrial processes. (Logging, urban tree removals, fire-guard creation, ski trail maintenance, etc.) It makes sense that we might try and derive some energy from it at an appropriate scale.

b. About the Biomass to Power Demonstration Project

This project involves the scientific testing of a commercially available wood gasifier with locally produced fuel wood. The technical research is being undertaken by the **Saskatchewan Research Council.** A public demonstration is to be held to show members of the forestry & logging community with an interest in alternative energy production how the unit works.

This report is an overview of the wood selection and chipping process which took place in July of 2012 at the Ness Creek Ecological Site. Fuel procurement was undertaken by Tayler Krawczyk of Hatchet & Seed Contracting. It focuses on small scale wood procurement, as done by a single operator with minimal machinery. Large-scale industrial processing of wood chips is outside the scope of this report.

While processed wood chips or pellets can be purchased from various national & international suppliers, we sought to explore a local, small scale approach as part of a low-impact woodlot management system. In this case, that meant removing 1-2 year old *deadfall* and *standing dead trees* from the ski trails at the Ness Creek site and surrounding area. This served the dual purpose of cleaning up excess wood on the ski trails and creating wood chips for the demo.

However, this scale of operations also makes a cost-benefit analysis slightly more difficult. If a crew is paid forestry wages to complete the work done in this demo, it is not economically viable, as we will see in Section 3. However, in this case, there are many positive externalities to the work completed within an owner-operated low-impact forest management system.

Objectives for Fuel Procurement:

1. to gain & share valuable insight on wood selection and best practices for fuel chip creation
2. to test the economic viability of small-scale wood chip creation for the purpose of fuel in a wood gasifier
3. to utilize 'dead-fall' wood that was blown down at the Ness Creek Ecological Site as part of a large wind storm in 2011 for testing the viability of that fuel source

This is what much of the forest looked like after the blow-down windstorms & small tornado that came through the Big River area in 2011. Many 4"-10" aspen trees were leaning or blown down, and make great fuel wood.

c. Specifications for the GEK Power Pallet

In the summer of 2012, the **Saskatchewan Research Council** purchased a 20kW GEK Power Pallet from All Power Labs in Berkeley, CA. Fuel specifications are 1cm-5cm wood chips, with less than 20% fines & sawdust. This unit costs ~$32,000, fully assembled after delivery.

More information is available at www.gekgasifier.com

The components of the GEK Gasifier.

d. Ness Creek Site Forest Management

The Ness Creek Ecological Site is home to over 20 km of ski, walking & biking trails. Currently, these trails also serve as woodlot-corridors for the harvesting of firewood & some timber. The vision is to keep these trails open for the selective harvesting of large timbers for cabin construction & value added building materials. For that reason, the site makes a good candidate for power production via wood gasification, since smaller wood that inevitably will get in the way of other activities can be selectively removed for chipping and fuel creation. Some of that fuel is from wind-fall, fire-guards, new trail development or thinning wood from the release of timber trees. It is in this setting that we wanted to test the feasibility of a small scale wood chip

The Ness Creek Ecological Site has over 20 m of ski trails from which the waste wood was harvested & processed into fuel wood.

gasification system like the GEK Power Pallet.

2. Chipping Operations

The end product we were looking for was 1-5 cm wood chunks, with less than 20% fines and less than 30% moisture content. At this scale, using a Vermeer BC 600 Chipper, the optimal size of wood was 4"- 6" pole wood roughly 6'-10' long. This is optimal for a single operator to handle, load wood on a flat-deck quad trailer and run through the chipper. It is important the wood has not been lying on the ground for several months in wet conditions. The best was one-year old deadfall that was leaning up off the ground. Some two-year old wood was used that was piled up off the ground in a sunny location. With foresight, as part of a larger woodlot management plan, one could also cut green wood and let it dry for a year before chipping it.

Pine wood collected for the widening of the Nesslin Lake road.

All chipped material was loaded onto this screen built of 1/4" hardware cloth. Shaking & banging it filtered out all fines and the finished material

a. Tools & Equipment

Tools used for the

procurement of the fuel-wood in this demo included:

- v6 Toyota Pickup truck
- Honda Foreman 4x4 quad
- flat deck quad trailer (6ft x 3ft)
- Husqvarna Rancher 55 Chainsaw
- chainsaw pants
- chainsaw boots
- Vermeer BC 600 Disk Chipper
- chain Oil
- gasoline
- ratchet-straps & bungees
- 2 stroke engine oil
- 5W30 engine oil
- safety glasses & ear plugs
- 15 large tarps
- 2 large snow shovels
- pitchfork
- 7 large black garbage bins
- 9' x 9' frame with 1/4" hardware cloth fastened on with fencing staples

More dead-fall on the Ness Creek trails. These 6" aspen were ideal for the Vermeer BC 600 Chipper.

Here is the chipping & sorting station created in July of 2012.

b. Work Flow

1. Assessing Trail System

- What type of wood is most available? Which areas have the most easily accessible deadfall? Is the dead fall suitable for chipping? It is too wet (punky)? Where is the easiest, lowest energy areas to remove wood from the trails?

2. Setting up the Chipping Station

- Keep open access for chipper; loading zone to drop off pole wood; tarps for drying; primary screen that chipper can blow material into; secondary screen close to chip piles for easy loading
- If loading with a tractor or skid-steer, leave extra room for that machinery

3. Wood Selection & Hauling

- Load quad & flat deck trailer with chainsaw, chainsaw pants, eye protection, ear plugs, chainsaw boots and ratchet-straps
- Cruise trails cutting down dead-fall that is leaning on trails; look for 4-6" wood; buck up wood into 8 foot lengths; load onto flat-deck trailer, strap the full load in and take back to chipping station

RIGHT. A Vermeer BC 600 Disk Chipper. LEFT, you see a primary screen filter, which all chips were blown against to remove the fines. In the background, you see the large screen that was used to filter out anything less than 1 cm (1/4 inch hardware cloth was used.)

A close up of the homemade sorting/sifting screen. Chips are loaded onto the screen and it is shaken to allow the larger chips to fall onto a collection tarp at the bottom, while fines fall through.

- Create large pile of pole wood at chipping station so that you can chip uninterrupted for several hours

4. Wood Chipping

- Ensure chipper is full of oil and gas
- Put in earplugs & eyewear
- Start chipper and run through a deck of wood until the pile needs to be screened to make more room

5. Wood Screening / Sifting

- Dump wood chips onto the sifting/sorting screen
- bang the hardware cloth with a shovel until all the chips bounce down to the bottom; unusable small chips will fall through (as seen on previous page)

* An electric shaker could easily be installed under the screen to automate this process

The finished product: 1-5 cm chips. These are dry pine chips, which burn nicely, but are a less dense fuel than hardwoods. Hardwoods (aspen, birch, etc..) will

Small pickup truck loading the easily collectable pole wood for chipping.

3. Cost Analyses

a. Powering the Average Household with a GEK

Useful Facts

- 1 yard of dry chips = 290 kgs[1]

- 10 yards = 2,905.31 kgs

- 20 yards = 5,810.62 kgs

- 30 yards = 8,640 kgs

- The average Calgary household uses 7,200 kilowatt hours (kWh) per year
- Commercially, chipped & screened fuel sells for ~$5-$50 / cubic yard[2]

Key calculation:

7,200 kWh (Average annual household consumption in Calgary, AB)[3]
x **1.2 kg / kWh** (from GEK specifications table)

= ~**8640 kg** of chipped / screened biomass

= ~ **30 yards** of wood chips
(at the rates mentioned above, fuel costs would be ~$750-$1500 to power the average household)

= a pile ~**3.1 yards long x 3.1 yards wide x 3.1 yards high**

= ~**322 hours (13.4 days)** of runtime at **full capacity**

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[1] http://www.aqua-calc.com/calculate/volume-to-weight/substance/Wood-blank-chips-coma-and-blank-dry

[2] Sourced: Mander Trucking, Chemanus, BC, Victoria Landscape & Gravel Mart, Victoria, BC & GEK Supplier in Berkeley, California

[3] Source for Calgary average household.
http://www.calgary.ca/UEP/ESM/Pages/Reducing-Calgarys-ecological-footprint/Home-energy-savings/What-you-can-do/Energy-use-in-your-home.aspx

= ~**1288 hours (53.6 days) at 1/4 capacity**

b. Cost of Small-Scale Chipping Process

These estimates represent the cost of chipping fuel oneself or with a 2 person crew with small scale equipment as part of an existing woodlot management program. Because of the inevitable learning curve, I estimate that at full capacity and a little experience, production of chips could increase around 30% with same resources used in this demo. While actual output was ~**7 cubic yards of finished chips**, I estimate a two-person crew should be able to create ~**10-20 yards / work week** of usable fuel wood with the tools & equipment listed above. This requires access to a trail system with blow-down wood. If a large wood pile has already been piled up, the yardage could go up.

In a cottage-scale industry, all bi-products are utilized. At the Ness Creek site, the un-usable fine materials were used in the orchard as pathway mulch for edible, medicinal & mycorrhizal mushroom cultivation as well as weed suppression.

Fuel & Labor Used in this Demo

Input:

40 L fuel in chipper
20 L fuel in quad / trailer
10 L fuel in chainsaw
60L in truck for chipping

**140L of fuel was also used to haul rental chipper to/from Saskatoon (not a permanent cost if owner has local access to chipper)

= 130 L of fuel * not including chipper hauling
= $162.50 of fuel (@ 1.25/L)
+ 80 hours of labor

Output:

- 7 yards of fuel wood (2030 kg) or 2436 kWh
- 7 yards of fines for garden mulching & pathway building
- several ski trails opened up & cleaned up after large storm

10kW & 20kW Power Pallet Specifications

	20kWPP		10kWPP	
Frequency (Hz)	50	60	50	60
Engine	GM Vortec 3000	GM Vortec 3000	Kubota DG-972	Kubota DG-972
Generator	Meccalte NPE32	Meccalte NPE32	Meccalte ECP3_2	Meccalte ECO3N_4
RPM	1500	1800	3000	1800
Gas Output (m3/hr)	54	54	27	27
Power Output Range (kW)	4-20	4-20	2-10	2-10
Generator Poles	4	4	2	4
Spark Advance	~7.5° from stock	~7.5° from stock	10° from stock	Stock
Biomass Consumption (kg/kWh)	1.2	1.2	1.2	1.2
Avg. Consumption at Max Power Output (kg/hr)	26.8	26.8	13.4	13.4
Db rating @7m	70	70	60	60

Source: GEK Power Pallet User's Manual.

6. Conclusions

a. For the 'cottage-scale fuel procurement' described above to be economically viable, it must be fit into existing forestry operations; including: a saw mill, recreational trail creation, fireguard creation, agro-forestry and/or orchard management.

Many pieces of equipment including a quad, trailer, chainsaw & truck must already be a part of this forestry system to benefit from the added cost of a chipper and the chipping process.

b. Economies of scale do create much cheaper fuel sources, as demonstrated by larger mills and their ability to create large quantities of chips as a 'waste-product'.

This technology is scaleable, but the chipping and screening process is very energy intensive and needs to be evaluated for its net energy benefit and ecological impact. Market research suggests that chipped and screened wood biomass should be able to be produced for around $25-$50 / yard.

c. Scale can also make a difference as to the 'ecological sustainability' of the technology. Depending on scale and harvesting practices, wood gasification as a source of power can range from 'degenerative' to 'sustainable' to 'regenerative'.

Degenerative - Continuous clear-cutting and chipping of round logs as a source of fuel with no attention paid to energy-conservation & ecological regeneration.

Sustainable - Using waste wood that is a bi-product of existing logging with proper regenerative forestry practices applied for re-growth; using fireguard biomass otherwise burnt; or cottage-scale dead-fall gathering.

Regenerative - If used in conjunction with coppice agro-forestry, wood gasification for power production could be regenerative; meaning it could have a net carbon storage; coppice agro-forestry is the practice of planting fast growing trees and shrubs that shoot back up if harvested. In a prairie climate, rotational willow or poplar stands could be planted to replace cleared land. These could be harvested once they reach 1"- 2" in girth and chipped into a uniform fuel wood, all while re-vegetating cleared land.

d. Roughly 40% - 50% of the chipped material will be too fine to put into the gasifier; find a use for it!

Small chips and sawdust can be used as a carbon-rich neutralizer in outhouses and composting toilets. They can be used as mulch around trees and shrubs in orchards to protect the soil for wind and rain erosion; to reduce evaporation; for weed suppression on garden pathways; and also as insulation in small outbuildings. Add value by finding a good way to use this great resource.

e. For someone looking to produce large amounts of power for the grid-system, buying chips in bulk from a local mill or producer maybe the best economic option.

If you do not have access to deadfall, a saw mill, a chipper, and other necessary equipment, an agreement with local sawmills or tree companies may be a very economical method of producing power. Generally however, the cheaper the fuel the less likely the harvesting practices are going to sustainable over the long run.

f. Urban tree companies often have to pay to dump their wood waste material at municipal green waste sites, making it a great opportunity for urban dwellers or municipal governments.

As a landscaper in Victoria, BC, I've had tree companies drop off 30 yards of wood chips for free. However, most often only 1/2-1/3 of that would be usable for the gasification and would need to be screened & sifted.

g. Practical tips for small-scale wood harvesting & chipping:

- Do not run wood with wet or moist bark through the chipper, it will get clogged and you will need to open up the chipper's flywheel casing for cleanout
- Subtract 1 inch from whatever a chipper company's specs say it can chip
- Hardwoods (aspen, birch, willow) are more dense a fuel than softwoods (pine, spruce)
- Multi-year planning of fuel wood would be beneficial for a serious power producer; cutting uniform green wood; allowing it to season, then chipping it would create a consistent fuel
- Even green chips can be dried with a month of sunny weather and hot winds, but the piles must be flipped & kept dry