Practical Solutions for Biomass Heating in the Hazelton Region
Appendix: Biomass Fuel Management & Emissions

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Introduction

Biomass heating technology is a combination of 19th century coal boiler design, advanced computer controlled combustion modelling which assures high efficiency and low emissions and specifically developed fuel processing and management systems which take into account the particularities of biomass fuels.

The collection, processing, transportation and storage of woody biomass fuel is usually the most challenging aspect of any biomass heating system. The challenges are particularly great when dealing with small amounts (< 2000 tonnes) of fuel since most equipment is designed for large and very large operations while the fuel quality requirements for small systems is inherently greater than for large systems.

Wood Chip Specifications

It is important to remember that wood chips suitable for biomass heating systems are NOT random wood waste but a manufactured product with defined characteristics.

Below are the specifications most commonly used in Europe. The G50 size is used most often in boilers with an output between 50 kw and 500 kw. Smaller boilers may require G30 and larger boilers may be able to process G100.

Note that the chips are rated based on 3 different screens (coarse, medium and fine) which filter both "overs" and "unders". Wood chips that are too big may interfere with the reliable transfer through augers and drop chutes while "fines" are undesirable because of increased particulate emissions; in extreme cases (f.e., pure sawdust) such material can also clog up augers and boiler grates if the equipment is not specifically designed for such materials.

Ideally, a wood chip is "chunky" and of mostly uniform size, this improves both handling and combustion characteristics.

Illustration 1: High quality wood chips

Illustration 2: Low quality hog fuel

Wood Chip Specification

The quality of the fuel used can have a significant impact on the reliability and the life of the boiler.

The use of contaminated material can lead to breaches of emissions and waste regulations as well as long term damage to the heating system.

We would recommend using wood chips rather than shredded wood

De-barked wood for wood chips reduces the ash content of the fuel, therefore benefits an automated boiler system, reducing the need for human intervention for servicing.

We recommend as a minimum the fuel should comply with the following specifications;

Wood Chips Classification acc. To OENORM M7133				
Description		G30 Size	G50 Size	G100 Size
Single Pieces	Edge Length Max	85mm	120mm	250mm
	Cross Section Max	3cm²	5cm²	10cm²
Retained in coarse sieve		Max. 20%	Max. 20%	Max. 20%
Coarse sieve mesh		16 x 16mm	31.5 x 31.5mm	63 x 63mm
Retained in medium sieve		60 to 100%	60 to 100%	60 to 100%
Main Quantity nominal length		30mm	50mm	100mm
Medium sieve mesh		2.8 x 2.8mm	5.6 x 5.6mm	11.2 x 11.2mm
Passing medium sieve		Max. 20%	Max. 20%	Max. 20%
Fine sieve mesh		1 x 1mm	1 x 1mm	1 x 1mm
Passing fine sieve		Max. 4%	Max. 4%	Max.4%

Water Content	
Class	Class Limits
W20	< 19.99%
W30	20 – 29.99%
W35	30 – 34.99%
W40	35 – 39.99%
W50	40 – 49.99%

Ash Content	
Class	Class Limits
A1	< 1% Small Ash Content
A2	1 – 1.5% Higher Ash Content

The size specifications are most important for a successful project but water content and ash content can affect the proper operation as well. Most medium (50 kw to 500 kw) sized boilers specify W35 or lower water content but whenever possible W20 should be the objective which corresponds to the moisture content of seasoned cord wood. In the Hazelton area it should not be a problem to source low moisture wood waste since there is an ample supply of standing dead wood with a moisture content of often below 10% and a ready supply of slabs from smaller sawmills which – even when green – dry very quickly to the desired degree within a couple of months during the summer.

Ash content is largely determined by bark content of the feedstock. Bark free wood has an average ash content between 0.5% and 1.0%, wood with bark is between 1.0% and 2.5% and bark alone is between 5% and 8%. Ash is an issue during combustion and as regards disposal. The melting point of the ash component during combustion can be a very serious problem since the “clinker” so generated can literally “weld” metal components within the boiler together. For woody biomass these critical ash melting temperatures are usually above 1000°C and the boiler design and controls manage this issue easily.

Other biomass fuels (grasses, husks, olive pits, etc.) have lower ash melting points which requires special designs and considerations.

Ash disposal is a required and recurring task for the boiler operator. The usual quantities involved are small and easily managed. For example, a 300 kw boiler may burn through 200 bone dry tonnes of fuel a year or about 1 tonne per day which – at 1% ash content – results in 10 kg or 13 litres of ash per day. The ash storage component on the boiler may hold between one to four weeks worth of ash which is easily disposed of either as waste or as quick acting lime on acidic soils.

There is currently no commercial wood chip production in the region since there is no demand. Wood chip production and supply would have to be an integral part of the project as a whole. The PIR sawmill in Smithers is producing very large quantities of high quality pulp chips which are suitable as biomass fuel but long term contracts currently prevent sales to third parties.

Wood Pellets

Pellets are made of pure wood waste – no binders or glues are used – that has been dried, pulverized and pressed through steel dies which results in a uniform product of 6 mm diameter and between 10 mm and 40 mm long. Premium pellets are mostly bark free with a moisture content of 5% or less and an ash content of often under 0.5%. Industrial pellets contain substantial amounts of bark and have correspondingly higher ash content. Wood pellets are the most refined biomass fuel currently available.

British Columbia's North West is one of the centres of world wide pellet production and the closest production facilities are in Houston, Burns Lake, Vanderhoof and Prince George. There are future production facilities announced for Hazelton and Terrace.

The major advantage of pellets over chips is the relative ease of handling, storage and conveyance. Readily available agricultural grain handling, storage and transportation equipment can be used for wood pellets without modifications.

The energy density of pellets per unit of volume is about 4 times larger than for chips which makes storage both simpler and less expensive. On the other hand, the actual cost per unit of energy is between 2 and 4 times more expensive than for wood chips.

Illustration 3: Wood pellets

Current cost for bulk wood pellets is around $120 per tonne, fob pellet mill. There are indications that the cost may rise to $150 within the next year since the cost of feedstock has been increasing recently.

Transportation cost are estimated at $15 per tonne and 100 km distance from the manufacturer.

As a rule, any boiler that can burn wood chips can also burn wood pellets although combustion settings will have to be adjusted manually. It is therefore not recommended to casually switch between chips and pellets.

Although wood pellet production is nearby, there is currently no organized bulk pellet distribution system in place in the region since there are no commercial pellet boilers operating. Bulk pellets are currently exported overseas and only bagged premium pellets are readily available and used in residential pellet stoves.

With the current pricing structure and the lack of readily available delivered on-site bulk pellets, it is recommended to focus on wood chips as the main fuel. If the circumstances should change, it will be possible to easily switch from chips to pellets. For example, if pellets were available at a delivered cost of $120 per tonne, it would be hard to justify the local production of wood chips.

Wood Chipping

The wood chipper is the most important component in the wood chip production cycle. They come in all sizes and with various chipping mechanisms. The production of wood chips as a biomass fuel is a fairly recent development in North America and the American manufacturers are just now catching up to the higher quality requirements. Until now, most chippers were strictly designed to turn waste wood into a smaller form of waste wood so it could be easily disposed of. The characteristics of the resulting chips were irrelevant. This is changing though and it should be possible to produce an adequate chip with the currently available equipment, the proper operation and the proper feedstock.

There are mixed opinions about the advantages and disadvantages of disk style versus drum style chippers. Disk style chippers may produce more uniform chips since the knives cut the wood at a constant angle while the angle on a drum chipper constantly changes depending on the location and the thickness of the feedstock. On the other hand, it is much easier to change the knives in a drum chipper and the sharpness of the blades is crucial for a good product.

Illustration 4: Laimet chipping screw

One of the few European chippers available in Canada is the Finnish Laimet product. It uses a unique screw type knife which produces high quality chips but is both expensive and very difficult to sharpen.

Built in screens to prevent “overs” are still not common but there are current developments which may improve the situation. European chippers with all the necessary features are not available in North America. Direct import cannot be recommended because of added expense, lack of support and spare parts.

The ideal feedstock is standing deadwood between 3” and 12” in diameter, this is incidentally the dimension not suitable for lumber/timber production. Thick, substantial slabs are easy to chip as well, issues occur with thin, light-weight slabs that do not provide enough resistance for proper chipping and result frequently in long and stringy chips that can cause problems in the auger systems.

It is highly recommended to test any chipper with the feedstock available before purchase.

Illustration 5: Mobile diesel powered chipper

Illustration 6: Tractor PTO powered chipper with feeding attachment

Storage & Transportation

Wood chips may not be contaminated with any foreign materials, in particular rocks or metals which would damage the boiler system. It is therefore important to either directly chip into a truck or trailer or onto a clean floor, concrete, asphalt pavement or wood are all suitable.

A simple metal or fabric roof structure is recommended although a specialized fabric tarp made of "ACS Moisture Guard (Toptex)" can be substituted. This fabric keeps rain and snow away but allows for air to circulate and promotes drying. These tarps are also ideal to protect feedstock while it is accumulated and stored before chipping.

Any building with an appropriate floor will cost between $20 and $30 per square foot. Any structure that could hold 500 tonnes (required for the Secondary, Elementary school and GWES College) of wood chips will cost between $120,000 and $200,000. As well, additional equipment (front end loader) and labour is required to operate this intermediary storage.

Unless intermediary storage is found in existing structures at very low cost, it is not recommended to invest into its construction since it is inherently inefficient and can lead to additional contamination of the fuel.

Illustration 7: 7 tonne payload dump trailer

Proposed wood chip supply chain

The following supply chain minimizes handling and cost and encourages high quality chip production. As well, it is easily scalable and promotes the use of wood chips by third parties. Ideally, both the GWES College and the Secondary School project would go ahead at the same time which assures the necessary wood chip demand to justify the required investments.

The Secondary School and GWES College would need large 19' diameter, 20 ' high, metal storage bins that can hold up to 30 tonnes (3 to 4 weeks of consumption) of wood chips.

The Elementary School requires a smaller 15 tonne (over one month of consumption) storage bin.

The following equipment is required:

1 mobile diesel powered wood chipper, preferably with screen ($50,000)
1 or 2 seven tonne dump trailer(s) ($10,000 to $20,000)
1 one ton pick-up truck, which may already be available.

The local wood chip supplier and sawmill operator signs a 5 to 10 year contract with the biomass boiler operators to supply wood chips as needed, delivered to the containerized boiler system with its vertical loading auger.

Dry logs and slabs to be chipped are selected and stored on the supplier's property, preferably protected from the elements (simple building or tarps).

When at least 4 loads at 6 to 7 tonnes are required, the wood is directly chipped into the dump trailer and delivered and unloaded by the chip supplier. It is estimated that 4 loads can be chipped and delivered by two workers in one day. A second trailer may be required if the distance to the boilers is greater than a few kilometres. This allows one trailer to be delivered while the other one is being loaded.

Payment is calculated by boiler energy meter and not by tonne. A price of about $6 per GJ of hot water corresponds to $100 per bone dry tonne of wood chips.

Advantages:

- No unnecessary wood chip handling or intermediary storage is required.
- Chip supplier controls the entire process.
- Payment per energy meter promotes good quality chips, no moisture content adjustment required.
- Gross wood chip revenue of $50,000 allows quick pay-off of equipment investment.
- Additional chip sales to third parties are possible and encouraged.

Emissions

Wood combustion appliances	Estimated number of appliances ('000)	Emission factors PM$_{2.5}$ g/kg	CO g/kg	VOCs g/kg	PAHs[a] g/kg
Wood Burning Fireplaces					
Fireplaces					
Without Glass Doors	846	18.4	77.7	6.5	0.0375
With Glass Doors	897	12.9	98.6	21	0.0375
Fireplaces With an Insert					
Conventional	129	13.6	115.4	21.3	0.215
Advanced Technology (catalytic)	22	4.8	70.4	7	0.064
Fireplaces Advanced Technology (any)	57	4.8	70.4	7	0.064
Wood Burning Stoves					
Conventional Stoves					
Not Air-Tight	445	23.2	100	35.5	0.215
Air-Tight	777	13.6	115.4	21.3	0.276
Advanced Technology Stoves	142	4.8	70.4	7	0.064
Central Furnaces/Boilers	278	13.3	68.5	21.3	0.288
Other Wood Burning Equipment	41	13.6	115.4	21.3	0.215
Pellet Stoves	13	1.1	8.8	1.5	0.0015

Illustration 8: Impact of Residential Wood Stove Replacement on Air Emissions in Canada; Environment Canada, 2005

Modern biomass combustion boilers have extremely low emissions, especially when compared to biomass appliances everybody is familiar with: wood stoves.

In comparison, a modern wood chip boiler will emit about 0.3 g/per kg of fuel of total particulate matter. This is about a factor 50 smaller than a conventional wood stove, a factor 15 smaller than an advanced wood stove and a factor 3 smaller than a pellet stove.

In other words: a single conventional wood stove (15 kW output) that can heat one house produces the same amount of smoke and dust than one modern wood chip boiler (750 kW) that could heat the secondary and elementary school and the GWES College.

Nevertheless it is true that any biomass boiler will have higher particulate matter emissions than a gas boiler or a baseboard powered with hydro electricity. It is technically possible to clean the exhaust gases further, to the point that particulate matter is almost undetectable: Ceramic bag filters and electro-static percipitators can reduce such emissions by another factor of 10, but this technology comes at a cost since the filter alone can cost as much as the boiler itself.

There are no BC wide emission standards for biomass combustion systems. For space heating, the responsibility rests with the local authorities which rarely request specific emission targets. An exception is Metro Vancouver which has extremely strict and detailed regulations which go beyond the strictest regulations anywhere in the world. For all practical purposes, biomass boilers have been outlawed in the Greater Vancouver region.

If a boiler is not used for space heating, it may fall under the jurisdiction of the Department of the Environment which treats every installation on a case by case basis. For example, Lillooet has a 400 kw pellet boiler which – among other buildings – also heats the local pool. Heating the pool water is NOT considered space or “comfort” heating and therefore the Department of the Environment has instituted a particulate emission limit and a testing protocol.

There are no expectations that the Department of the Environment has any reason to get involved in the project(s) in Hazelton and there are no local emission by-laws.

It is nevertheless recommended that the local population is informed and educated about the project since local support is crucial for the acceptance of the technology.

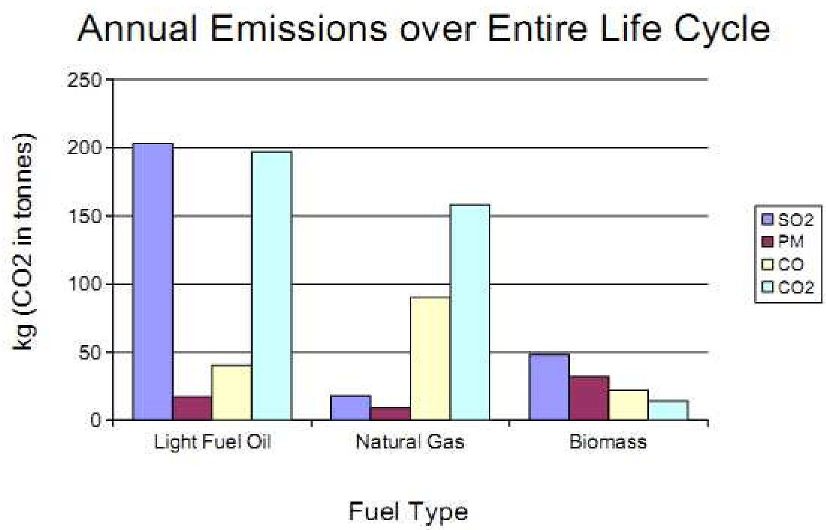

Illustration 9: Life Cycle Analysis (Vienna)

This life cycle analysis shows that advanced biomass boilers have extremely low emissions when compared to conventional heating fuels. Only particulate matter is higher, all other emissions are lower. These values apply for advanced biomass systems only.