

**An Economic Evaluation of
a Bioenergy Opportunity
in Yukon**

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I. INTRODUCTION

Executive Summary

Yukon is positioned well to expand its bioenergy use. Conversion to biomass heating offers real savings for both residential and commercial customers, while reducing fossil fuel dependence and emissions. Further value is added in terms of economic benefits such as jobs and profits when local forest biomass is processed for Yukon's energy needs. All areas of Yukon currently face disproportionate heating costs compared to the rest of the country, primarily due to the severe winters and high transportation costs to remote locations, and stand to benefit from conversion to biomass heating instead of oil and propane. Even with continued importing of wood pellets, biomass heating should be encouraged in all of Yukon. However, a Yukon biomass production facility should be the ultimate goal.

There are 4 main types of processed wood biomass potentially available in Yukon for heating: cordwood; wood chips; briquettes, and pellets. This report focuses primarily on pellets for the following reasons:

1. Pellets are currently being used by many residential customers in Yukon, with estimated consumption of about 1,000 tons per year (imported from BC). Wood chip delivery, handling and storage in residential neighbourhoods would be quite difficult, and, chip appliances are generally larger and meant for commercial use;
2. The existing pellet use is dependent on pellet specific stoves and boilers which cannot utilize other forms of wood such as cordwood, chips or briquettes;
3. The technology for pellet use (stoves and boilers) is well proven, stable and uses a uniform product with minimal inconvenience to the customer and provides a major reduction in levels of emissions when compared to cordwood;
4. Briquettes, while an improvement over cordwood, require a residual feedstock, for example a furniture manufacturing facility, for the source material. This does not exist in large enough quantities in Yukon;
5. Pellets have a significant advantage when it comes to transportation because of the bulk density of the product. If an export market came available from a production facility based in Yukon, pellets have the best transportation advantage per unit of heat energy;
6. If there is to be consideration of a Yukon based pellet production facility, demand first needs to increase significantly, so a consistent program of encouraging use of one type of product (pellets) vs. various products is recommended. (Note, there are some site specific locations where wood chips can and should be the preferred product, such as Dawson City, depending on available quality and local supply)

A preliminary analysis reveals that a wood pellet mill in Yukon could produce pellets for approximately \$215.00 CAD per tonne (bulk, wholesale), making it competitive in local markets. In order for pellet production to be viable in Yukon, demand in Yukon would need to grow substantially. Additionally, reasonable access to the timber/fibre will be a necessary provision for pellet production of any scale.

Clear Yukon government policies; that provide for access to feedstock for biomass proponents; that support a local bioenergy industry using Yukon raw materials; that supports and mandates for bioenergy use in government facilities; and a well - planned

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incentive program to encourage and grow local demand at the consumer level, is recommended. Should this occur, a local Yukon production facility for wood pellets producing approx. 8000 tonnes/yr., with associated benefits of employment, energy self-sufficiency and environmental improvements, could be a reality within the next couple of years. A local bulk storage and bagging facility with Yukon branding would be a logical first step.

Introduction

In February 2009 Yukon government released *Yukon Government Climate Change Action Plan*, outlining specific steps being taken, and future steps planned towards meeting the challenges of climate change. In this plan, the government outlines four goals, and the measures by which they will reach the goals. Of greatest importance to this present report is Yukon's third goal, "Reduce our greenhouse gas (GHG) emissions." Present uses of biomass fuel and energy applications around the globe are already achieving results, and with increasing popularity. As an internationally recognized CO₂ neutral fuel source, increased use of wood biomass as an alternative to non-renewable fuels is helping reduce GHG emissions.

Within Yukon's goal to reduce greenhouse gas emissions, three measures are relevant to this present study:

- Conduct an energy analysis of all Yukon government buildings and complete energy saving retrofits.
- Develop pilot projects to demonstrate home and commercial energy efficiency and heating technology.
- Develop wood energy opportunities for residential and institutional heating.

More specifically, *Energy Strategy for Yukon* (January 2009) outlines a vision for the Yukon, calling for an increase in renewable energy sources, including biomass. The strategy sets as priorities the increase of renewable energy by 20% before 2020, and the development of a wood-based bioenergy industry. In order to achieve this vision, the economics of such projects must be outlined as both possible and reasonable.

Keeping Yukon's vision and measures in mind, this report evaluates the economic aspects of bioenergy technologies that could act to reduce Yukon's dependency on fossil fuels, reduce GHG emissions, and create opportunity within the forest industry.

Background Information

As a traditional heating source, wood continues to be used in Yukon by a number of families and businesses. In 2005 wood was the principle heating fuel for 17.7% of households, compared to the national average of 4.5%.¹ Although statistics are unavailable, the majority of this consumption is cordwood, and while considered carbon neutral under Kyoto, burning cordwood may be producing particulate emissions much greater than new burning methods.

¹ Bureau of Statistics: Yukon Energy Facts (2007)

Annual Gigajoules (J * 10⁹ or 1,000,000J) of Heating Energy Used in the Yukon

Oil and Propane	955,283 GJ
Other	38 GJ
Wood	396,000 GJ
Total	1,351,321 GJ

Source: Dept. of Energy, Mines and Resources

There is an abundance of wood in Yukon to supply both existing cordwood demand to consumers and support a larger biomass industry. In fact, considering the forests damaged by fire or spruce beetle infestation, the approximate volume of timber impacted is 35,200ha annually (see Table 1). At only a conservative 10% access, this volume of timber translates into 71,760 mt (metric tonnes) or 1,291,680 GJ of energy. **At 10% access, this dead timber would provide enough energy to meet the entire current heating demand of Yukon, on an annual sustainable basis.** Presently, heating demand in Yukon is met using mostly fossil fuels (oil and propane) amounting to 955,283 GJ or more than 37 million litres of propane or 24 million litres of oil annually. With these realities in mind, it is the economics and logistics of the forest usage that require further investigation.

Table 1. Summary of estimated area and volume burned in past 10 years by geographic area with differing access assumptions.

Geographic Area	Average Forest Area Burned in Past 10 Years (hectares / year)	Average Annual Estimate of Volume (m ³ /year) Burned in Past 10 years at Differing Access Assumptions (Average for area burned per year x %Access Assumption x volume estimate)		Equivalent Heating Value at 10% of Forest Area Burned Accessible for Salvage (mt/year x 18 GJ/mt)
		25% of Forest Area is Accessible and Feasible	10% of Forest Area is Accessible and Feasible	
Dawson (within 75 km from main access routes.)	21,700	275,000 m ³ /year or 110,000 mt/year	110,000 m ³ /year or 44,000 mt/year	792,000
Whitehorse (within 150 km from main access routes.)	5,000	63,000 m ³ /year or 25,200 mt/year	25,000 m ³ /year or 10,800 mt/year	194,400
Watson Lake (within the Timber Harvesting Land Base Identified in draft KFRSC Forest Plan)	8,500	106,000 m ³ /year or 42,400 mt/year	42,500 m ³ /year or 16,960 mt/year	305,280
Total	35,200	444,000 m ³ /year or 177,600 mt/year	177,500 m ³ /year or 71,760 mt/year	1,291,680

Assumptions behind estimates:

The wood supply numbers are a simplification of more detailed wood supply analysis and planning operations. However, the numbers do provide the means to evaluate the bio-energy opportunity at a strategic level. The following assumptions and caveats are stated so as not to mislead the reader into believing that these wood supplies are certain and available.

- The wood supply regions differ greatly in timber profile. For simplicity, an average 50 m³/ha for all three regions was used to estimate total volume in all 3 geographic areas. It should be noted that this assumption may underestimate or overestimate depending on the region. Note, a range could be provided quite easily for the report to help illustrate the uncertainty in assumptions and data along with differences in the region.
- Dawson region assumed fires within 75 km of existing access of from Dawson City may be accessible. Whitehorse region assumed fires with 150 km of existing access of Whitehorse may be accessible. Watson Lake region used the timber harvesting land base identified in the draft Kaska Forest Stewardship Council forest management plan.
- Fire events are unpredictable. Forecasting the rates of fire disturbance into the future is highly speculative. It is also highly speculative of the location of fires. For example, 200k+ ha of area burned in 2009 of which little is accessible for salvage. Therefore, the annual estimates into the future are uncertain.
- Forest management planning will ultimately determine what areas are available for wood supply. In lieu of planning, the forest land base available for wood supply is uncertain.

In 2005, oil and propane was the principle heating fuel for 64.4% of Yukon households, compared to the national average of 9.6%.² What these statistics demonstrate is the lack of options available in Yukon. While reserves of oil and natural gas do exist in Yukon, the infrastructure required for extraction and distribution is not present, so the fuel is imported. Even with consideration of present limitations, the picture revealed by Yukon heating statistics highlights a great dependency on imported fossil fuels.

II. ASSESSMENT OF YUKON BIOENERGY DEMAND

Data specific to Yukon is unavailable, but national trends in heating energy consumption reveal a 60% residential, 40% commercial/institutional division.³ If the trend applies in Yukon, the annual heating energy demand from Yukon commercial/institutional buildings would be approximately 540,000 GJ. To meet this entire heating demand, 30,000 tonnes of pellet fuel (or 35,000 tonnes of chips at 20% moisture) would be required. Table 2 highlights the total potential market for commercial/institutional sales based on the percentage converting to biomass heating.

² Bureau of Statistics: Yukon Energy Facts (2005)

³ Canada's Secondary Energy Use by Sector, End-Use and Sub-Sector (NEUD Publications)

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Table 2: Potential Commercial/Institutional Demand for Wood Pellets

Percentage (%) converting to wood pellet heat	Wood pellet volume required to meet heating demand (tonnes)
5%	1,500
10%	3,000
15%	4,500
25%	7,500

To give a real example of how quickly wood pellet demand can change, there was a recent inquiry from the Keno Hill area mine development proponents. It was calculated that this potential industrial customer would pay \$400,000/yr less using pellet fuel than they would pay for propane heating, based on current prices. If this project goes ahead and uses wood pellet heating, the annual demand for wood pellets from this one customer would be approximately 1000 tonnes per year.

Other real examples of potential wood biomass demand include schools such as Elijah Smith School with an annual requirement of 85 tonnes of pellets, Hidden Valley School with an annual requirement of 50 tonnes of pellets, as well as Dawson City's sewage effluent plant/water pump house, which would require approx. 500 tonnes of wood chips per year.

Yukon Residential Market

As revealed by sales volume, the present usage of wood pellets in Yukon is about 1000 tons annually (industry standard is for bagged product to be measured in 2000lb "tons" and bulk product is measured in 1000kg, or 2200lb "tonnes"), primarily used for space heating purposes and burned in unique pellet stoves (see picture shown below). Sales of stoves indicate growth in residential demand, but the market remains small. Yukon government's Good Energy Rebate program, active April 2009 through February 2010, offers consumers a \$300 rebate on the purchase of a ULC certified pellet stove. This incentive should help to increase sales in Yukon. More aggressive programs currently work very well in New Zealand, where residents are offered up to \$1200 NZD (\$900 CAD) via the Energywise program, and in Ireland where grants range from €800 (\$1280 CAD) for a pellet stove to €2500 (\$4000 CAD) for a biomass boiler. In addition, just recently the US government has announced a tax credit of up to \$1500 for installation of pellet stoves and boilers in residential homes. Such increased incentives in Yukon could rapidly grow the residential market and support the local transition to carbon neutral alternatives, as well as support local industry and forest fibre usage.

The current retail price of a ton of imported BC wood pellets is approximately \$375 in Yukon. This price includes approximately \$115 per tonne in transportation costs from BC mills. It would be through savings on shipping that a Yukon producer could potentially compete favourably in Yukon residential markets (even based on higher feedstock costs and reduced economies of scale benefits for a small Yukon producer).

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The 2006 census reveals a total of 12,615 private households in Yukon, with an average household size of 2.4 people. Table 3 highlights the total potential market for residential sales based on the percentage of homes converting to biomass heating.

Table 3: Potential Residential Demand for Wood Pellets⁴

Percentage (%) of households converting to wood pellet heat	Total number of households represented	Wood pellet volume required to meet heating demands (5 ton/yr avg.)
5%	631	3,155
10%	1,262	6,130
15%	1,893	9,465
25%	3,155	15,775
50%	6,310	31,550
100%	12,620	63,100

Source: Author



Typical wood pellet stove installed in Whitehorse home

⁴ Based on an average household usage of 5 tonnes per year.

Despite the possibility of promising growth in residential demand, the present demand and uncertainty regarding growth makes it difficult to justify construction of a pellet production facility based on residential sales alone. Instead, the residential market should be considered a complementary market to larger commercial and industrial markets in Yukon.

Export Market

The evaluation when considering transportation of any distance should realistically focus on densified products such as wood pellets. It is more economical to transport wood pellets than raw material by a factor of approximately 10 to one⁵. As such, while outlining the prospect of an export market for Yukon biomass production, wood pellets will be the example given.

Global demand for wood pellets is extensive, and growing annually. Although the wood pellet industry and market are relatively new in North America, the European market is well ahead of the situation here. In 2007, the estimated consumption of wood pellets in Europe was approximately 7 million tonnes. To put that into perspective, Canada's entire wood pellet production for the same year was 1.4 million tonnes. By 2010, it is estimated that European imports required to meet demand will be approximately 4.5 million tonnes. By 2015, European demand for wood pellets is expected to double.

In Yukon, several barriers exist preventing access to the global pellet markets. In combination with the cost of transportation to port, (the nearest port is Skagway, AK) the estimated FOB (freight on board) price for pellets is approximately \$220 per tonne. This compares poorly with the FOB pricing in the British Columbia ports of Vancouver and Prince Rupert, which offer prices in the range of \$125 per tonne. Additionally, the availability of suitable ships at Skagway may be questionable or inconsistent, and, there would need to be some costly bulk handling facility changes made for shipping pellets into and through Skagway. For these and other reasons, it is recognized that a Yukon pellet producer would be unable to compete exporting globally at this time.

Yukon's prospects for sales within a national market are also limited. Without a source of inexpensive raw material (e.g. from a local sawmill), a Yukon pellet plant would already be at a competitive disadvantage compared to BC mills. The least expensive form of raw material feedstock for pellet production is kiln dried shavings and green sawdust residuals from sawmill operations. The next best material for feedstock is hog fuel, another residual from sawmills, which is a combination of white wood, bark, and shavings processed to four inch minus sizing. The most expensive feedstock is round wood, the type of feedstock most available in Yukon. Because BC mills use raw materials costing between \$20-\$40 per tonne and Yukon producers currently face round wood feedstock prices of between \$80-\$100 per tonne, Yukon's ability to compete much beyond their local markets is unlikely.

⁵ Wood pellets have a typical "bulk density" of 42-44lbs per cubic foot and a moisture content of approx. 5%. Wood chips have a bulk density of +/- 20 lbs per cubic foot and moisture of 25-50%.

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Despite the competitive challenges outlined above, transportation advantages for distribution to markets in southeast Alaska and Northwest Territories might give a Yukon pellet producer a competitive advantage over BC or Alaska producers. For example, if a pellet mill was located in Haines Junction, the transportation cost of wood pellets to market or ferry in Skagway, Alaska would be approx. \$34.00/tonne, comparing favourably to a pellet mill in Fairbanks AK. which would pay approx. \$87.50 per tonne to transport to Skagway. And, there is growing market potential in southeast Alaska. An example is the planned conversion of the SEAlaska corporate building in Juneau to wood pellets.

III. FEASIBILITY OF BIOMASS PRODUCTION IN YUKON

While there is no current wood pellet production in Yukon, there is a short history of production worth mention. Approximately 10 years ago, wood pellet production began in Teslin at a facility owned by the Hazard family. Reports are that while the pellets were good quality and were in demand by local consumers, the challenge of producing such small volumes in this location was uneconomic. Inexpensive and good quality feedstock was not available so green forest material that required drying was used, and this added to the challenge and cost. As well, the lack of an air handling system to remove moisture from the building housing the production equipment resulted in problems.

The project serves as an example for future endeavours, as its lack of success accentuates challenges around biomass production. Related considerations of transportation, adequate market demand, secure/quality sources of raw material, cost competitiveness, and capital costs will be outlined in more detail below.



Hazard facility in Teslin, not in operation.

Pellets Versus Chips

The greatest consideration when deciding between production of wood chips or wood pellets is the distance from the production facility to the consumer, as well as issues related to quality and handling. The greater the distance between production and consumer, the more advantageous densification of the wood product becomes. These benefits are realized in the transportation savings of the product related to bulk density and moisture. Due to the greater moisture content and surface volume of wood chips, shipping costs are up to ten times higher than that of wood pellets.

Wood chips and wood pellets do not provide equal heating results. While a more accurate comparison depends on the moisture content of the wood chips, wood pellets produce 18 GJ of heating energy per tonne while a reasonable estimate for wood chips is 12 GJ per tonne. Having said that, Yukon's forests affected by fire and spruce infestations have excellent moisture content, in the range of 15-20%, resulting in higher than normal wood chip heating output.

Storage of product is also a consideration when choosing between wood pellets or wood chips. While wood pellets require storage protected from the elements – typically in silos, bulk bags, or smaller retail bags – wood chips are able to be stored with greater ease, albeit taking up about twice the space. Although storing wood chips outside may advantageously decrease moisture content through evaporation, care must be taken to protect chips from rain and snow, which can result in clumping and bridging, negatively impacting quality and more importantly flow of fuel prior to combustion.

In terms of their burning, technological improvements continue to make both wood pellets and wood chips viable options for a number of applications. Both fuels can be burned using biomass boilers appropriate for commercial or institutional heating; however, wood pellets are a more compatible consistent fuel. When burning wood chips in a biomass boiler, factors such as chip size, consistency, moisture content, and percentage of fines can result in higher maintenance demands. Additionally, use of chips with inconsistent composition will require manual adjustments of the boiler and may result in premature equipment failure. And, typical wood chip boilers available in N America are larger than required for residential use.

If the owner of a Yukon biomass production facility is considering possible future export of the product, densification in the form of pellets is the best option. Pellets are also preferable for most consumers because their uniform size, density and moisture content provide a clean, consistent, and efficient burn.

It is worth noting that the quality of pellet production will be an important factor for the growth of the consumer market. Past examples of inconsistent product quality, in other jurisdictions, have resulted in customer dissatisfaction and marketing challenges. For this reason, attracting companies with an understanding of necessary production engineering and quality control will be an important consideration for Yukon.



Available fibre for potential wood chip supply at Dawson City

Scale

Decisions regarding the scale of a wood pellet production facility are connected to the risk an investor would be willing to incur. One of the major barriers to investment in a pellet mill is the high capital cost at start-up; the larger the facility, the greater these initial costs will be. Typical pellet mills, measured in terms of production per hour, range in size from 4-20 tonnes, resulting in annual production of 20,000 – 100,000 tonnes per year. It is worth noting that the start up costs follow the economy of scale; the start up cost of a 20 tonne per hour mill is not five times that of a 4 tonne per hour mill. Normally, production costs on a per tonne basis increase when pellet plants are built with lower production capacities, or run on less than a continuous 24/7 basis. The specific details of various possibilities will be shown below.

While in many cases the decision of production scale is determined largely on wood fibre availability, this is not the major consideration for Yukon. If access to round wood is secured, there will be an abundant supply of fibre for a mill, regardless of the scale of production.

Because production scale is not limited by fibre supply in Yukon, the question of an economical size of production for a potential mill is primarily determined by market

considerations. Based on potential demand in Yukon, and limitations for export, the recommended production capacity for a Yukon pellet mill is in the range of an annual maximum production capacity of 25,000-40,000 tonnes. If operations of a 25,000 tonne mill were reduced to 8hrs/day, five days per week, the annual production would be approximately 8300 tonnes. This could be expanded based on demand. In order to justify greater production, the Yukon market would have to grow substantially, or a viable export market would need to be secured.

Basic steps of the pellet production process

Grinding. The raw material is first freed from heavy contaminants (e.g. rocks, metals), and then reduced in size, typically in a hammermill. The maximum particle size must be inferior to the thickness of the pellet to be produced.

Drying. If the raw material is wet (which is typically the case for fresh forest residues, around 50% moisture content), it has to be dried (generally a rotary drum type one) where the moisture content is reduced to about 8-10 %.

Conditioning. The material can be conditioned with dry steam and water to the required temperature and moisture content to activate the lignin as a pellet binding agent and to obtain the necessary malleability of the product. Note, in N America, softwood pellet producers generally do not use steam.

Milling. After conditioning, the particles are then moved by conveyor to a pellet mill, where the pellets are extruded through the action of rollers acting on a perforated matrix. Two main types of pellet presses can be distinguished: flat die and ring die types. The flat die type has a circular perforated disk on which two or more rollers rotate and force the material through the holes. The ring die press features a rotating perforated ring on which rollers press on the material to the inner perimeter. The most common output range for pellet presses is 3-5 t/h. According to manufacturers, pellet dies have an average service life of 1,000-1,500 hours, corresponding approximately to 10,000 tons.

Cooling. After extrusion, pellets are very hot (90-100°C) and are immediately air quenched down to 25°C. This sets up the lignin and hardens the product, and contributes to maintain its quality during storage and handling. Finally, pellets are screened so as to separate the residual fines, which are generally re-used in the process. Dust free pellets are then ready for storage or for automatic packing (in 40lb bags or big bags).

Air Handling and Filtering. A considerable amount of moisture is extracted from the wood fibre during the process of drying and pelletizing – as much as 45% of the wood gross weight. This moisture needs to be discharged from the building in an environmentally friendly way, depending on local air permit requirements. As well, screening of the finished product is necessary to ensure quality measures are met, and the handling of the “fines” is by an air system returning the material into the production process.

The Typical Pellet Mill

All pellet mills require the following components: building, dryer, hammermill, infeed to pellet equipment, pelletizing machine, cooler, screening system, air and filter system, and storage. Additionally, if residential sales are intended, the facility requires a bagging system.

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Capital Cost

The full capital cost will depend on such factors as the manufacturer, equipment transportation and installation costs, but for comparison sake, a mill capable of producing 60,000 tonnes annually costs approx. \$7,000,000.⁶ This estimate includes the required equipment, buildings, and development costs. Not included in the estimate are additional costs of enhanced emission controls (\$0.5-1 million). Capital costs may also include bagging systems, semi-automated (\$150,000) or fully automated (\$300,000); a semi-automated bagging system requires hand stacking, while a fully automated system does not.

Below is the new Superior Pellet plant in Fairbanks Alaska, nearing completion in September 2009. The production capacity of this plant is 60,000 tons/year, however their anticipated start-up volume is 15,000 tons, based on an 8-hour shift 5 days/wk. One advantage this plant has available is 10,000 tons of raw material in the form of sawdust and shavings residual from a local sawmill. The stated capital cost is \$6mUSD. The expected sale price of bagged pellets FOB the plant is \$275USD.



New Superior Pellet mill in Fairbanks, rotary dryer in front, about to be installed.

Operation and Maintenance Costs⁷

Operations at a wood pellet mill should be continuous, 24 hours per day, seven days per week, for best economies. Factoring in approximately 10% of non-production hours for

⁶ Base capital cost = \$125 per tonne output

⁷ Private source

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scheduled and unscheduled maintenance, the mill would operate approximately 8,000 hours per year.

Labour requirements of a full-scale pellet mill would produce 15-30 jobs in the plant (plus a similar number potentially involved in harvesting, transportation and packaging), summarized as follows:

	Staff per shift	Shifts	Total staff	Hourly rate	Employee salary	Total
General Manager	1	1	1	\$40.00	\$105,120	\$105,120
Plant Operator	1	3	3	\$25.00	\$65,700	\$197,000
Millwright	1	1	3	\$30.00	\$78,840	\$78,840
Material Handling	1	3	3	\$20.00	\$52,560	\$157,680
Logistics	1	1	1	\$20.00	\$52,560	\$52,560
Maintenance	1	1	1	\$20.00	\$52,560	\$52,560
Electrician/Programmer	.3	1	.3	\$30.00	\$23,652	\$23,652
Finance/ Administration	2	1	2	\$18.00	\$47,304	\$94,608
Total	8.3		14.3			\$762,020

A Production Option for Yukon

Given the export limitations in Yukon, building an oversized pellet mill would require that disproportionate capital to be locked into infrastructure. A feasible option for Yukon might be to produce pellets using a modular, or “mod-mill”. For example, SBC Firemaster,⁸ a company based in Kamloops, B.C., is currently marketing three models of pellet mills specifically designed for smaller-scale pellet production. These mills are sold as a complete package, including all components required for production.

Technical Data for SBC Firemaster Mod-Mills:

	Model A	Model B	Model C
Qty of Pellet Press	1	2	3
Diameter of Pellet Mill	520mm / 20.5"	520mm / 20.5"	520mm / 20.5"
Pellet Diameter	5-12MM	5-12MM	5-12MM
Hammermill Size Range	150-200 HP	200-300 HP	300-400HP
Power (per Press)	200 HP	200 HP	200 HP
Hourly Production	2.2 TPH/7.35mm	4.4 TPH/7.35mm	6.6 TPH/7.35mm

⁸ <http://sbcfiremaster.com/> Note, project proponents should ensure due diligence related to, among other things, a review of actual operating plants utilizing this equipment.

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Capacity	Pellets	Pellets	Pellets
Annual Production Capacity	15,000	30,000	45,000
Total Power Requirement	600 HP	900 HP	1200 HP
Dryer Drum Size	2.2m x 12.0m	2.2m x 12.0m	2.2m x 12.0m
Dryer Drum Type	Triple Pass	Triple Pass	Triple Pass

This option for production is attractive for several reasons: the capital cost for a 30,000 tonne mill (Model B) is approximately \$2.5 million, offering substantial savings over alternatives; as demand increases, mod-mills are able to grow by adding modules; labour costs are reduced; a single supplier for all mill components eliminates configuration challenges and simplifies ordering of replacement parts.

Capital Costs

Mod-Mill Model B –	\$2,500,000
Building -	\$1,000,000
Storage -	\$500,000
TOTAL	\$4,000,000

Operation and Maintenance Costs

Labour Requirements for a Mod-Mill⁹

	Staff per shift	Shifts	Total staff	Hourly rate	Employee salary	Total
General Manager	1	1	1	\$30.00	\$78,840	\$78,840
Plant Operator	1	3	3	\$25.00	\$65,700	\$197,000
Millwright/Electrical	.5	1	.5	\$30.00	\$39,420	\$39,420
Material Handling/logistics	1	3	3	\$20.00	\$52,560	\$157,680
Logistics/Maintenance	1	1	1	\$20.00	\$52,560	\$52,560
Finance/Administration	.5	1	.5	\$25.00	\$65,700	\$32,850
Total			9			\$558,350

⁹ The labour requirements could possibly be less than this depending on the skilled labour available. It is likely that with this scale of production, a few of the jobs could be combined to reduce labour costs.

Fibre Material

Since there is not an adequate supply of wood shavings or hog fuel in Yukon, fibre for a wood pellet mill must come from round wood, possibly forests damaged by fire or spruce beetle infestation. Round wood is the most expensive fibre source material for pellet production.

This report relies on multiple sources to estimate the cost of fibre material from round wood. Because the pellet industry in BC does not currently have mills producing pellets exclusively from round wood, the estimate provided below is speculative, but is supported by the input from various sources.

The estimate of total delivered cost of raw material is \$48.99 per m³. This cost is deemed to be a realistic estimate and it is derived from an average of seven separate location studies. Of the seven locations used to create the \$48.99 per m³ average, the low cost is \$37.17 per m³ and the high cost is \$50.13 per m³. Adding a chipping cost of \$5.00 per m³ to the delivered cost increases the average price to \$53.99 per m³, resulting in a dry tonne cost for raw material of approximately \$105.28.¹⁰

Case Study: Delivered cost of biomass

	Cost (\$ per m ³)
Harvest Cost	\$15.90
Slashing/Bucking	\$4.00
Road Construction and Maintenance	\$5.39
Haulage (m ³ /~100kms)	\$13.21
Renewal Fees	\$5.00 (BC: \$0.25)
Stumpage Fee	\$1.00 (BC: \$1.07)
Administration	\$4.49
Total Delivered Cost	\$48.99

Source: Private

Note, the combination of Renewal Fees and Stumpage above are higher than in BC, and could be a good opportunity for Forest Management to provide supply side incentives for a Yukon production facility.

Total Production Estimate

Considering three possible locations for a pellet mill – Haines Junction area, Whitehorse area, and Watson Lake area – it is possible to make reasonable estimates for the cost of production in each area. Based on Yukon demand, annual production of 30,000 tonne is the suggested maximum scale for the mill.

¹⁰ One “dry”, meaning zero moisture, tonne of wood pellets requires approximately 1.95 m³ of “dry” biomass.

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Estimated cost of pellet mill in Yukon

	Cost/tonne (\$ - CAD)
Fibre Supply	\$105.28
Dryer Fuel	\$12.79
Grinding	\$7.12
O&M + Lifecycle ¹¹	\$55.47
Total	\$180.66
Financing (\$7m, 10 yrs, @ 5%, 20k tonnes/yr)	\$44.00
Cost per tonne/ton	\$224.66/\$204.23
Cost per ton packaged (@\$40)	\$244.23

Transportation

A reasonable estimate for transportation costs is \$150 per hour for a load of 40 tonnes. To estimate the cost per tonne, various distances must be considered. Using the possible mill location of Haines Junction, Table 4 shows transportation costs that would be reflected in the delivered price of pellets.

Table 4 - Transportation Costs from Haines Junction

Destination	Approximate hours of trucking (Return trip from Haines Junction)	Transportation cost per tonne. (40 tonne load @ \$150 per/hr)
Whitehorse	4 hrs.	\$15.00
Carcross	6 hrs.	\$22.50
Carmacks	8 hrs	\$30.00
Dawson City	16 hrs.	\$60.00
Watson Lake	14 hrs.	\$52.50
Marsh Lake	5 hrs	\$18.76
Teslin	8 hrs	\$30.00
Mayo	14 hrs.	\$52.50

Source: Author

¹¹ Includes Energy, Labour, Materials and Maintenance, Repairs and Lifecycle Maintenance.

Retail Price

Current retail price in Whitehorse for a ton (the industry standard is for packaged product to be measured in ton - 2000 lbs and for bulk to measure in tonne - 2200 lbs or 1000kg) of imported wood pellets is in the range of \$375, produced in BC and shipped to Yukon. The current retail price must absorb the \$115 transportation cost per ton, meaning a ton of pellets without these transportation costs would realistically retail in the range of \$260. In fact, the August 2009 retail price for a ton of wood pellets in Quesnel, BC was \$200, a price that does not require absorption of transportation costs. (the difference is in the feedstock cost).

Based on the cost analysis of production, a Yukon pellet plant should be able to produce packaged pellets for \$244.00, FOB the plant. Given a profit margin at the production level, and a mark-up at the retail level, net price before any transportation costs, Yukon produced pellets would appear economically possible compared to the current retail price of \$375.00. Bulk pricing would be a similar comparison, minus approx. \$40 for packaging. At these prices, a Yukon producer would be competitive with imported pellets. Again, a review of policy and incentive options to support development of a local bioenergy industry would help to initiate action towards a local industry using Yukon raw materials.

IV. BIOMASS IMPORTS

Importing wood pellet fuel will continue to be a probability for Yukon at least for the near term, pending a local production facility being developed. Recognizing that the environmental impact of transportation reduces the environment benefits of using such fuel and considering the environmental and employment goals of Yukon, a better long-term option would be to foster biomass production locally. Regardless, analysis of using biomass imports is still warranted because of its simple implementation, reduced cost for customers compared to fossil fuel, and net overall environmental benefit.

Cost Comparison

A simple cost comparison of household heating costs for various fuels, based on Yukon fuel costs in March 2009 reveals the following:

Table 5 – Heating Cost Comparison

Fuel	Price (as of March, 2009)	Appliance Efficiency (avg.)	Cost per million BTU	Annual Heating Cost ¹²
Wood	\$230 per cord	60%	\$19.17	\$1,917.00
Wood Pellets	\$372 per ton	80%	\$28.35	\$2,835.00
Electricity	\$0.12	100%	\$35.17	\$3,517.00
Oil	\$0.887 /L	78%	\$31.22	\$3,122.00
Propane	\$0.958 /L	78%	\$50.96	\$5,096.00

¹² Based on a 2,000 square foot home, annual requirements of 100,000,000 BTU.

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In the recent community housing reports done by the Yukon Housing Corporation, it was identified that certain Yukon residents are experiencing higher heating costs than the territorial average. Specifically, the Yukon-wide average price per square foot data from the Yukon Housing Corporation (Table 6) shows what individuals are currently paying to heat their homes. Additionally, Table 7 shows what annual heating costs would result based on each square foot heating cost, including for comparison sake the annual price of heating the same space using wood pellets.¹³ Clearly, it is the approximately 30% of households with current per-square-foot heating costs of over \$2.00 that stand to benefit most from conversion to wood pellet heating.

Table 6 - Annual Energy Costs per Square Foot – Yukon Wide

	Included in Rent	< \$1.00	\$1.00 - \$1.99	\$2.00 – \$2.99	\$3.00 +
Percentage of Responses	31.6	9.6	28.7	19.7	10.4

Source: Whitehorse Community Housing Report – Yukon Housing Corporation (2000)

Table 7 - Annual Heating cost for a 2,000 square foot home based on average heating costs per square foot in Yukon.

	Households paying < \$1.00 per ft ²	Households paying \$1.00 - \$1.99 per ft ²	Households paying \$2.00 – \$2.99 per ft ²	Households paying \$3.00 + per ft ²	Pellet Heat cost, \$1.42 per square foot
Annual Heating Cost	< \$2,000	\$2,000 - \$3,980	\$4,000 - \$5,980	\$6,000 +	\$2,480

Source: Author

It is also important to recognize that not all communities in Yukon experience equitable heating costs. As shown in Table 8, communities with disproportionate numbers of households paying high heating costs include Burwash Landing, Carcross, Haines Junction, Mayo, Ross River and Watson Lake.

¹³ Based on an average home size of 2,000 square feet.

Economic Evaluation of Bioenergy Opportunity in Yukon

YUKON RESIDENTIAL HEATING FUEL PRICES

Collected on behalf of Energy, Mines and Resources

Prices are in Canadian cents per litre, including all applicable taxes

Average Prices as of:

09-Sep-09	Residential Heating Fuels		
	Furnace Oil	Arctic Stove Oil	Propane (500 gallon tank cost)
Carmacks	98.0	101.6	88.9
Dawson	101.1	102.9	88.9
Faro	98.2	101.9	88.9
Haines Junction	94.8	96.7	86.8
Mayo	111.9	113.7	88.9
Ross River	99.2	102.9	88.9
Teslin	98.0	101.6	86.8
Watson Lake	95.8	99.2	86.8
Whitehorse	94.4	98.0	78.6

Note, the price per litre of oil equivalent for wood pellets in Whitehorse, fall 2009 is approx. 81.0 cents, based on a retail price of approx. \$375 per ton, bagged product.

V. ECONOMIC CONSIDERATIONS FOR BIOENERGY USE IN YUKON

Costs for new and retrofit conversions are difficult to estimate because of the number of factors involved. Depending on factors such as the existing systems, building efficiency and building location, total costs will vary. Several reputable companies are able to provide specific recommendations and price quotes for specific projects, but there are some general considerations worth mentioning.

Economic Benefits

As governments increasingly face the problem of beetle infestation and standing dead timber, actions need to be carefully considered, but they must also proceed at a reasonable pace. Yukon has rich forest resources that are ready to be accessed; opening this opportunity to bioenergy production will result in many benefits for the region. Timber harvesting, chipping, transportation, and pellet production would provide regional employment and industry growth potential. To take full advantage of the opportunity, it is vital that plans to take advantage of Yukon's forest resources be enacted soon.

Environmental Considerations

While increased bioenergy use is possible using imported wood pellets, Yukon pellet production would be an important step in realizing the vision set out by the Yukon government. Increasing bioenergy use is one possible way of reducing the territorial dependence on fossil fuels. As a renewable resource, use of biomass represents the environmental stewardship and leadership needed in the age of climate change.

Cost Savings

Commercial

In March 2009, Ventek Energy Systems Inc. produced a feasibility study for bioenergy systems retrofits. This report describes real examples of cost saving for commercial sized buildings.¹⁴

Elijah Smith School, 49,000 square feet in size, presently using a propane boiler with 2.8 million BTH output could be fitted with an equivalent biomass boiler for the price of \$515,000. While the initial capital expense would be sizeable, the payback would be 4.4 years. Estimated fuel usage would be approximately 85 tonnes of wood pellets, delivered in four truckloads annually.



Recently converted Nazko Elementary School in BC, replacing propane with wood pellets using Viessmann KOB Boiler

¹⁴ Ventek Energy Systems (2009) Feasibility of and options for bioenergy heating systems retrofit for energy solutions centre: Government of Yukon.

Economic Evaluation of Bioenergy Opportunity in Yukon

Hidden Valley School, 28,600 square feet in size, presently using three propane boilers that provide a combined 997,920 million BTU output could be fitted with an equivalent biomass boiler for the price of \$565,000. In this scenario, the payback would be 9.8 years. Estimated fuel usage would be approximately 50 tonnes of wood pellets.

Comparison of Calculated Heating Costs – Elijah Smith School¹⁵

Year	Recommended Biomass Boiler Total NPV	Existing Propane Boiler Total NPV
0	\$515,000	\$160,000
1	\$537,609	\$239,762
2	\$560,288	\$320,076
3	\$583,037	\$400,944
4	\$605,857	\$482,372
5	\$628,749	\$564,362
6	\$651,712	\$646,918
7	\$674,747	\$730,045
8	\$697,855	\$813,747
9	\$721,035	\$898,027
10	\$744,289	\$982,889
11	\$767,615	\$1,068,338
12	\$791,016	\$1,154,377
13	\$814,491	\$1,241,011
14	\$838,040	\$1,328,244
15	\$861,665	\$1,416,080
16	\$885,364	\$1,504,523
17	\$909,140	\$1,593,577
18	\$932,991	\$1,683,246
19	\$956,919	\$1,773,536
20	\$980,924	\$1,864,449
21	\$1,005,006	\$1,955,991
22	\$1,029,166	\$2,048,166
23	\$1,053,404	\$2,140,978
24	\$1,077,720	\$2,234,431
25	\$1,102,116	\$2,328,531

Comparison of Calculated Heating Costs – Hidden Valley School

Year	Recommended Biomass Boiler Total NPV	Existing Propane Boiler Total NPV
0	\$565,000	\$0
1	\$578,858	\$44,757
2	\$592,768	\$89,824
3	\$606,731	\$135,205
4	\$620,746	\$180,901
5	\$634,814	\$226,915
6	\$648,935	\$273,248
7	\$663,110	\$319,903
8	\$677,338	\$366,882
9	\$691,621	\$414,188
10	\$705,959	\$461,823
11	\$720,352	\$509,788
12	\$734,799	\$558,087
13	\$749,303	\$606,721
14	\$763,863	\$655,694
15	\$778,478	\$705,066
16	\$793,151	\$754,661
17	\$807,881	\$804,662
18	\$822,668	\$854,662
19	\$837,513	\$904,662
20	\$852,416	\$954,662
21	\$867,378	\$1,004,662
22	\$882,398	\$1,054,662
23	\$897,478	\$1,104,662
24	\$912,618	\$1,154,662
25	\$927,817	\$1,204,662

¹⁵ “Total NPV” – includes capital investment, fuel cost with estimated price increases, maintenance with cost increases.

Economic Evaluation of Bioenergy Opportunity in Yukon

Included within the same Ventek report is an estimate of boiler operations and maintenance requirements and costs over 25 years. To maintain a biomass boiler using wood pellets, service is required every 500-1000 hours of running time, as outlined by the boiler manual.

Using 3% annual escalation Ventek estimates that maintenance costs for the Elijah Smith system would grow from \$2,600 the first year to \$5,285 the twenty fifth year; this compared to projected costs for the existing system of \$1,300 in year one to \$2,643 in year twenty-five.

With the same escalation, the Hidden Valley biomass boiler maintenance costs are projected at \$2,800 year one and \$5,692 year twenty-five. Comparatively, the existing system costs are projected at \$1,300 year one to \$2,643 year twenty-five.

Although the projected maintenance costs are higher following the biomass boiler conversion, the total NPV remains favourable.

Residential

Depending on current heating method and costs, a residential customer stands to save \$287 - \$2261 annually following a conversion to wood pellet heating. Using an approximated installed cost for a high quality pellet stove of \$4000, Table 9 illustrates potential savings and payback. There are no cost direct savings for conversion from cordwood heating. An enhanced payback period details results if a \$1500 incentive was applied.

Table 9 - Cost savings of Conversion to Wood Pellet Heat¹⁶

Current Heating Method	Annual Savings	Payback Period	Enhanced Payback Period
Propane	\$2261	1 year 9 months	1 year, 1 month
Heating Oil	\$1205	3 years, 4 months	2 years, 1 month
Electricity	\$1600	2 years 6 months	1 year, 7 months

Source: Author

Electricity Production

Electricity production in Yukon predominantly uses renewable sources (hydro), but has a very high reliance on diesel generation as well.

¹⁶ Based on a 2,000 square foot home, annual requirements of 100,000,000 BTU. Does not include government grants or other incentives.

Economic Evaluation of Bioenergy Opportunity in Yukon

In terms of production capacity, Yukon Energy Corporation and Yukon Electrical Company Ltd. combined have four main hydro facilities, one wind facility, and 16 diesel facilities. The production capacity of Yukon infrastructure is 138.5 MW, with 55% from hydro facilities, 45% from diesel facilities and less than 1% from the wind facilities at Haeckel Hill.¹⁷ Because many of the diesel facilities are used for peaking and as back-up systems, actual generation statistics reveal a greater use of renewable energy than the infrastructure would suggest (Table 10). Of primary environmental concern is the use of diesel electricity generation for several communities: Beaver Creek, Burwash Landing, Destruction Bay, Old Crow, Pelly Crossing, and Watson Lake. Based on 2004 statistics, Yukon Electrical Company Ltd. diesel generation facilities produced 16,480 tonnes of CO₂ emissions.¹⁸

Table 10 - Electricity Generation, Yukon

	Total (MW/hr)	Hydro ¹⁹ (MW/hr)	Internal Combustion (MW/hr)
2008	369,934	346,202	23,732
2007	354,694	331,039	23,655
2006	359,031	335,187	23,844
2005	343,748	321,335	22,413

Source: Yukon Statistical Review – 2008 Annual Report

While large-scale production of electricity from biomass is well proven, tremendous progress is currently taking place in technology for the production of small-scale electricity from biomass fuels. Two noteworthy companies, Nexterra of Vancouver, BC and Zilkha Biomass of Houston, TX, are demonstrating the current and future potential for electricity production from biomass.

At this time, biomass electricity production does not appear to be a reasonable option for Yukon. Considering that the technology for small-scale biomass based electricity production is relatively new and untested in N. America, especially in severe remote northern environments, proximity to the point of manufacturing is an important safeguard. Without having expertise and maintenance readily available from the manufacturers, the risk appears to be too great to justify the high capital expense of such a project. However, this industry is changing quickly and within the next 2-4 years it could be possible to consider a wood biomass electric facility for Yukon.

¹⁷ YEC Annual Report - 2008

¹⁸ www.yukonelectrical.com

¹⁹ Wind included, although not significant.

VI. SUMMARY AND RECOMMENDATIONS

1. Given that Yukon has ample wood fibre resources to provide for the thermal energy needs of the entire population, at a cost that is much less than current imported fossil fuel, it is recommended that Forest Management implement a bioenergy fibre acquisition policy, providing clear direction to potential developers of bioenergy production facilities, with possible incentives to encourage local industry.
2. The Yukon Government should support and encourage the implementation of biomass heating in government owned and managed facilities. Where there is an assurance of quality and cost effective provision of wood chips, such as appears to be the case in Dawson City, support should be given to local initiatives that result in employment gains and biomass supply in those locations.
3. Where current demand for wood pellets has reached a critical mass such as around Whitehorse, Yukon Government support should encourage continued rapid growth of this demand. Consideration should be given to an enhanced consumer incentive for purchase of pellet appliances and boilers, e.g. \$1500 per certified biomass stove and \$5000 per certified biomass boiler, providing that such appliances meet minimum emission standards.
4. A communication plan should detail the benefits of the biomass policies, including employment gains, emission reductions (particulate and CO₂), sustainability, local energy supply with the associated economic benefits, and most important to Yukon constituents, energy cost savings.

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